Microwaves are a form of electromagnetic radiation with wavelengths ranging from one meter to one millimeter; with frequencies between 300 MHz (100 cm) and 300 GHz (0.1 cm)

main properties of Microwaves.

- ✓ Microwaves are the waves that radiate electromagnetic energy with shorter wavelength.
- ✓ Microwaves are not reflected by Ionosphere.
- ✓ Microwaves travel in a straight line and are reflected by the conducting surfaces.
- ✓ Microwaves are easily attenuated within shorter distances.
- ✓ Microwave currents can flow through a thin layer of a cable

advantages of Microwaves such as the following −

- ✓ Supports larger bandwidth and hence more information is transmitted. For this reason, microwaves are used for point-to-point communications.
- ✓ More antenna gain is possible.
- ✓ Higher data rates are transmitted as the bandwidth is more.
- ✓ Antenna size gets reduced, as the frequencies are higher.
- ✓ Low power consumption as the signals are of higher frequencies.
- ✓ Effect of fading gets reduced by using line of sight propagation.
- ✓ Provides effective reflection area in the radar systems.
- ✓ Satellite and terrestrial communications with high capacities are possible.
- ✓ Low-cost miniature microwave components can be developed.
- ✓ Effective spectrum usage with wide variety of applications in all available frequency ranges of operation.

There are a few disadvantages of Microwaves such as the following −

- ✓ Cost of equipment or installation cost is high.
- ✓ They are hefty and occupy more space.
- ✓ Electromagnetic interference may occur.
- ✓ Variations in dielectric properties with temperatures may occur.
- ✓ Inherent inefficiency of electric power.

Microwaves

Microwaves are sometimes considered to be very short radio waves (highfrequency and high-energy radio waves).

Some important properties of microwaves are:

- They are reflected by metal surfaces.
- They heat materials if they can make atoms or molecules in the material vibrate. The amount of heating depends on the intensity of the microwave radiation, and the time that the material is exposed to the radiation.
- They pass through glass and plastics.
- They pass through the atmosphere.
- They pass through the ionosphere without being reflected.
- They are absorbed by water molecules, how well depends on the frequency (energy) of the microwaves.
- Transmission is affected by wave effects such as reflection, refraction, diffraction and interference.

<u>Microwaves and water molecules</u>

A microwave frequency (energy) can be selected which is strongly absorbed by water molecules, causing them to vibrate, and increasing their kinetic energy. This effect can be used to heat materials containing water, for example food. If the most strongly absorbed frequency (energy) is used in a microwave oven it only cooks the outside of the food because it is all absorbed before it penetrates the food. So the frequency (energy) used in a microwave oven is changed slightly to one that will penetrate about 1cm into the food.

Conduction and convection processes then spread the heat through the food.

As our bodies contain water molecules in our cells, microwave oven radiation will heat up our cells and is very dangerous at high intensity because it will burn body tissue. The radiation is kept inside the oven by the reflecting metal case and metal grid in the door.

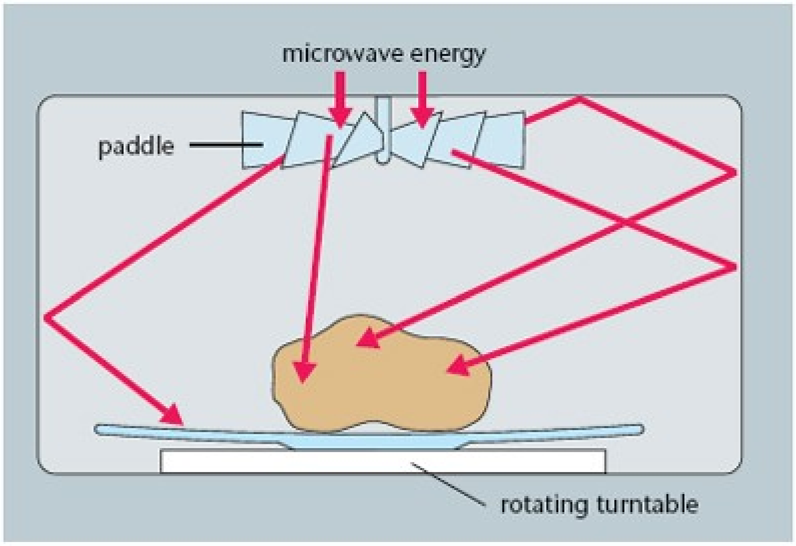


Fig. 12.6 A microwave oven.

Microwaves sent through the atmosphere will be absorbed by water so they can be used to monitor rain. The weaker the signal reaching the detector, the more rain the microwaves have passed through.

Microwave transmissions

Wireless technology uses microwaves and radio waves to transmit information. Advantages are:

- we can receive phone calls and email 24 hours a day
- no wiring is needed to connect laptops to the Internet, or for mobile phones or radio
- communication with wireless technology is portable and convenient.

Microwaves can be used to transmit signals over large distances if there are no obstacles between to reflect or absorb the beam. Another way to say this is that the transmitter and receiver are in line of sight (one can be seen from the other). This is why the transmitters are positioned high up, often on tall microwave masts. They cannot be spaced so far apart that, for example, hills or the curvature of the Earth stop the beam.

Microwaves are used to send signals to and from satellites. The satellites can relay signals around the Earth. Microwaves are used because they pass through the atmosphere and through the ionosphere. The signals may be for television programmes, telephone conversations, or monitoring the Earth (for example, weather forecasting).

When microwaves are transmitted from a dish the wavelength must be small compared to the dish diameter to reduce diffraction – the spreading out of the beam. The dish is made of metal because metal reflects microwaves well.

Mobile phones use microwave signals. The signals from the transmitting phones reflect off metal surfaces and walls to communicate with the nearest transmitter mast. There is a network of transmitter masts to relay the signals on to the nearest mast to the receiving phone.

Mobile phones have not been in widespread use for many years, so there is not much data about the possible dangers of using them. The transmitter is held close to the user's head so the microwaves must have a small heating effect on the brain. There are questions about whether this could be dangerous, or whether it is not large enough to be a problem. So far studies have not found that users have suffered any serious ill effects. There may also be a risk to residents living close to mobile phone masts.

Low-intensity microwave radiation, from mobile phone masts and handsets, may be a health risk, but there is disagreement about this.

{{{{ attachment}}}

Radio Waves

Radio waves are the lowest-energy, lowest-frequency and longest-wavelength electromagnetic waves. They are produced when an **alternating current** flows in an aerial and they spread out and travel through the atmosphere. They are not strongly absorbed by the atmosphere. Another aerial is used as a detector and the waves produce an alternating current in it, with a frequency that matches that of the radio waves. Anyone with a receiver can tune it to this frequency to pick up the radio waves so they are suitable for broadcasting (for example, radio and TV programmes) to large numbers of people. An advantage is that this method of communicating does not require wires to transmit information. A disadvantage is that radio stations using similar transmission frequencies sometimes interfere.

A common mistake is to think that we can hear radio waves. We cannot hear any electromagnetic radiation. The radiation is used to carry a signal that is converted into a sound wave by the receiver.

Medium wavelength radio waves are reflected from the ionosphere, a layer of charged particles in the upper atmosphere, so they can be used for long distance communication.

Digital radio has better-quality reception as it uses digital signals and so does not have problems of noise and interference.

How does a microwave turn electricity into heat? Like this!

1. Inside the strong metal box, there is a microwave generator called a magnetron. When you start cooking, the magnetron takes electricity from the power outlet and converts it into high-powered, 12cm (4.7 inch) radio waves.

2. The magnetron blasts these waves into the food compartment through a channel called a wave guide.
3. The food sits on a turntable, spinning slowly round so the microwaves cook it evenly.
4. The microwaves bounce back and forth off the reflective metal walls of the food compartment, just like light bounces off a mirror. When the microwaves reach the food itself, they don't simply bounce off. Just as radio waves can pass straight through the walls of your house, so microwaves penetrate inside the food. As they travel through it, they make the molecules inside it vibrate more quickly.
5. Vibrating molecules have heat so, the faster the molecules vibrate, the hotter the food becomes. Thus the microwaves pass their energy onto the molecules in the food, rapidly heating it up.

Inside out?

In a conventional oven, heat has to pass from electric heating elements (or gas burners) positioned in the bottom and sides of the cooker into the food, which cooks mostly by conduction from the outside in—from the outer layers to the inner ones. That's why a cake cooked in a conventional oven can be burned on the edges and not cooked at all in the middle. People sometimes say microwave ovens cook food from the "inside out," which is a bit of a gloss and isn't quite correct. When people say this, what they really mean is that the microwaves are simultaneously exciting molecules right through the food, so it's generally cooking more quickly and evenly than it would otherwise.

Exactly how the food cooks in a microwave depends mostly on what it's made from. Microwaves excite the liquids in foods more strongly, so something like a fruit pie (with a higher liquid content in the center) will indeed cook from the inside out, because the inside has the highest water content. You have to be very careful eating a microwaved apple pie because the inside may be boiling hot, while the outside crust is barely even warm. With other foods, where the water content is more evenly dispersed, you'll probably find they cook from the outside in, just like in a conventional oven.

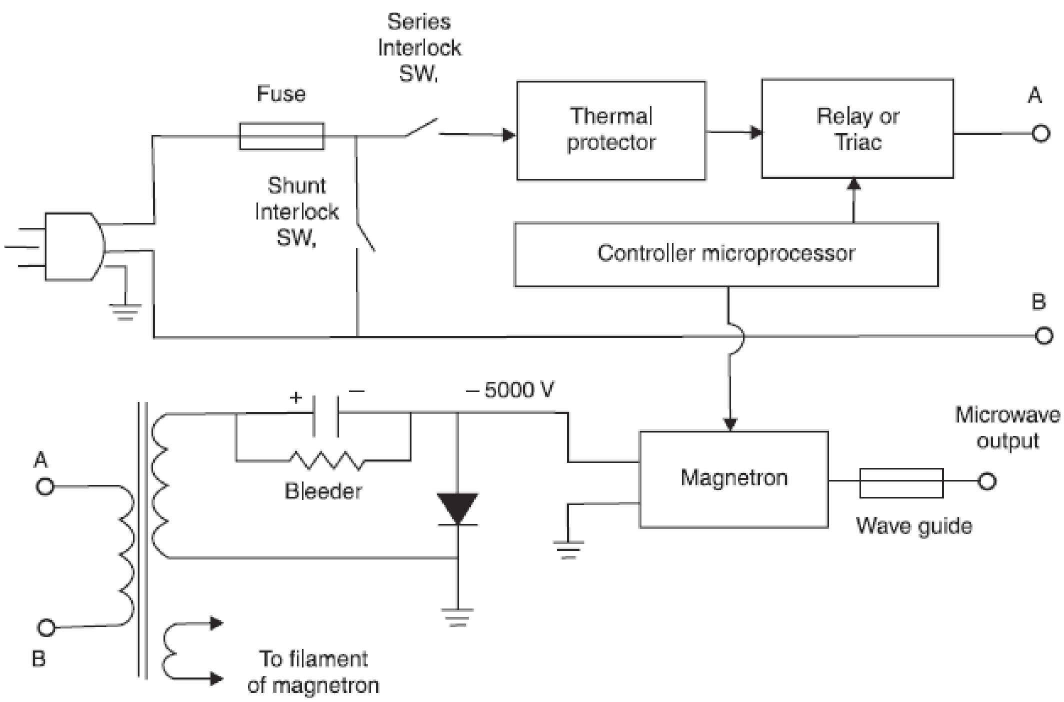
Another important factor is the size and shape of what you're cooking. Microwaves can't penetrate more than a centimeter or two (perhaps an inch or so) into food. Like swimmers diving into water, they're losing energy from the moment they enter the food, and after that first centimeter or so they don't have enough energy left to penetrate any deeper. If you're cooking anything big (say a joint of meat in a large microwave oven), only the outer "skin" layer will be cooked by the waves themselves; the interior will be cooked from the outside in by conduction. Fortunately, most of the things people cook in small microwave ovens aren't much more than a couple of centimeters across (think about a microwaveable meat or fruit pie).

You'll notice that microwaveable dinners specify a "cooking time" of so many minutes, followed by a "standing time" that's often just as long (where you leave the cooked food alone before eating it). During this period, the food effectively keeps on cooking: the hotter parts of the food will pass heat by conduction to the cooler parts, hopefully giving uniform cooking throughout.

The way microwave ovens distribute their microwaves can also cook things in unusual ways, as Evil Mad Scientists Laboratories found out when they tried cooking Indian snack food in a selection of different microwave ovens.

block diagram

The block diagram of a microwave oven is given in Fig. 50.6. The mains plug and socket are three-pin earthing type. The fast blow ceramic fuse is of 15 A, 250 V. *Interlock switches are linked with the oven door.* Power will be applied to the mains transformer only when the oven door is closed. At least one interlock switch is in series with the transformer primary, hence even a spot of dirt in the relay or trial, cannot turn the oven on when the door is open.



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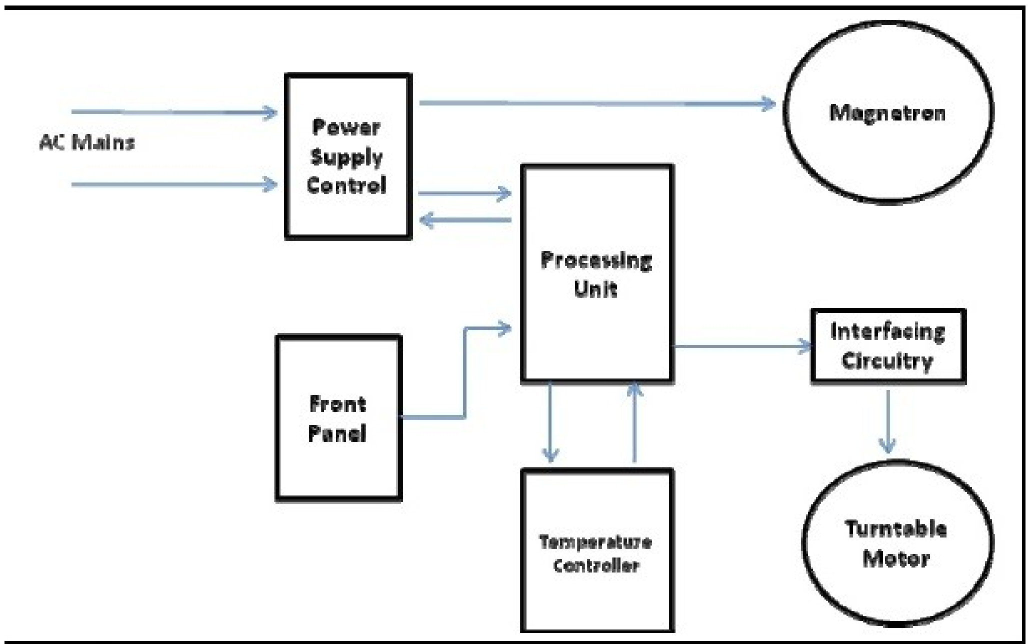


Controller

The controller usually includes a microcomputer, though very inexpensive units may simply have a mechanical timer (which ironically, is probably more expensive to manufacture!). The controller runs the digital clock and cook timer; sets microwave power levels; runs the display; and in high performance ovens, monitors the moisture or temperature sensors.

Power level is set by pulse width control of the microwave generator usually with a cycle that lasts 10-30 seconds. For example, HIGH will be continuous on, MEDIUM may be 10 seconds on, 10 seconds off, and LOW may be 5 seconds on, 15 seconds off. The power ratios are not quite linear as there is a 1 to 3 second warmup period after microwave power is switched on.

The operating voltages for the controller usually are derived from a stepdown transformer. The controller activates the microwave generating circuitry using either a relay or triac.

Safety Tips

1. Follow the manufacturer's instructions for use. Directions in the user manual provide recommended operating procedures and safety precautions. For instance, you should not use some microwave ovens when they are empty. In addition, you should not heat water or liquids longer than the manufacturer's instructions and recommendations.

2. Use microwave-safe containers. Use cookware specially manufactured for use in the microwave oven. Generally, you should not use metal pans or aluminum foil because microwaves reflect off them, causing food to cook unevenly and possibly damaging the oven. And you should not use some plastic containers because heated food can cause them to melt. The FDA recommends using glass, ceramic, and plastic containers labeled for microwave oven use.

3. Avoid super-heated water. “Super-heated” means water is heated beyond its boiling temperature, without signs of boiling. If you use a microwave oven to heat water in a clean cup beyond the boiling temperature, a slight disturbance or movement may cause the water to violently explode out of the cup. There have been reports of serious skin burns or scalding injuries around people’s hands and faces as a result of this phenomenon.

Adding ingredients such as instant coffee or sugar to water *before* heating greatly reduces the risk of hot-water eruption. Also remember to follow the manufacturer’s heating instructions.

4. Check for leakage. There should be little cause for concern about excess microwave radiation leaking from these ovens unless the door hinges, latch, or seals are damaged. The FDA recommends looking at your oven carefully to see if any of these issues exist. The agency also recommends that you do not use an oven if the door doesn’t close firmly or is bent, warped, or otherwise damaged.

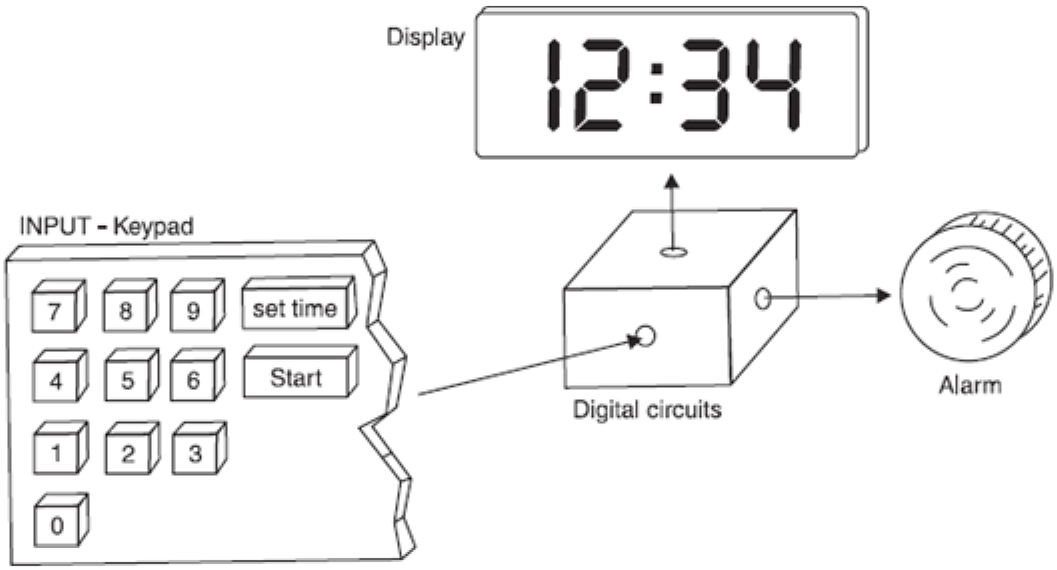
5. Don’t use ovens that seem to operate when the door is open. The FDA monitors these appliances for radiation safety issues and has received increasing reports about microwave ovens that appear to stay on—and operate—when the door is open. The FDA recommends that you immediately stop using a microwave oven if this happens.

“A failure in the door sensing switch can sometimes allow the fan, light, and/or turntable to operate when the door is open. But safety interlocks in microwave ovens are intended to stop the magnetron from generating microwaves,” explains Ting Song, Ph.D., a biomedical engineer with the FDA’s Magnetic Resonance and Electronic Products branch. “When interlocks work normally, the magnetron will not operate. However, since each oven design is different, consumers cannot be 100 percent sure that microwave radiation is not being emitted in this situation.”

Properties of Microwaves

- 300 MHz to 300 GHz (Frequency) & (3 x 10^8 m/sec)/frequency, which gives you a range from 1 mm to 1 meter. (Wavelength)
- Microwaves have wavelengths that can be measured in centimeters.
- microwave energy can penetrate haze, light rain and snow, clouds, and smoke.
- The prefix "micro-" in "microwave" means "small" compared to waves used in typical radio broadcasting, in that they have shorter wavelengths.

LCD TIMER WITH ALARM



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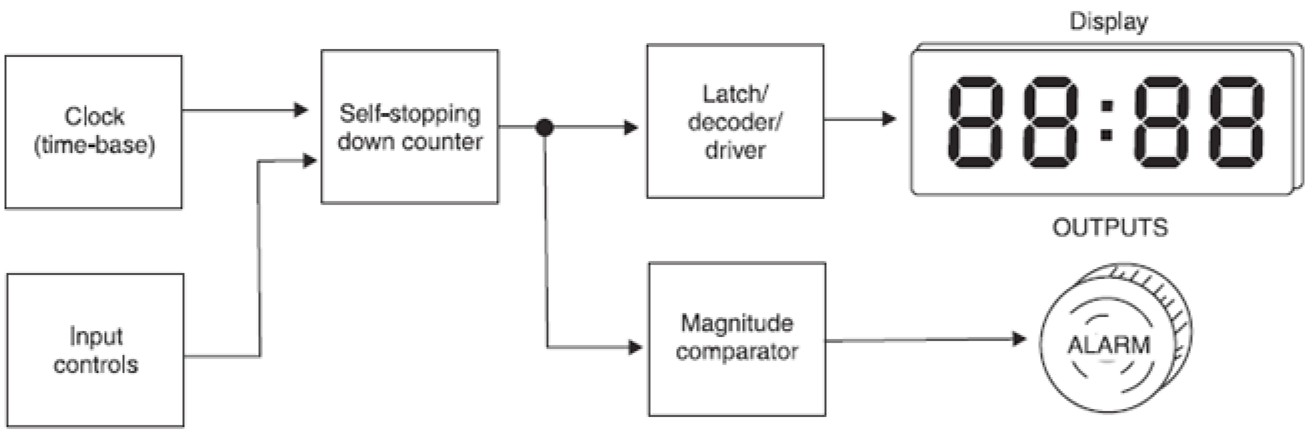


(b)

Microwave oven

A **microwave oven** (commonly referred to as a **microwave**) is a kitchen appliance that heats and cooks food by exposing it to electromagnetic radiation in the microwave frequency range. This induces polar molecules in the food to rotate and produce thermal energy in a process known as dielectric heating. Microwave ovens heat foods quickly and efficiently because excitation is fairly uniform in the outer 25–38 mm (1–1.5 inches) of a homogeneous, high water content food item; food is more evenly heated throughout than generally occurs in other cooking techniques.

A modern microwave oven (2016)

The development of the cavity magnetron in the UK made possible the production of electromagnetic waves of a small enough wavelength (microwaves). American engineer Percy Spencer is generally credited with inventing the modern microwave oven after World War II from radar technology developed during the war. Named the "Radarange", it was first sold in 1946. Raytheon later licensed its patents for a home-use microwave oven that was first introduced by Tappan in 1955, but these units were still too large and expensive for general home use. The countertop microwave oven was first introduced in 1967 by the Amana Corporation, and their use has spread into commercial and residential kitchens around the world. In addition to their use in cooking food, types of microwave ovens are used for heating in many industrial processes.

Panasonic NN-E225M

A cup of tea is heated for 20 seconds in a Panasonic NN-E225M microwave oven

Problems playing this file? See media help.

Microwave ovens are popular for reheating previously cooked foods and cooking a variety of foods. They are also useful for rapid heating of otherwise slowly prepared cooking items, such as hot butter, fats, and chocolate. Unlike conventional ovens, microwave ovens usually do not directly brown or caramelize food, since they rarely attain the necessary temperatures to produce Maillard reactions. Exceptions occur in rare cases where the oven is used to heat frying-oil and other very oily items (such as bacon), which attain far higher temperatures than that of boiling water

Microwave ovens have a limited role in professional cooking,[1] because the boiling-range temperatures produced in especially hydrous foods impede flavors produced by the higher temperatures of frying, browning, or baking. However, additional heat sources can be added to microwave ovens

Contents

History

Early developments

The exploitation of high-frequency radio waves for heating substances was made possible by the development of vacuum tube radio transmitters around 1920. By 1930 the application of short waves to heat human tissue had developed into the medical therapy of diathermy. At the 1933 Chicago World's Fair, Westinghouse demonstrated the cooking of foods between two metal plates attached to a 10 kW, 60 MHz shortwave transmitter.[2] The Westinghouse team, led by I. F. Mouromtseff, found that foods like steaks and potatoes could be cooked in minutes.

The 1937 United States patent application by Bell Laboratories states:[3]

> "This invention relates to heating systems for dielectric materials and the object of the invention is to heat such materials uniformly and substantially simultaneously throughout their mass. ... It has been proposed therefore to heat such materials simultaneously throughout their mass by means of the dielectric loss produced in them when they are subjected to a high voltage, high frequency field."

However, lower-frequency dielectric heating, as described in the aforementioned patent, is (like induction heating) an electromagnetic heating effect, the result of the so-called near-field effects that exist in an electromagnetic cavity that is small compared with the wavelength of the electromagnetic field. This patent proposed radio frequency heating, at 10 to 20 megahertz (wavelength 15 to 30 meters).[4] Heating from microwaves that have a wavelength that is small relative to the cavity (as in a modern microwave oven) is due to "far-field" effects that are due to classical electromagnetic radiation that describes freely propagating light and microwaves suitably far from their source. Nevertheless, the primary heating effect of all types of electromagnetic fields at both radio and microwave frequencies occurs via the dielectric heating effect, as polarized molecules are affected by a rapidly alternating electric field.

Cavity magnetron

The invention of the cavity magnetron made possible the production of electromagnetic waves of a small enough wavelength (microwaves). The magnetron was originally a crucial component in the development of short wavelength radar during World War II.[5] In 1937–1940, a multi-cavity magnetron was built by the British physicist Sir John Turton Randall, FRSE, together with a team of British coworkers, for the British and American military radar installations in World War II.[6] A more high-powered microwave generator that worked at shorter wavelengths was needed, and in 1940, at the University of Birmingham in England, Randall and Harry Boot produced a working prototype.[7] They invented a valve that could spit out pulses of microwave radio energy on a wavelength of 10cm, an unprecedented discovery.[6]

Sir Henry Tizard travelled to the U.S. in late September 1940 to offer the magnetron in exchange for their financial and industrial help (see Tizard Mission).[6] An early 6 kW version, built in England by the General Electric Company Research Laboratories, Wembley, London, was given to the U.S. government in September 1940. The magnetron was later described by American historian James Phinney Baxter III as "[t]he most valuable cargo ever brought to our shores".[8] Contracts were awarded to Raytheon and other companies for mass production of the magnetron.

The cavity magnetron developed by John Randall and Harry Boot in 1940 at the University of Birmingham, England

Discovery

In 1945, the specific heating effect of a high-power microwave beam was accidentally discovered by Percy Spencer, an American self-taught engineer from Howland, Maine. Employed by Raytheon at the time, he noticed that microwaves from an active radar set he was working on started to melt a candy bar he had in his pocket. The first food deliberately cooked with Spencer's microwave was popcorn, and the second was an egg, which exploded in the face of one of the experimenters.[9][10] To verify his finding, Spencer created a high density electromagnetic field by feeding microwave power from a magnetron into a metal box from which it had no way to escape. When food was placed in the box with the microwave energy, the temperature of the food rose rapidly. On 8 October 1945, Raytheon filed a United States patent application for Spencer's microwave cooking process, and an oven that heated food using microwave energy from a magnetron was soon placed in a Boston restaurant for testing.[11]

Microwave ovens, several from the 1980s

Commercial availability

Raytheon RadaRange aboard the NS *Savannah* nuclear-powered cargo ship, installed circa 1961

In 1947, Raytheon built the "Radarange", the first commercially available microwave oven.[12] It was almost 1.8 metres (5 ft 11 in) tall, weighed 340 kilograms (750 lb) and cost about US$5,000 ($54,000 in 2016 dollars) each. It consumed 3 kilowatts, about three times as much as today's microwave ovens, and was water-cooled. The name was the winning entry in an employee contest.[13] An early Radarange was installed (and remains) in the galley of the nuclear-powered passenger/cargo ship NS *Savannah*. An early commercial model introduced in 1954 consumed 1.6 kilowatts and sold for US$2,000 to US$3,000 ($18,000 to $27,000 in 2016 dollars). Raytheon licensed its technology to the Tappan Stove company of Mansfield, Ohio in 1952.[14] They tried to market a large 220 volt wall unit as a home microwave oven in 1955 for a price of US$1,295 ($12,000 in 2016 dollars), but it did not sell well. In 1965, Raytheon acquired Amana. In 1967, they introduced the first popular home model, the countertop Radarange, at a price of US$495 ($4,000 in 2016 dollars).

In the 1960s, Litton bought Studebaker's Franklin Manufacturing assets, which had been manufacturing magnetrons and building and selling microwave ovens similar to the Radarange. Litton then developed a new configuration of the microwave: the short, wide shape that is now common. The magnetron feed was also unique. This resulted in an oven that could survive a no-load condition: an empty microwave oven where there is nothing to absorb the microwaves. The new oven was shown at a trade show in Chicago, and helped begin a rapid growth of the market for home microwave ovens. Sales volume of 40,000 units for the U.S. industry in 1970 grew to one million by 1975. Market penetration was faster in Japan, due to a re-engineered magnetron allowing for less expensive units. Several other companies joined in the market, and for a time most systems were built by defense contractors, who were most familiar with the magnetron. Litton was particularly well known in the restaurant business.

Residential use

Formerly found only in large industrial applications, microwave ovens increasingly became a standard fixture of residential kitchens in developed countries. By 1986, roughly 25% of households in the U.S. owned a microwave oven, up from only about 1% in 1971;[15] the U.S. Bureau of Labor Statistics reported that over 90% of American households owned a microwave oven in 1997.[15][16] In Australia, a 2008 market research study found that 95% of kitchens contained a microwave oven and that 83% of them were used daily.[17] In Canada, fewer than 5% of households had a microwave oven in 1979, but more than 88% of households owned one by 1998.[18] In France, 40% of households owned a microwave oven in 1994, but that number had increased to 65% by 2004.[19]

1971 Radar Range RR-4. By the late 1970s, technological advances led to rapidly falling prices. Often called "electronic ovens" in the 1960s, the name "microwave oven" later gained currency, and they are now informally called "microwaves".

Adoption has been slower in less-developed countries, as households with disposable income concentrate on more important household appliances like refrigerators and ovens. In India, for example, only about 5% of households owned a microwave in 2013, well behind refrigerators at 31% ownership.[20] However, microwave ovens are gaining popularity. In Russia, for example, the number of households with a microwave grew from almost 24% in 2002 to almost 40% in 2008.[21] Almost twice as many households in South Africa owned microwaves in 2008 (38.7%) as in 2002 (19.8%).[21] Microwave ownership in Vietnam was at 16% of households in 2008—versus 30% ownership of refrigerators; this rate was up significantly from 6.7% microwave ownership in 2002, with 14% ownership for refrigerators that year.[21]

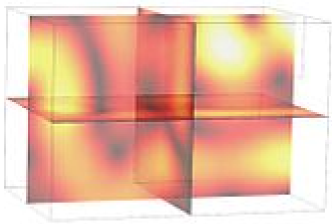
Principles

A microwave oven heats food by passing microwave radiation through it. Microwaves are a form of non-ionizing electromagnetic radiation with a frequency higher than ordinary radio waves but lower than infrared light. Microwave ovens use frequencies in one of the ISM (industrial, scientific, medical) bands, which are reserved for this use, so they do not interfere with other vital radio services. Consumer ovens usually use 2.45 gigahertz (GHz)—a wavelength of 12.2 centimetres (4.80 in)—while large industrial/commercial ovens often use 915 megahertz (MHz)—32.8 centimetres (12.9 in).[22] Water, fat, and other substances in the food absorb energy from the microwaves in a process called dielectric heating. Many molecules (such as those of water) are electric dipoles, meaning that they have a partial positive charge at one end and a partial negative charge at the other, and therefore rotate as they try to align themselves with the alternating electric field of the microwaves. Rotating molecules hit other molecules and put them into motion, thus dispersing energy. This energy, dispersed as molecular rotations, vibrations and/or translations in solids and liquids raises the temperature of the food, in a process similar to heat transfer by contact with a hotter body[23].

A microwave oven, c. 2005

Microwave heating is more efficient on liquid water than on frozen water, where the movement of molecules is more restricted. Dielectric heating of liquid water is also temperature-dependent: At 0 °C, dielectric loss is greatest at a field frequency of about 10 GHz, and for higher water temperatures at higher field frequencies.[24]

Compared to liquid water, microwave heating is less efficient on fats and sugars (which have a smaller molecular dipole moment).[25] Sugars and triglycerides (fats and oils) absorb microwaves due to the dipole moments of their hydroxyl groups or ester groups. However, due to the lower specific heat capacity of fats and oils and their higher vaporization temperature, they often attain much higher temperatures inside microwave ovens.[24] This can induce temperatures in oil or very fatty foods like bacon far above the boiling point of water, and high enough to induce some browning reactions, much in the manner of conventional broiling (UK: grilling), braising, or deep fat frying. Foods high in water content and with little oil rarely exceed the boiling temperature of water.



Play media
Simulation of the electric field inside a microwave oven for the first 8 ns of operation

Microwave heating can cause localized thermal runaways in some materials with low thermal conductivity which also have dielectric constants that increase with temperature. An example is glass, which can exhibit thermal runaway in a microwave to the point of melting if preheated. Additionally, microwaves can melt certain types of rocks, producing small quantities of synthetic lava. Some ceramics can also be melted, and may even become clear upon cooling. Thermal runaway is more typical of electrically conductive liquids such as salty water.

A common misconception is that microwave ovens cook food "from the inside out", meaning from the center of the entire mass of food outwards. This idea arises from heating behavior seen if an absorbent layer of water lies beneath a less absorbent drier layer at the surface of a food; in this case, the deposition of heat energy inside a food can exceed that on its surface. This can also occur if the inner layer has a lower heat capacity than the outer layer causing it to reach a higher temperature, or even if the inner layer is more thermally conductive than the outer layer making it feel hotter despite having a lower temperature. In most cases, however, with uniformly structured or reasonably homogenous food item, microwaves are absorbed in the outer layers of the item at a similar level to that of the inner layers. Depending on water content, the depth of initial heat deposition may be several centimetres or more with microwave ovens, in contrast to broiling/grilling (infrared) or convection heating—methods which deposit heat thinly at the food surface. Penetration depth of microwaves is dependent on food composition and the frequency, with lower microwave frequencies (longer wavelengths) penetrating further.

Heating efficiency

A microwave oven converts only part of its electrical input into microwave energy. An average consumer microwave oven consumes 1100 W of electricity in producing 700 W of microwave power, an efficiency of 64%. The other 400 W are dissipated as heat, mostly in the magnetron tube. Such wasted heat, along with heat from the product being microwaved, is exhausted as warm air through cooling vents. Additional power is used to operate the lamps, AC power transformer, magnetron cooling fan, food turntable motor and the control circuits, although the power consumed by the electronic control circuits of a modern microwave oven is negligible (< 1% of the input power) during cooking.

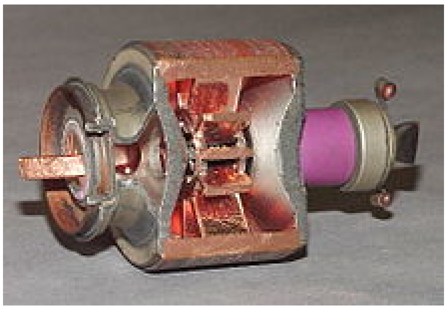
For cooking or reheating small amounts of food, the microwave oven may use less energy than a cook stove.[26] Although microwave ovens are touted as the most efficient appliance,[27] the energy savings are largely due to the reduced heat mass of the food's container.[28] The amount of energy used to heat food is generally small compared to total energy usage in typical residences in the United States.[29]

Design

A microwave oven consists of:

- a high-voltage power source, commonly a simple transformer or an electronic power converter, which passes energy to the magnetron
- a high-voltage capacitor connected to the magnetron, transformer and via a diode to the chassis
- a cavity magnetron, which converts high-voltage electric energy to microwave radiation

- a magnetron control circuit (usually with a microcontroller)
- a short waveguide (to couple microwave power from the magnetron into the cooking chamber)
- a metal cooking chamber
- a turntable or metal wave guide stirring fan.
- a digital / manual control panel



A magnetron with section removed (magnet is not shown)

Modern microwave ovens use either an analog dial-type timer or a digital control panel for operation. Control panels feature an LED, liquid crystal or vacuum fluorescent display, in the 90s brands such as Panasonic and GE began offering models with a scrolling-text display showing cooking instructions, numeric buttons for entering the cook time, a power level selection feature and other possible functions such as a defrost setting and pre-programmed settings for different food types, such as meat, fish, poultry, vegetables, frozen vegetables, frozen dinners, and popcorn. In most ovens, the magnetron is driven by a linear transformer which can only feasibly be switched completely on or off. As such, the choice of power level does not affect the intensity of the microwave radiation; instead, the magnetron is cycled on and off every few seconds, thus altering the large scale duty cycle. Newer models have inverter power supplies that use pulse-width modulation to provide effectively continuous heating at reduced power, so that foods are heated more evenly at a given power level and can be heated more quickly without being damaged by uneven heating.

The microwave frequencies used in microwave ovens are chosen based on regulatory and cost constraints. The first is that they should be in one of the industrial, scientific, and medical (ISM) frequency bands set aside for non-communication purposes. For household purposes, 2.45 GHz has the advantage over 915 MHz in that 915 MHz is only an ISM band in the ITU Region 2 while 2.45 GHz is available worldwide. Three additional ISM bands exist in the microwave frequencies, but are not used for microwave cooking. Two of them are centered on 5.8 GHz and 24.125 GHz, but are not used for microwave cooking because of the very high cost of power generation at these frequencies. The third, centered on 433.92 MHz, is a narrow band that would require expensive equipment to generate sufficient power without creating interference outside the band, and is only available in some countries.

The cooking chamber is similar to a Faraday cage to prevent the waves from coming out of the oven. Even though there is no continuous metal-to-metal contact around the rim of the door, choke connections on the door edges act like metal-to-metal contact, at the frequency of the microwaves, to prevent leakage. The oven door usually has a window for easy viewing, with a layer of conductive mesh some distance from the outer panel to maintain the shielding. Because the size of the perforations in the mesh is much less than the microwaves' wavelength (12.2 cm for the usual 2.45 GHz), microwave radiation cannot pass through the door, while visible light (with its much shorter wavelength) can.

Variants and accessories

A microwave oven with convection feature

A variant of the conventional microwave is the convection microwave. A convection microwave oven is a combination of a standard microwave and a convection oven. It allows food to be cooked quickly, yet come out browned or crisped, as from a convection oven. Convection microwaves are more expensive than conventional microwave ovens. Some convection microwaves—those with exposed heating elements—can produce smoke and burning odors as food spatter from earlier microwave-only use is burned of the heating elements.

In 2000,[30] some manufacturers began offering high power quartz halogen bulbs to their convection microwave models, marketing them under names such as "Speedcook", "Advantium", "Lightwave" and "Optimawave" to emphasize their ability to cook food rapidly and with good browning. The bulbs heat the food's surface with infrared (IR) radiation, browning surfaces as in a conventional oven. The food browns while also being heated by the microwave radiation and heated through conduction through contact with heated air. The IR energy which is delivered to the outer surface of food by the lamps is sufficient to initiate browning caramelization in foods primarily made up of carbohydrates and Maillard reactions in foods primarily made up of protein. These reactions in food produce a texture and taste similar to that typically expected of conventional oven cooking rather than the bland boiled and steamed taste that microwave-only cooking tends to create.

In order to aid browning, sometimes an accessory browning tray is used, usually composed of glass or porcelain. It makes food crisp by oxidizing the top layer until it turns brown. Ordinary plastic cookware is unsuitable for this purpose because it could melt.

Frozen dinners, pies, and microwave popcorn bags often contain a susceptor made from thin aluminium film in the packaging or included on a small paper tray. The metal film absorbs microwave energy efficiently and consequently becomes extremely hot and radiates in the infrared, concentrating the heating of oil for popcorn or even browning surfaces of frozen foods. Heating packages or trays containing susceptors are designed for a single use and are then discarded as waste.

Microwave-safe plastics

Some current plastic containers and food wraps are specifically designed to resist radiation from microwaves. Products may use the term "microwave safe", may carry a microwave symbol (three lines of waves, one above the other) or simply provide instructions for proper microwave use. Any of these is an indication that a product is suitable for microwaving when used in accordance with the directions provided.[31]

Benefits and safety features

All microwaves use a timer for the cooking time, at the end of cooking time, the oven switches itself off

Microwave ovens heat food without getting hot themselves. Taking a pot off a stove, unless it is an induction cooktop, leaves a potentially dangerous heating element or trivet that will stay hot for some time. Likewise, when taking a casserole out of a conventional oven, one's arms are exposed to the very hot walls of the oven. A microwave oven does not pose this problem.

Food and cookware taken out of a microwave oven are rarely much hotter than 100 °C (212 °F). Cookware used in a microwave ove is often much cooler than the food because the cookware is transparent to microwaves; the microwaves heat the food directly and the cookware is indirectly heated by the food. Food and cookware from a conventional oven, on the other hand, are the same temperature as the rest of the oven; a typical cooking temperature is 180 °C (356 °F). That means that conventional stoves and ovens can cause more serious burns.

The lower temperature of cooking (the boiling point of water) is a significant safety benefit compared to baking in the oven or frying, because it eliminates the formation of tars and char, which are carcinogenic.[32] Microwave radiation also penetrates deeper than direct heat, so that the food is heated by its own internal water content. In contrast, direct heat can burn the surface while the inside is still cold. Pre-heating the food in a microwave oven before putting it into the grill or pan reduces the time needed to heat up the food and reduces the formation of carcinogenic char. Unlike frying and baking, microwaving does not produce acrylamide in potatoes,[33] however unlike deep-frying, it is of only limited effectiveness in reducing glycoalkaloid (i.e. solanine) levels.[34] Acrylamide has been found in other microwaved products like popcorn.

Heating characteristics

Microwave ovens are frequently used for reheating leftover food, and bacterial contamination may not be repressed if the safe temperature is not reached, resulting in foodborne illness, as with all inadequate reheating methods.

Uneven heating in microwaved food can be partly due to the uneven distribution of microwave energy inside the oven, and partly due to the different rates of energy absorption in different parts of the food. The first problem is reduced by a stirrer, a type of fan that reflects microwave energy to different parts of the oven as it rotates, or by a turntable or carousel that turns the food; turntables, however, may still leave spots, such as the center of the oven, which receive uneven energy distribution. The location of dead spots and hot spots in a microwave can be mapped out by placing a damp piece of thermal paper in the oven. When the water saturated paper is subjected to the microwave radiation it becomes hot enough to cause the dye to be released which will provide a visual representation of the microwaves. If multiple layers of paper are constructed in the oven with a sufficient distance between them a three-dimensional map can be created. Many store receipts are printed on thermal paper which allows this to be easily done at home.[35]

The second problem is due to food composition and geometry, and must be addressed by the cook, by arranging the food so that it absorbs energy evenly, and periodically testing and shielding any parts of the food that overheat. In some materials with low thermal conductivity, where dielectric constant increases with temperature, microwave heating can cause localized thermal runaway. Under certain conditions, glass can exhibit thermal runaway in a microwave to the point of melting.[36]

In addition to their use in heating food, microwave ovens are widely used for heating in industrial processes. A microwave tunnel oven for softening plastic rods prior to extrusion.

Due to this phenomenon, microwave ovens set at too-high power levels may even start to cook the edges of frozen food while the inside of the food remains frozen. Another case of uneven heating can be observed in baked goods containing berries. In these items, the berries absorb more energy than the drier surrounding bread and cannot dissipate the heat due to the low thermal conductivity of the bread. Often this results in overheating the berries relative to the rest of the food. "Defrost" oven settings use low power levels designed to allow time for heat to be conducted within frozen foods from areas that absorb heat more readily to those which heat more slowly. In turntable-equipped ovens, more even heating will take place by placing food off-centre on the turntable tray instead of exactly in the centre, assuming the food item so placed covers less of the center "dead zone".

There are microwave ovens on the market that allow full-power defrosting. They do this by exploiting the properties of the electromagnetic radiation LSM modes. LSM full-power defrosting may actually achieve more even results than slow defrosting.[37]

Microwave heating can be deliberately uneven by design. Some microwavable packages (notably pies) may include materials that contain ceramic or aluminium flakes, which are designed to absorb microwaves and heat up, which aids in baking or crust preparation by depositing more energy shallowly in these areas. Such ceramic patches affixed to cardboard are positioned next to the food, and are typically smokey blue or gray in colour, usually making them easily identifiable; the cardboard sleeves included with Hot Pockets, which have a silver surface on the inside, are a good example of such packaging. Microwavable cardboard packaging may also contain overhead ceramic patches which function in the same way. The technical term for such a microwave-absorbing patch is a susceptor.[38]

Effects on food and nutrients

Microwaved food and irradiated food creates similar dangers. Microwave kills 95% of all microorganisms including the Probiotic bacteria. Also, Microwave changes a liquid's ionic bonding of it's molecules,[39] resulting in changes in nutritional value.[40]

Any form of cooking will destroy some nutrients in food, but the key variables are how much water is used in the cooking, how long the food is cooked, and at what temperature.[41] Nutrients are primarily lost by leaching into cooking water, which tends to make microwave cooking healthier, given the shorter cooking times it requires.[42] Like other heating methods, microwaving converts vitamin B_{12} from an active to inactive form; the amount of conversion depends on the temperature reached, as well as the cooking time. Boiled food reaches a maximum of 100 °C (212 °F) (the boiling point of water), whereas microwaved food can get locally hotter than this, leading to faster breakdown of vitamin B_{12}. The higher rate of loss is partially offset by the shorter cooking times required.[43]

Spinach retains nearly all its folate when cooked in a microwave; in comparison, it loses about 77% when boiled, leaching out nutrients. Bacon cooked by microwave has significantly lower levels of carcinogenic nitrosamines than conventionally cooked bacon.[41] Steamed vegetables tend to maintain more nutrients when microwaved than when cooked on a stovetop.[41] Microwave blanching is 3–4 times more effective than boiled water blanching in the retaining of the water-soluble vitamins folic acid, thiamin and riboflavin, with the exception of ascorbic acid, of which 28.8% is lost (vs. 16% with boiled water blanching).[44]

Microwaving human milk at high temperatures is not recommended as it causes a marked decrease in activity of anti-infective factors.[45]

Use in cleaning kitchen sponges

Studies have investigated the use of the microwave to clean non-metallic domestic sponges which have been thoroughly wetted. A 2006 study found that microwaving wet sponges for two minutes (at 1000 watt power) removed 99% of coliforms, E. coli and MS2 phages. Bacillus cereus spores were killed at 4 minutes of microwaving.[46]

A 2017 study was less affirmative: about 60% of the germs were killed but the remaining ones quickly re-colonized the sponge.[47]

Hazards

High temperatures

Water and other homogeneous liquids can superheat[48][49] when heated in a microwave oven in a container with a smooth surface. That is, the liquid reaches a temperature slightly above its normal boiling point without bubbles of vapour forming inside the liquid. The boiling process can start explosively when the liquid is disturbed, such as when the user takes hold of the container to remove it from the oven or while adding solid ingredients such as powdered creamer or sugar. This can result in spontaneous boiling (nucleation) which may be violent enough to eject the boiling liquid from the container and cause severe scalding.[50]

Closed containers, such as eggs, can explode when heated in a microwave oven due to the increased pressure from steam. Intact fresh egg yolks outside the shell will also explode, as a result of superheating. Insulating plastic foams of all types generally contain closed air pockets, and are generally not recommended for use in a microwave, as the air pockets explode and the foam (which can be toxic if consumed) may melt. Not all plastics are microwave-safe, and some plastics absorb microwaves to the point that they may become dangerously hot.

Products that are heated for too long can catch fire. Though this is inherent to any form of cooking, the rapid cooking and unattended nature of the use of microwave ovens results in additional hazard.

Metal objects

Any metal or conductive object placed into the microwave will act as an antenna to some degree, resulting in an electric current. This causes the object to act as a heating element. This effect varies with the object's shape and composition, and is sometimes utilized for cooking.

Any object containing pointed metal can create an electric arc (sparks) when microwaved. This includes cutlery, crumpled aluminium foil (though some foil used in microwaves are safe, see below), twist-ties containing metal wire, the metal wire carry-handles in paper Chinese take-out food containers, or almost any metal formed into a poorly conductive foil or thin wire; or into a pointed shape.[51] Forks are a good example: the tines of the fork respond to the electric field by producing high concentrations of electric charge at the tips. This has the effect of exceeding the dielectric breakdown of air, about 3 megavolts per meter (3×10^6 V/m). The air forms a conductive plasma, which is visible as a spark. The plasma and the tines may then form a conductive loop, which may be a more effective antenna, resulting in a longer lived spark. When dielectric breakdown occurs in air, some ozone and nitrogen oxides are formed, both of which are unhealthy in large quantities.

It is possible for metal objects to be microwave-oven compatible, although experimentation by users is not encouraged. Microwaving an individual smooth metal object without pointed ends, for example, a spoon or shallow metal pan, usually does not produce sparking. Thick metal wire racks can be part of the interior design in microwave ovens (see illustration). In a similar way, the interior wall plates with perforating holes which allow light and air into the oven, and allow interior-viewing through the oven door, are all made of conductive metal formed in a safe shape.

The effect of microwaving thin metal films can be seen clearly on a Compact Disc or DVD (particularly the factory pressed type). The microwaves induce electric currents in the metal film, which heats up, melting the plastic in the disc and leaving a visible pattern of concentric and radial scars. Similarly, porcelain with thin metal films can also be destroyed or damaged by microwaving. Aluminium foil is thick enough to be used in microwave ovens as a shield against heating parts of food items, if the foil is not badly warped. When wrinkled, aluminium foil is generally unsafe in microwaves, as manipulation of the foil causes sharp bends and gaps that invite sparking. The USDA recommends that aluminium foil used as a partial food shield in microwave cooking cover no more than one quarter of a food object, and be carefully smoothed to eliminate sparking hazards.[52]

A microwave oven with a metal shelf

A microwaved DVD-R disc showing the effects of electrical discharge through its metal film

Another hazard is the resonance of the magnetron tube itself. If the microwave is run without an object to absorb the radiation, a standing wave will form. The energy is reflected back and forth between the tube and the cooking chamber. This may cause the tube to overload and burn out. For the same reason, dehydrated food, or food wrapped in metal which does not arc, is problematic for overload reasons, without necessarily being a fire hazard.

Certain foods such as grapes, if properly arranged, can produce an electric arc.[53] Prolonged arcing from food carries similar risks to arcing from other sources as noted above.

Some other objects that may conduct sparks are plastic/holographic print thermoses (such as Starbuck's novelty cups) or cups with metal lining. If any bit of the metal is exposed, all the outer shell will burst off the object or melt.

The high electrical fields generated inside a microwave often can be illustrated by placing a radiometer or neon glow-bulb inside the cooking chamber, creating glowing plasma inside the low-pressure bulb of the device.

Direct microwave exposure

Direct microwave exposure is not generally possible, as microwaves emitted by the source in a microwave oven are confined in the oven by the material out of which the oven is constructed. Furthermore, ovens are equipped with redundant safety interlocks, which remove power from the magnetron if the door is opened. This safety mechanism is required by United States federal regulations.[54] Tests have shown confinement of the microwaves in commercially available ovens to be so nearly universal as to make routine testing unnecessary.[55] According to the United States Food and Drug Administration's Center for Devices and Radiological Health, a U.S. Federal Standard limits the amount of microwaves that can leak from an oven throughout its lifetime to 5 milliwatts of microwave radiation per square centimeter at approximately 5 cm (2 in) from the surface of the oven.[56] This is far below the exposure level currently considered to be harmful to human health.[57]

The radiation produced by a microwave oven is non-ionizing. It therefore does not have the cancer risks associated with ionizing radiation such as X-rays and high-energy particles. Long-term rodent studies to assess cancer risk have so far failed to identify any carcinogenicity from 2.45 GHz microwave radiation even with chronic exposure levels (i.e. large fraction of life span) far larger than humans are likely to encounter from any leaking ovens.[58][59] However, with the oven door open, the radiation may cause damage by heating. Every microwave oven sold has a protective interlock so that it cannot be run when the door is open or improperly latched.

Microwaves generated in microwave ovens cease to exist once the electrical power is turned off. They do not remain in the food when the power is turned off, any more than light from an electric lamp remains in the walls and furnishings of a room when the lamp is turned off. They do not make the food or the oven radioactive. Compared to conventional cooking, the nutritional content of some foods may be altered differently, but generally in a positive way by preserving more micronutrients - see above. There is no indication of detrimental health issues associated with microwaved food.[60]

There are, however, a few cases where people have been exposed to direct microwave radiation, either from appliance malfunction or deliberate action.[61][62] The general effect of this exposure will be physical burns to the body, as human tissue, particularly the outer fat and muscle layers, has similar composition to some foods that are typically cooked in microwave ovens and so experiences similar dielectric heating effects when exposed to microwave electromagnetic radiation.

Chemical exposure

Some magnetrons have ceramic insulators with beryllium oxide (beryllia) added. The beryllium in such oxides is a serious chemical hazard if crushed then inhaled or ingested. In addition, beryllia is listed as a confirmed human carcinogen by the IARC; therefore, broken ceramic insulators or magnetrons should not be handled. This is a danger if the microwave oven becomes physically damaged, if the insulator cracks, or when the magnetron is opened and handled, yet not during normal usage.

See also

- Induction cooker
- List of cooking appliances
- List of home appliances
- Microwave chemistry
- Peryton (astronomy)
- Robert V. Decareau
- Thelma Pressman

References

1. Hervé This, Révélations gastronomiques, Éditions Belin ISBN 2-7011-1756-9
2. "Cooking with Short Waves" (http://www.americanradiohistory.com/Archive-Short-Wave-Television/30s/SW-TV-1933-11.pdf) (PDF). *Short Wave Craft*. New York: Popular Book Corp. **4** (7): 394. November 1933 Retrieved 23 March 2015.
3. U.S. Patent 2,147,689 (https://www.google.com/patents/US2147689) Chaffee, Joseph G., *Method and apparatus for heating dielectric materials*, filed 11 August 1937; granted 21 February 1939
4. Chaffee, Joseph G. (21 February 1939). *2,147,689: Method and Apparatus for Heating Dielectric Materials* (http://pdfpiw.uspto.gov/.piw?PageNum=0&docid=02147689&IDKey=49D95666A76C&HomeUrl=http%3A%2F%2Fpatft.uspto.gov%2Fnetacgi%2Fnph-Parser%3FSect1%3DPTO2%2526Sect2%3DHITOFF%2526u%3D%25252Fnetahtml%25252FPTO%25252Fsearch-adv.htm%2526r%3D1%2526p%3D1%2526f%3DG%2526l%3D50%2526d%3DALL%2526S1%3D2147689.PN.%2526OS%3Dpn%2F2147689%2526RS%3DPN%2F2147689). United States Patent and Trademark Office
5. "The Magnetron" (http://histru.bournemouth.ac.uk/Oral_History/Talking_About_Technology/radar_research/the_magnetron.html). *Radar Recollections - A Bournemouth University/CHiDE/HLF project*. Defence Electronics History Society (formerly CHiDE).
6. "Briefcase 'that changed the world'" (http://news.bbc.co.uk/1/hi/sci/tech/6331897.stm). BBC. October 20, 2017.
7. Willshaw, W. E.; L. Rushforth; A. G. Stainsby; R. Latham; A. W. Balls; A. H. King (1946). "The high-power pulsed magnetron: development and design for radar applications" (http://ieeexplore.ieee.org/xpls/abs_all.jsp?arnumber=5299321&tag=1). *The Journal of the Institution of Electrical Engineers — Part IIIA: Radiolocation*. **93** (5): 985–1005. doi:10.1049/ji-3a-1.1946.0188 (https://doi.org/10.1049%2Fji-3a-1.1946.0188). Retrieved 22 June 2012.
8. James Phinney Baxter III (Official Historian of the Office of Scientific Research and Development), *Scientists Against Time* (Boston: Little, Brown, and Co., 1946), page 142.
9. John Carlton Gallawa (1998). "The history of the microwave oven" (http://www.gallawa.com/history.html).
10. Radar — Father of the Microwave Oven (https://www.youtube.com/watch?v=4h1ESUz2H3E) on YouTube

11. US patent 2495429 (https://worldwide.espacenet.com/textdoc?DB=EPODOC&IDX=US2495429) Spencer, Percy L., "Method of treating foodstuffs", issued 1950-January-24
12. "Technology Leadership" (https://web.archive.org/web/20130322044917/http://www.raytheon.com/ourcompany/history/leadership/). Raytheon. Archived from the original (http://www.raytheon.com/ourcompany/history/leadership/) on 2013-03-22.
13. Gallawa, J Carlton (1989). "A Brief History of the Microwave Oven" (http://www.smecc.org/microwave_oven.htm). *The complete microwave oven service handbook : operation, maintenance, troubleshooting, and repair*. Englewood Cliffs, N.J.: Prentice Hall. ISBN 9780131620179. OCLC 18559256 (https://www.worldcat.org/oclc/18559256). Retrieved 2017-10-11. Chapter link is hosted at the Southwest Museum of Engineering, Communication and Computation; Glendale, Arizona.
14. "Do you remember your family's first microwave?" (https://web.archive.org/web/20160422025448/https://ohiohistory.wordpress.com/2010/11/02/do-you-remember-your-familys-first-microwave/). *Ohio Historical Society*. 2 November 2010. Archived from the original on 22 April 2016.
15. Liegey, Paul R. (16 October 2001), *Hedonic Quality Adjustment Methods For Microwave Ovens In the U.S. CPI* (http://www.bls.gov/cpi/cpimwo.htm), Bureau of Labor Statistics, United States Department of Labor, retrieved 5 October 2013
16. Cox, W. Michael; Alm, Richard (1997), "Time Well Spent: The Declining Real Cost of Living in America" (http://www.dallasfed.org/assets/documents/fed/annual/1999/ar97.pdf) (PDF), *1997 Annual Report*, Federal Reserve Bank of Dallas, p. 22 (see Exhibit 8), archived from the original (http://www.dallasfed.org/htm/pubs/pdfs/anreport/arpt97.pdf) (PDF) on 13 August 2006, retrieved 8 May 2016
17. *The Westinghouse How Australia Cooks Report* (http://newsroom.electrolux.com/au/files/2010/01/Westinghouse-How-Australia-Cooks-Report1.pdf) (PDF), Westinghouse, October 2008, retrieved 5 February 2015
18. Williams, Cara (Winter 2000). "Income and expenditures" (http://www.statcan.gc.ca/pub/11-008-x/11-008-x2000003-eng.pdf) (PDF). *Canadian Social Trends — Catalogue No. 11-008*. Statistics Canada (59): 7–12. "Microwaves have been adopted even more avidly: in 1979, less than 5% of households had one, but by 1998 over 88% did."
19. *World Major Household Appliances: World Industry Study with Forecasts to 2009 & 2014 (Study #2015)* (http://www.freedoniagroup.com/brochure/20xx/2015smwe.pdf) (PDF), Cleveland, Ohio: The Freedonia Group, January 2006, TABLE VI-5: FRANCE COOKING APPLIANCES SUPPLY & DEMAND (million dollars)
20. "Household penetration rate of home appliances in India in 2013" (http://www.statista.com/statistics/370635/household-penetration-home-appliances-india/). *Statistica*. Retrieved 5 February 2015.
21. *Ownership of household amenities among selected countries* (http://www.ers.usda.gov/media/612721/householdamenities.xls) (XLS), Economic Research Service, United States Department of Agriculture, 2009, retrieved 5 February 2015
22. "Litton — For Heat, Tune to 915 or 2450 Megacycles" (http://www.smecc.org/litton_-_for_heat,_tune_to_915_or_2450_megacycles.htm). *Litton Industries*. *1965*. Southwest Museum of Engineering, Communications and Computation. 2007. Retrieved 12 December 2006.
23. Zitzewitz, Paul W. (2011-02-01). *The Handy Physics Answer Book* (https://books.google.it/books?id=qGTkgFZBJZQC&pg=PA153&dq=microwave+oven+principle&hl=en&sa=X&ved=0ahUKEwjd9oSgn7vXAhUS4qQKHSp7APMQ6AEITzAH#v=onepage&q=microwave%20oven%20principle&f=false). Visible Ink Press. ISBN 9781578593576.
24. Chaplin, Martin (28 May 2012). "Water and Microwaves" (http://www.lsbu.ac.uk/water/microwave.html). *Water Structure and Science*. London South Bank University. Retrieved 4 December 2012.
25. "Efficient" here meaning more energy is deposited, not necessarily that the temperature rises more, because the latter also is a function of the specific heat capacity, which is often less than water for most substances. For a practical example, milk heats slightly faster than water in a microwave oven, but only because milk solids have less heat capacity than the water they replace.
26. Wortham, Darryl L. (2011-08-10). *Transforming from Consumer to Producer in 90 Days: $aving Money, Energy, and Time Equals More Money to INVEST* (https://books.google.com/books?id=Xmwe2zHZ6UcC&pg=PA69&dq=For+cooking+small+amounts+of+food,+microwave+oven+may+use+less+energy+than+stove&hl=en&sa=X&ved=0ahUKEwWivSRnKbVAhWqg1QKHVpJC88Q6AEIKjAB#v=onepage&q=For%20cooking%20small%20amounts%20of%20food,%20microwave%20oven%20may%20use%20less%20energy%20than%20stove&f=false). AuthorHouse. ISBN 9781449045258.
27. ACEE American Council for Energy Efficient Economy - Cooking (http://www.aceee.org/consumer/cooking) Retrieved 16 March 2012

28. Stove versus Microwave: Which Uses Less Energy to Make Tea? (http://www.scientificamerican.com/article.cfm?id=stove-versus-microwave-energy-use) Retrieved 18 June 2012
29. "Heating and cooling no longer majority of U.S. home energy use - Today in Energy - U.S. Energy Information Administration (EIA)" (http://www.eia.gov/todayinenergy/detail.cfm?id=10271&src=%25E2%2580%25B9%2520Consumption%2520%2520%2520%2520%2520%2520Residential%2520Energy%2520Consumption%2520Survey%2520(RECS)-b1). *www.eia.gov*. Retrieved 2016-02-22.
30. Fabricant, Florence (27 September 2000). "Son of Microwave: Fast and Crisp" (https://www.nytimes.com/2000/09/27/dining/test-kitchen-son-of-microwave-fast-and-crisp.html). Retrieved 6 January 2015. "a new generation of ovens now arriving on the market"
31. "FAQs: Using Plastics in the Microwave" (http://www.plasticsinfo.org/s_plasticsinfo/sec_level2_faq.asp?CID=703&DID=2837). American Chemistry Council.
32. "The Five Worst Foods to Grill" (https://web.archive.org/web/20101230043041/http://www.pcrm.org/health/reports/worst_grill.html). Physicians Committee for Responsible Medicine. 2005. Archived from the original (http://www.pcrm.org/health/reports/worst_grill.html) on 30 December 2010.
33. "Acrylamide: Information on Diet, Food Storage, and Food Preparation" (http://www.fda.gov/Food/FoodborneIllnessContaminants/ChemicalContaminants/ucm151000.htm). *Food*. U.S. Food and Drug Administration. 22 May 2008. "Boiling potatoes and microwaving whole potatoes with skin on to make "microwaved baked potatoes" does not produce acrylamide.1 (Footnote1: Based on FDA studies.")
34. Tice, Raymond; Brevard, Brigette (February 1999), *3-Picoline [108-99-6]: Review of Toxicological Literature* (http://ntp.niehs.nih.gov/ntp/htdocs/Chem_Background/ExSumPdf/Picoline_508.pdf) (PDF), Research Triangle Park, North Carolina: Integrated Laboratory Systems
35. Rutgers, Maarten (1999). "Physics inside a Microwave Oven" (https://web.archive.org/web/20030720183703/http://maartenrutgers.org/fun/microwave/microwave.html). Finding the hot spots in your microwave with fax paper. Archived from the original (http://maartenrutgers.org/fun/microwave/microwave.html#fax) on 20 July 2003.
36. Video of microwave effects (https://www.youtube.com/watch?v=cskB5c0nJ58#t=98s) on YouTube
37. P Risman, "Advanced topics in microwave heating uniformity", pp. 76-77, in, M W Lorence, P S Pesheck (eds), *Development of Packaging and Products for Use in Microwave Ovens*, Elsevier, 2009 ISBN 1845696573.
38. Labuza, T; Meister (1992). "An Alternate Method for Measuring the Heating Potential of Microwave Susceptor Films" (http://www.jmpee.org/JMPEE_PDFs/27-4_bl/JMPEE-Vol27-Pg205-Labuza.pdf) (PDF). *J. International Microwave Power and Electromagnetic Energy*. **27** (4): 205–208. Retrieved 23 September 2011.
39. Water and Microwaves (http://www1.lsbu.ac.uk/water/microwave_water.html)
40. Da-Wen Sun. *Thermal Food Processing: New Technologies and Quality Issues*. Taylor & Francis.
41. O'Connor, Anahad (17 October 2006). "The Claim: Microwave Ovens Kill Nutrients in Food" (https://www.nytimes.com/2006/10/17/health/17real.html). *The New York Times*.
42. "Microwave cooking and nutrition" (http://www.health.harvard.edu/fhg/updates/Microwave-cooking-and-nutrition.shtml). *Family Health Guide*. Harvard Medical School. Retrieved 23 July 2011.
43. Fumio Watanabe; Katsuo Abe; Tomoyuki Fujita; Mashahiro Goto; Miki Hiemori; Yoshihisa Nakano (January 1998). "Effects of Microwave Heating on the Loss of Vitamin B(12) in Foods" (http://pubs.acs.org/cgi-bin/abstract.cgi/jafcau/1998/46/i01/abs/jf970670x.html). *Journal of Agricultural and Food Chemistry*. **46** (1): 206–210. doi:10.1021/jf970670x (https://doi.org/10.1021%2Fjf970670x). PMID 10554220 (https://www.ncbi.nlm.nih.gov/pubmed/10554220).
44. M. A. OSINBOYEJO; L. T Walker; S. Ogutu & M. Verghese. "Effects of microwave blanching vs. boiling water blanching on retention of selected water-soluble vitamins in turnips, foods, and greens using HPLC" (http://www.uga.edu/nchfp/papers/2003/03iftturnipgreensposter.html). National Center for Home Food Preservation, University of Georgia. Retrieved 23 July 2011.
45. Quan R, Yang C, Rubinstein S, et al. (April 1992). "Effects of microwave radiation on anti-infective factors in human milk". *Pediatrics*. **89** (4 Pt 1): 667–9. PMID 1557249 (https://www.ncbi.nlm.nih.gov/pubmed/1557249).
46. "Hygiene in the home kitchen: Changes in behaviour and impact of key microbiological hazard control measures" (http://www.sciencedirect.com/science/article/pii/S0956713513003745). *Food Control*. **35**: 392–400. doi:10.1016/j.foodcont.2013.07.026 (https://doi.org/10.1016%2Fj.foodcont.2013.07.026)
47. "Microbiome analysis and confocal microscopy of used kitchen sponges reveal massive colonization by *Acinetobacter*, *Moraxella* and *Chryseobacterium* species" (https://www.nature.com/articles/s41598-017-06055-9). *Nature*. doi:10.1038/s41598-017-06055-9 (https://doi.org/10.1038%2Fs41598-017-06055-9)

48. Mike P.; Alcir Grohmann; Darin Wagner; Richard E. Barrans Jr; Vince Calder (2001–2002). "Superheated Water" (https://web.archive.org/web/20090322201613/http://newton.dep.anl.gov/askasci/chem00/chem00636.htm). *NEWTON Ask-A-Scientist*. Argonne National Laboratory. Archived from the original (http://www.newton.dep.anl.gov/askasci/chem00/chem00636.htm) on 2009-03-22. Retrieved 28 March 2009. (from the U.S. Dept. of Energy "Ask A Scientist" series's "Chemistry Archive" 2001315)
49. "Superheating and microwave ovens" (http://www.phys.unsw.edu.au/~jw/superheating.html). *School of Physics*. University of New South Wales. Retrieved 25 October 2010.
50. Beaty, William J. "High Voltage in your Kitchen: Unwise Microwave Oven Experiments" (http://amasci.com/weird/microwave/voltage3.html#dirt). Amasci.com. Retrieved 21 January 2006.
51. List of microwave safe and unsafe items. (http://www.conagrafoods.com/utilities/mwbasics.jsp?cookietest=true) Accessed 25 October 2009.
52. "Microwave Ovens and Food Safety" (https://web.archive.org/web/20110108064919/http://www.fsis.usda.gov/PDF/Microwave_Ovens_and_Food_Safety.pdf) (PDF). *Food Safety and Inspection Service*. United States Department of Agriculture. October 2011. Archived from the original (http://www.fsis.usda.gov/PDF/Microwave_Ovens_and_Food_Safety.pdf) (PDF) on 8 January 2011. Retrieved 10 August 2011.
53. Popa, Adrian (23 December 1997). "Re: Why do grapes spark in the microwave?" (http://madsci.org/posts/archives/dec97/882909591.Ph.r.html). MadSci Network. Retrieved 23 February 2006.
54. 21 C.F.R. 1030.10 (http://www.gpo.gov/fdsys/pkg/CFR-2012-title21-vol8/pdf/CFR-2012-title21-vol8-sec1030-10.pdf) Retrieved 12 Aug 2014.
55. "Radiation Emissions from Microwave ovens: How safe are Microwave Ovens?" (http://www.arpansa.gov.au/RadiationProtection/Factsheets/is_Microwave.cfm#6). ARPANSA. Retrieved 5 March 2009.
56. "Microwave Oven Radiation: Microwave Oven Safety Standard" (http://www.fda.gov/Radiation-EmittingProducts/RadiationEmittingProductsandProcedures/HomeBusinessandEntertainment/ucm142616.htm#4). U.S. Food and Drug Administration. 13 January 2010. Retrieved 16 February 2009.
57. "Advanced Measurements of Microwave Oven Leakage" (http://www.arpansa.gov.au/pubs/emr/microwave.pdf) (PDF). ARPANSA. 2004. Retrieved 8 January 2011.
58. Frei, MR; Jauchem, JR; Dusch, SJ; Merritt, JH; Berger, RE; Stedham, MA (1998). "Chronic, low-level (1.0 W/kg) exposure of mice prone to mammary cancer to 2450 MHz microwaves". *Radiation research*. **150** (5): 568–76. doi:10.2307/3579874 (https://doi.org/10.2307%2F3579874). PMID 9806599 (https://www.ncbi.nlm.nih.gov/pubmed/9806599).
59. Frei, MR; Berger, RE; Dusch, SJ; Guel, V; Jauchem, JR; Merritt, JH; Stedham, MA (1998). "Chronic exposure of cancer-prone mice to low-level 2450 MHz radiofrequency radiation". *Bioelectromagnetics*. **19** (1): 20–31. doi:10.1002/(SICI)1521-186X(1998)19:1<20::AID-BEM2>3.0.CO;2-6 (https://doi.org/10.1002%2F%28SICI%291521-186X%281998%2919%3A1%3C20%3A%3AAID-BEM2%3E3.0.CO%3B2-6). PMID 9453703 (https://www.ncbi.nlm.nih.gov/pubmed/9453703).
60. ARPANSA - Microwave Ovens and Health (http://www.arpansa.gov.au/radiationprotection/factsheets/is_microwave.cfm#safe)
61. Frost, Joe L. (30 September 2001). *Children and Injuries* (https://books.google.com/?id=pHXdUbiRiA8C&pg=PA87&dq=microwave+injury&cd=2#v=onepage&q=microwave%20injury&f=false). Lawyers & Judges Publishing. p. 593. ISBN 978-0-913875-96-4. Retrieved 29 January 2011.
62. Geddesm, Leslie Alexander; Roeder, Rebecca A. (2006). *Handbook of electrical hazards and accidents* (https://books.google.com/?id=Pb4lUnSsMa0C&pg=PA370&dq=microwave+injury&cd=66#v=onepage&q=microwave%20injury&f=false). Lawyers & Judges Publishing. pp. 369ff. ISBN 0-913875-44-9.

External links

- Ask a Scientist Chemistry Archives, Argonne National Laboratory
- Further Reading On The History Of Microwaves and Microwave Ovens
- Microwave oven history from American Heritage magazine
- Superheating and microwave ovens
- Superheating and Microwave Ovens, University of New South Wales (includes video)
- "The Microwave Oven" Short explanation of microwave oven in terms of microwave cavities and waveguides, intended for use in a class in Electrical Engineering

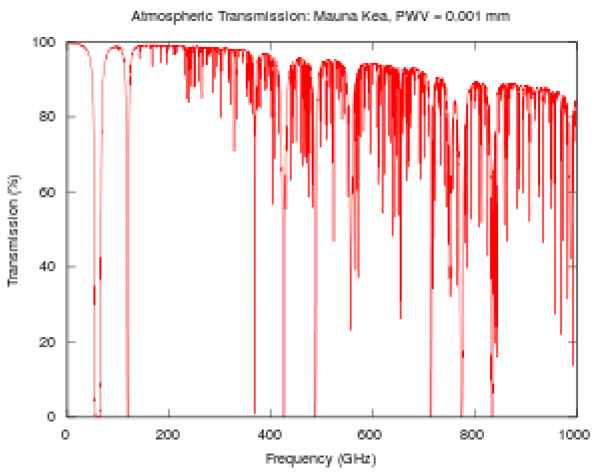
Microwave

Microwaves are a form of electromagnetic radiation with wavelengths ranging from one meter to one millimeter; with frequencies between 300 MHz (100 cm) and 300 GHz (0.1 cm).[1][2][3][4][5] Different sources define different frequency ranges as microwaves; the above broad definition includes both UHF and EHF (millimeter wave) bands. A more common definition in radio engineering is the range between 1 and 100 GHz (300 and 3 mm).[2] In all cases, microwaves include the entire SHF band (3 to 30 GHz, or 10 to 1 cm) at minimum. Frequencies in the microwave range are often referred to by their IEEE radar band designations: S, C, X, K_u, K, or K_a band, or by similar NATO or EU designations.

A telecommunications tower with a variety of dish antennas for microwave relay links on Frazier Peak, Ventura County, California.

The prefix *micro-* in *microwave* is not meant to suggest a wavelength in the micrometer range. It indicates that microwaves are "small", compared to the radio waves used prior to microwave technology, in that they have shorter wavelengths. The boundaries between far infrared, terahertz radiation, microwaves, and ultra-high-frequency radio waves are fairly arbitrary and are used variously between different fields of study.

Microwaves travel by line-of-sight; unlike lower frequency radio waves they do not diffract around hills, follow the earth's surface as ground waves, or reflect from the ionosphere, so terrestrial microwave communication links are limited by the visual horizon to about 40 miles (64 km). At the high end of the band they are absorbed by gases in the atmosphere, limiting practical communication distances to around a kilometer. Microwaves are extremely widely used in modern technology. They are used for point-to-point communication links, wireless networks, microwave radio relay networks, radar, satellite and spacecraft communication, medical diathermy and cancer treatment, remote sensing, radio astronomy, particle accelerators, spectroscopy, industrial heating, collision avoidance systems, garage door openers and keyless entry systems, and for cooking food in microwave ovens.



The atmospheric attenuation of microwaves and far infrared radiation in dry air with a precipitable water vapor level of 0.001 mm. The downward spikes in the graph correspond to frequencies at which microwaves are absorbed more strongly. This graph includes a range of frequencies from 0 to 1 THz; the microwaves are the subset in the range between 0.3 and 300 gigahertz.

Contents

Electromagnetic spectrum

Microwaves occupy a place in the electromagnetic spectrum with frequency above ordinary radio waves, and below infrared light:

Electromagnetic spectrum			
Name	**Wavelength**	**Frequency (Hz)**	**Photon energy (eV))**
Gamma ray	< 0.02 nm	> 15 EHz	> 62.1 keV
X-ray	0.01 nm – 10 nm	30 EHz – 30 PHz	124 keV – 124 eV
Ultraviolet	10 nm – 400 nm	30 PHz – 750 THz	124 eV – 3 eV
Visible light	390 nm – 750 nm	770 THz – 400 THz	3.2 eV – 1.7 eV
Infrared	750 nm – 1 mm	400 THz – 300 GHz	1.7 eV – 1.24 meV
Microwave	1 mm – 1 m	300 GHz – 300 MHz	1.24 meV – 1.24 µeV
Radio	1 mm – 100 km	300 GHz – 3 kHz	1.24 µeV – 12.4 feV

In descriptions of the electromagnetic spectrum, many sources classify microwaves as radio waves; microwaves are a subset of the radio wave band; while others classify microwaves and radio waves as distinct types of radiation. This is an arbitrary distinction.

Propagation

Microwaves travel solely by line-of-sight paths; unlike lower frequency radio waves, they do not travel as ground waves which follow the contour of the Earth, or reflect off the ionosphere (skywaves).[6] Although at the low end of the band they can pass through building walls enough for useful reception, usually rights of way cleared to the first Fresnel zone are required. Therefore, on the surface of the Earth, microwave communication links are limited by the visual horizon to about 30–40 miles (48–64 km). Microwaves are absorbed by moisture in the atmosphere, and the attenuation increases with frequency, becoming a significant factor (rain fade) at the high end of the band. Beginning at about 40 GHz, atmospheric gases also begin to absorb microwaves, so above this frequency microwave transmission is limited to a few kilometers. A spectral band structure causes absorption peaks at specific frequencies (see graph at right). Above 100 GHz, the absorption of electromagnetic radiation by Earth's atmosphere is so great that it is in effect opaque, until the atmosphere becomes transparent again in the so-called infrared and optical window frequency ranges.

Troposcatter

In a microwave beam directed at an angle into the sky, a small amount of the power will be randomly scattered as the beam passes through the troposphere.[6] A sensitive receiver beyond the horizon with a high gain antenna focused on that area of the troposphere can pick up the signal. This technique has been used at frequencies between 0.45 and 5 GHz in tropospheric scatter (troposcatter) communication systems to communicate beyond the horizon, at distances up to 300 km.

Antennas

Their short wavelength allows narrow beams of microwaves to be produced by conveniently small high gain antennas from a half meter to 5 meters in diameter. Therefore, beams of microwaves are used for point-to-point communication links, and for radar. An advantage of narrow beams is that they don't interfere with nearby equipment using the same frequency, allowing frequency reuse by nearby transmitters. Parabolic ("dish") antennasare the most widely used directive antennas at microwave frequencies, but horn antennas, slot antennas and dielectric lens antennas are also used. Flat microstrip antennas are being increasingly used in consumer devices. Another directive antenna practical at microwave frequencies is the phased array, a computer-controlled array of antennas which produces a beam which can be electronically steered in different directions. Where omnidirectional antennas are required, for example in wireless devices and Wifi routers for wireless LANs, small monopoles, such as the inverted F antenna (PIFA) in cell phones, dipole, or patch antennas are used.

Waveguide is used to carry microwaves. Example ofwaveguides and a diplexer in an air traffic control radar

At microwave frequencies, the transmission lines which are used to carry lower frequency radio waves to and from antennas, such as coaxial cable and parallel wire lines, have excessive power losses, so when low attenuation is required microwaves are carried by metal pipes called waveguides. Due to the high cost and maintenance requirements of waveguide runs, in many microwave antennas the output stage of the transmitter or the RF front end of the receiver is located at the antenna.

Difference between microwave and radio frequency technology

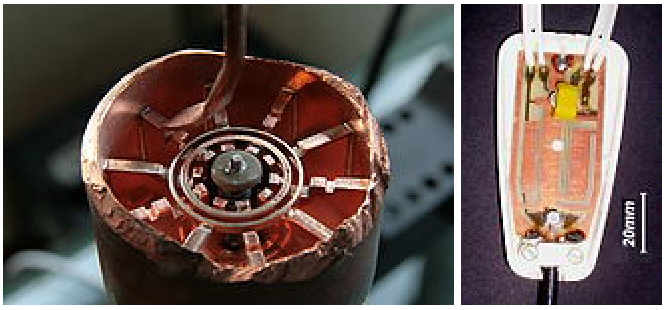
The term *microwave* also has a more technical meaning in electromagnetics and circuit theory. Apparatus and techniques may be described qualitatively as "microwave" when the frequencies used are high enough that wavelengths of signals are roughly the same as the dimensions of the circuit, so that lumped-element circuit theory is inaccurate, and instead distributed circuit elements and transmission-line theory are more useful methods for design and analysis. As a consequence, practical microwave circuits tend to move away from the discrete resistors, capacitors, and inductors used with lower-frequency radio waves. Open-wire and coaxial transmission lines used at lower frequencies are replaced by waveguides and stripline, and lumped-element tuned circuits are replaced by cavity resonators or resonant stubs. In turn, at even higher frequencies, where the wavelength of the electromagnetic waves becomes small in comparison to the size of the structures used to process them, microwave techniques become inadequate, an the methods of optics are used.

Microwave sources

High-power microwave sources use specialized vacuum tubes to generate microwaves. These devices operate on different principles from low-frequency vacuum tubes, using the ballistic motion of electrons in a vacuum under the influence of controlling electric or magnetic fields, and include the magnetron (used in microwave ovens), klystron, traveling-wave tube (TWT), and gyrotron. These devices work in the density modulated mode, rather than the current modulated mode. This means that they work on the basis of clumps of electrons flying ballistically through them, rather than using a continuous stream of electrons.

Low-power microwave sources use solid-state devices such as the field-effect transistor (at least at lower frequencies), tunnel diodes, Gunn diodes, and IMPATT diodes.[7] Low-power sources are available as benchtop instruments, rackmount instruments, embeddable modules and in card-level formats. A maser is a solid state device which amplifies microwaves using similar principles to the laser, which amplifies higher frequency light waves.

All warm objects emit low level microwave black-body radiation, depending on their temperature, so in meteorology and remote sensing microwave radiometers are used to measure the temperature of objects or terrain.[8] The sun[9] and other astronomical radio sources such as Cassiopeia A emit low level microwave radiation which carries information about their makeup, which is studied by radio astronomers using receivers called radio telescopes.[8] The cosmic microwave background radiation (CMBR), for example, is a weak microwave noise filling empty space which is a major source of information on cosmology's Big Bang theory of the origin of the Universe.



Cutaway view inside a cavity magnetron as used in a microwave oven *(left)*. Antenna splitter: microstrip techniques become increasingly necessary at higher frequencies *(right)*.

Microwave uses

Disassembled radar speed gun. The grey assembly attached to the end of the copper-colored horn antenna is the Gunn diode which generates the microwaves.

Microwave technology is extensively used for point-to-point telecommunications (i.e. non-broadcast uses). Microwaves are especially suitable for this use since they are more easily focused into narrower beams than radio waves, allowing frequency reuse; their comparatively higher frequencies allow broad bandwidth and high data transmission rates, and antenna sizes are smaller than at lower frequencies because antenna size is inversely proportional to transmitted frequency. Microwaves are used in spacecraft communication, and much of the world's data, TV, and telephone communications are transmitted long distances by microwaves between ground stations and communications satellites. Microwaves are also employed in microwave ovens and in radar technology.

Communication

A satellite dish on a residence, which receives satellite television over a K_u band 12–14 GHz microwave beam from a direct broadcast communications satellite in a geostationary orbit 35,700 kilometres (22,000 miles) above the Earth.

Before the advent of fiber-optic transmission, most long-distance telephone calls were carried via networks of microwave radio relay links run by carriers such as AT&T Long Lines. Starting in the early 1950s, frequency division multiplex was used to send up to 5,400 telephone channels on each microwave radio channel, with as many as ten radio channels combined into one antenna for the *hop* to the next site, up to 70 km away.

Wireless LAN protocols, such as Bluetooth and the IEEE 802.11 specifications used for Wi-Fi, also use microwaves in the 2.4 GHz ISM band, although 802.11a uses ISM band and U-NII frequencies in the 5 GHz range. Licensed long-range (up to about 25 km) Wireless Internet Access services have been used for almost a decade in many countries in the 3.5–4.0 GHz range. The FCC recently carved out spectrum for carriers that wish to offer services in this range in the U.S. — with emphasis on 3.65 GHz. Dozens of service providers across the country are securing or have already received licenses from the FCC to operate in this band. The WIMAX service offerings that can be carried on the 3.65 GHz band will give business customers another option for connectivity.

Metropolitan area network (MAN) protocols, such as WiMAX (Worldwide Interoperability for Microwave Access) are based on standards such as IEEE 802.16, designed to operate between 2 and 11 GHz. Commercial implementations are in the 2.3 GHz, 2.5 GHz, 3.5 GHz and 5.8 GHz ranges.

Mobile Broadband Wireless Access (MBWA) protocols based on standards specifications such as IEEE 802.20 or ATIS/ANSI HC-SDMA (such as iBurst) operate between 1.6 and 2.3 GHz to give mobility and in-building penetration characteristics similar to mobile phones but with vastly greater spectral efficiency.[10]

Some mobile phone networks, like GSM, use the low-microwave/high-UHF frequencies around 1.8 and 1.9 GHz in the Americas and elsewhere, respectively. DVB-SH and S-DMB use 1.452 to 1.492 GHz, while proprietary/incompatible satellite radio in the U.S. uses around 2.3 GHz for DARS.

Microwave radio is used in broadcasting and telecommunication transmissions because, due to their short wavelength, highly directional antennas are smaller and therefore more practical than they would be at longer wavelengths (lower frequencies). There is also more bandwidth in the microwave spectrum than in the rest of the radio spectrum; the usable bandwidth below 300 MHz is less than 300 MHz while many GHz can be used above 300 MHz. Typically, microwaves are used in television news to transmit a signal from a remote location to a television station from a specially equipped van. See broadcast auxiliary service (BAS), remote pickup unit (RPU), and studio/transmitter link (STL).

Most satellite communications systems operate in the C, X, K_a, or K_u bands of the microwave spectrum. These frequencies allow large bandwidth while avoiding the crowded UHF frequencies and staying below the atmospheric absorption of EHF frequencies. Satellite TV either operates in the C band for the traditional large dish fixed satellite service or K_u band for direct-broadcast satellite. Military communications run primarily over X or K_u-band links, with K_a band being used for Milstar.

Navigation

Global Navigation Satellite Systems (GNSS) including the Chinese Beidou, the American Global Positioning System (introduced in 1978) and the Russian GLONASS broadcast navigational signals in various bands between about 1.2 GHz and 1.6 GHz.

Radar

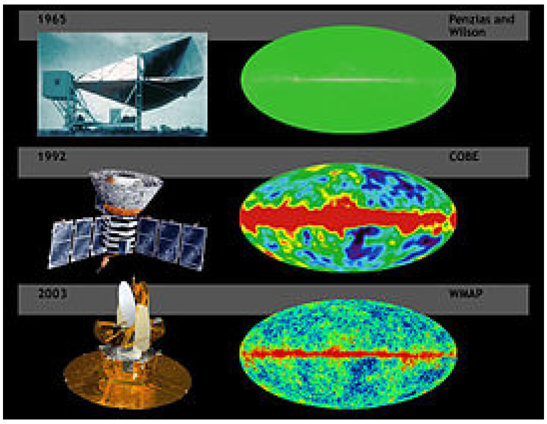
Radar is a radiolocation technique in which a beam of radio waves emitted by a transmitter bounces off an object and returns to a receiver, allowing the location, range, speed, and other characteristics of the object to be determined. The short wavelength of microwaves causes large reflections from objects the size of motor vehicles, ships and aircraft. Also, at these wavelengths, the high gain antennas such as parabolic antennas which are required to produce the narrow beamwidths needed to accurately locate objects are conveniently small, allowing them to be rapidly turned to scan for objects. Therefore, microwave frequencies are the main frequencies used in radar. Microwave radar is widely used for applications such as air traffic control, weather forecasting, navigation of ships, and speed limit enforcement. Long distance radars use the lower microwave frequencies since at the upper end of the band atmospheric absorption limits the range, but millimeter waves are used for short range radar such as collision avoidance systems.

The parabolic antenna (lower curved surface) of an ASR-9 airport surveillance radar which radiates a narrow vertical fan-shaped beam of 2.7–2.9 GHz (S band) microwaves to locate aircraft in the airspace surrounding an airport.

Radio astronomy

Microwaves emitted by astronomical radio sources; planets, stars, galaxies, and nebulas are studied in radio astronomy with large dish antennas called radio telescopes. In addition to receiving naturally occurring microwave radiation, radio telescopes have been used in active radar experiments to bounce microwaves off planets in the solar system, to determine the distance to the Moon or map the invisible surface of Venus through cloud cover.

Some of the dish antennas of theAtacama Large Millimeter Array(ALMA) a radio telescope located in northern Chile. It receives microwaves in themillimeter wave range, 31 – 1000 GHz.



Maps of the cosmic microwave background radiation (CMBR), showing the improved resolution which has been achieved with better microwave radio telescopes

A recently completed microwave radio telescope is the Atacama Large Millimeter Array, located at more than 5,000 meters (16,597 ft) altitude in Chile, observes the universe in the millimetre and submillimetre wavelength ranges. The world's largest ground-based astronomy project to date, it consists of more than 66 dishes and was built in an international collaboration by Europe, North America, East Asia and Chile.[11][12]

A major recent focus of microwave radio astronomy has been mapping the cosmic microwave background radiation (CMBR) discovered in 1964 by radio astronomers Arno Penzias and Robert Wilson. This faint background radiation, which fills the universe and is almost the same in all directions, is "relic radiation" from the Big Bang, and is one of the few sources of information about conditions in the early universe. Due to the expansion and thus cooling of the Universe, the originally high-energy radiation has been shifted into the microwave region of the radio spectrum. Sufficiently sensitive radio telescopes can detected the CMBR as a faint signal that is not associated with any star, galaxy, or other object.[13]

Heating and power application

Small microwave oven on a kitchen counter

A microwave oven passes microwave radiation at a frequency near 2.45 GHz (12 cm) through food, causing dielectric heating primarily by absorption of the energy in water. Microwave ovens became common kitchen appliances in Western countries in the late 1970s, following the development of less expensive cavity magnetrons. Water in the liquid state possesses many molecular interactions that broaden the absorption peak. In the vapor phase, isolated water molecules absorb at around 22 GHz, almost ten times the frequency of the microwave oven.

Microwave heating is used in industrial processes for drying and curing products.

Microwaves are widely used for heating in industrial processes. A microwave tunnel oven for softening plastic rods prior to extrusion.

Many semiconductor processing techniques use microwaves to generate plasma for such purposes as reactive ion etching and plasma-enhanced chemical vapor deposition (PECVD).

Microwave frequencies typically ranging from 110 – 140 GHz are used in stellarators and tokamak experimental fusion reactors to help heat the fuel into a plasma state. The upcoming ITER thermonuclear reactor[14] is expected to range from 110–170 GHz and will employ electron cyclotron resonance heating (ECRH).[15]

Microwaves can be used to transmit power over long distances, and post-World War II research was done to examine possibilities. NASA worked in the 1970s and early 1980s to research the possibilities of using solar power satellite (SPS) systems with large solar arrays that would beam power down to the Earth's surface via microwaves.

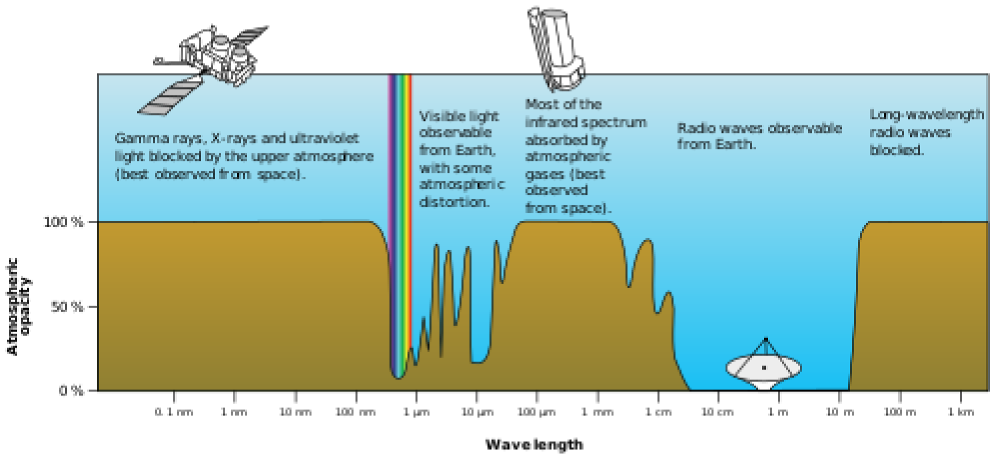
Less-than-lethal weaponry exists that uses millimeter waves to heat a thin layer of human skin to an intolerable temperature so as to make the targeted person move away. A two-second burst of the 95 GHz focused beam heats the skin to a temperature of 54 °C (129 °F) at a depth of 0.4 millimetres ($^1\!/_{64}$ in). The United States Air Force and Marines are currently using this type of active denial system in fixed installations.[16]

Spectroscopy

Microwave radiation is used in electron paramagnetic resonance (EPR or ESR) spectroscopy, typically in the X-band region (~9 GHz) in conjunction typically with magnetic fields of 0.3 T. This technique provides information on unpaired electrons in chemical systems, such as free radicals or transition metal ions such as Cu(II). Microwave radiation is also used to perform rotational spectroscopy and can be combined with electrochemistry as in microwave enhanced electrochemistry

Microwave frequency bands

The microwave spectrum is usually defined as electromagnetic energy ranging from approximately 1 GHz to 100 GHz in frequency, but older use includes lower frequencies. Most common applications are within the 1 to 40 GHz range. One set of microwave frequency bands designations by the Radio Society of Great Britain (RSGB), is tabulated below:



Rough plot of Earth's atmospheric transmittance (or opacity) to various wavelengths of electromagnetic radiation. Microwaves are strongly absorbed at wavelengths shorter than about 1.5 cm (above 20 GHz) by water and other molecules in the air

Microwave frequency bands

Designation	Frequency range	Wavelength range	Typical uses
L band	1 to 2 GHz	15 cm to 30 cm	military telemetry, GPS, mobile phones (GSM), amateur radio
S band	2 to 4 GHz	7.5 cm to 15 cm	weather radar, surface ship radar, and some communications satellites (microwave ovens, microwave devices/communications, radio astronomy, mobile phones, wireless LAN, Bluetooth, ZigBee, GPS, amateur radio)
C band	4 to 8 GHz	3.75 cm to 7.5 cm	long-distance radio telecommunications
X band	8 to 12 GHz	25 mm to 37.5 mm	satellite communications, radar, terrestrial broadband, space communications, amateur radio, molecular rotational spectroscopy
K_u band	12 to 18 GHz	16.7 mm to 25 mm	satellite communications, molecular rotational spectroscopy
K band	18 to 26.5 GHz	11.3 mm to 16.7 mm	radar, satellite communications, astronomical observations, automotive radar, molecular rotational spectroscopy
K_a band	26.5 to 40 GHz	5.0 mm to 11.3 mm	satellite communications, molecular rotational spectroscopy
Q band	33 to 50 GHz	6.0 mm to 9.0 mm	satellite communications, terrestrial microwave communications, radio astronomy, automotive radar, molecular rotational spectroscopy
U band	40 to 60 GHz	5.0 mm to 7.5 mm	
V band	50 to 75 GHz	4.0 mm to 6.0 mm	millimeter wave radar research, molecular rotational spectroscopy and other kinds of scientific research
W band	75 to 110 GHz	2.7 mm to 4.0 mm	satellite communications, millimeter-wave radar research, military radar targeting and tracking applications, and some non-military applications, automotive radar
F band	90 to 140 GHz	2.1 mm to 3.3 mm	SHF transmissions: Radio astronomy, microwave devices/communications, wireless LAN, most modern radars, communications satellites, satellite television broadcasting, DBS, amateur radio
D band	110 to 170 GHz	1.8 mm to 2.7 mm	EHF transmissions: Radio astronomy, high-frequency microwave radio relay, microwave remote sensing, amateur radio, directed-energy weapon, millimeter wave scanner

P band is sometimes used for K_u Band. "P" for "previous" was a radar band used in the UK ranging from 250 to 500 MHz and now obsolete per IEEE Std 521.[17][18][19]

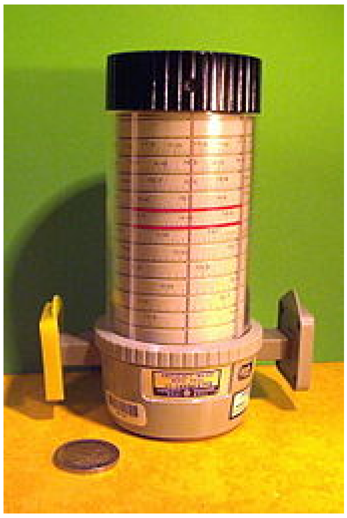
When radars were first developed at K band during World War II, it was not known that there was a nearby absorption band (due to water vapor and oxygen in the atmosphere). To avoid this problem, the original K band was split into a lower band, K_u, and upper band, K_a.[20]

Microwave frequency measurement

Microwave frequency can be measured by either electronic or mechanical techniques.

Frequency counters or high frequency heterodyne systems can be used. Here the unknown frequency is compared with harmonics of a known lower frequency by use of a low frequency generator, a harmonic generator and a mixer. Accuracy of the measurement is limited by the accuracy and stability of the reference source.

Mechanical methods require a tunable resonator such as an absorption wavemeter, which has a known relation between a physical dimension and frequency.



Absorption wavemeter for measuring in the K_u band.

In a laboratory setting, Lecher lines can be used to directly measure the wavelength on a transmission line made of parallel wires, the frequency can then be calculated. A similar technique is to use a slotted waveguide or slotted coaxial line to directly measure the wavelength. These devices consist of a probe introduced into the line through a longitudinal slot, so that the probe is free to travel up and down the line. Slotted lines are primarily intended for measurement of the voltage standing wave ratio on the line. However, provided a standing wave is present, they may also be used to measure the distance between the nodes, which is equal to half the wavelength. Precision of this method is limited by the determination of the nodal locations.

Effects on health

Microwaves do not contain sufficient energy to chemically change substances by ionization, and so are an example of non-ionizing radiation.[21] The word "radiation" refers to energy radiating from a source and not to radioactivity. It has not been shown conclusively that microwaves (or other non-ionizing electromagnetic radiation) have significant adverse biological effects at low levels. Some, but not all, studies suggest that long-term exposure may have a carcinogenic effect.[22] This is separate from the risks associated with very high-intensity exposure, which can cause heating and burns like any heat source, and not a unique property of microwaves specifically.

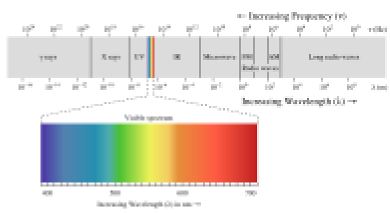
During World War II, it was observed that individuals in the radiation path of radar installations experienced clicks and buzzing sounds in response to microwave radiation. This microwave auditory effect was thought to be caused by the microwaves inducing an electric current in the hearing centers of the brain.[23] Research by NASA in the 1970s has shown this to be caused by thermal expansion in parts of the inner ear. In 1955 Dr. James Lovelock was able to reanimate rats frozen at 0 °C using microwave diathermy.[24]

When injury from exposure to microwaves occurs, it usually results from dielectric heating induced in the body. Exposure to microwave radiation can produce cataracts by this mechanism,[25] because the microwave heating denatures proteins in the crystalline lens of the eye (in the same way that heat turns egg whites white and opaque). The lens and cornea of the eye are especially vulnerable because they contain no blood vessels that can carry away heat. Exposure to heavy doses of microwave radiation (as from an oven that has been tampered with to allow operation even with the door open) can produce heat damage in other tissues as well, up to and including serious burns that may not be immediately evident because of the tendency for microwaves to heat deeper tissues with higher moisture content.

Eleanor R. Adair conducted microwave health research by exposing herself, animals and humans to microwave levels that made them feel warm or even start to sweat and feel quite uncomfortable. She found no adverse health effects other than heat.

History and research

The existence of radio waves was predicted by James Clerk Maxwell in 1864 from his equations. In 1888, Heinrich Hertz was the first to demonstrate the existence of radio waves by building a spark gap radio transmitter that produced 450 MHz microwaves, in the UHF region. The equipment he used was primitive, including a horse trough, a wrought iron point spark, and Leyden jars. He also built the first parabolic antenna, using a zinc gutter sheet. In 1894, Indian radio pioneer Jagdish Chandra Bose publicly demonstrated radio control of a bell using millimeter wavelengths, and conducted research into the propagation of microwaves.[26]



Electromagnetic spectrum (visible-light range highlighted).

Perhaps the first, documented, formal use of the term *microwave* occurred in 1931:

> "When trials with wavelengths as low as 18 cm were made known, there was undisguised surprise that the problem of the micro-wave had been solved so soon." *Telegraph & Telephone Journal* XVII. 179/1

In 1943, the Hungarian engineer Zoltán Bay sent ultra-short radio waves to the moon, which, reflected from there, worked as a radar, and could be used to measure distance, as well as to study the moon.

Perhaps the first use of the word *microwave* in an astronomical context occurred in 1946 in an article "Microwave Radiation from the Sun and Moon" by Robert Dicke and Robert Beringer. This same article also made a showing in the *New York Times* issued in 1951. Ernst Weber pioneered microwave technologies.

In the history of electromagnetic theory, significant work specifically in the area of microwaves and their applications was carried out by researchers including:

Specific work on microwaves

Names	Area of work
Barkhausen and Kurz	Positive grid oscillators
Hull	Smooth bore magnetron
Russell and Sigurd Varian	Velocity-modulated electron beam (→klystron tube)
Randall and Boot	Cavity magnetron

See also

- Block upconverter (BUC)
- Cosmic microwave background
- Electron cyclotron resonance
- International Microwave Power Institute
- Lens Antenna / klystron / magnetron / radar gun
- Low-noise block converter (LNB)
- Maser
- Microwave auditory effect
- Microwave cavity
- Microwave chemistry
- Microwave radio relay
- Microwave transmission
- Orthomode transducer (OMT)
- Plasma-enhanced chemical vapor deposition
- Rain fade
- RF switch matrix
- The Thing (listening device)
- Tropospheric scatter

References

1. Hitchcock, R. Timothy (2004). *Radio-frequency and Microwave Radiation* (https://books.google.com/books?id=0TUIQ9-Ap5cC&pg=PA1&dq=microwave). American Industrial Hygiene Assn. p. 1. ISBN 1931504555.
2. Kumar, Sanjay; Shukla, Saurabh (2014). *Concepts and Applications of Microwave Engineering* (https://books.google.com/books?id=GY9eBAAAQBAJ&pg=PA3&dq=microwave). PHI Learning Pvt. Ltd. p. 3. ISBN 8120349350.
3. Jones, Graham A.; Layer, David H.; Osenkowsky, Thomas G. (2013). *National Association of Broadcasters Engineering Handbook, 10th Ed.* (https://books.google.com/books?id=K9N1TVhf82YC&pg=PA6&dq=microwave). Taylor & Francis. p. 6. ISBN 1136034102.
4. Pozar, David M. (1993). *Microwave Engineering* Addison–Wesley Publishing Company. ISBN 0-201-50418-9.

5. Sorrentino, R. and Bianchi, Giovanni (2010). *Microwave and RF Engineering* (https://books.google.com/books?id=6Hc30XnqdPwC). John Wiley & Sons. p. 4. ISBN 047066021X.
6. Seybold, John S. (2005). *Introduction to RF Propagation* (https://books.google.com/books?id=4LtmjGNwOPIC&pg=PA57&dq=cross+polarization+discrimination). John Wiley and Sons. pp. 55–58. ISBN 0471743682.
7. Microwave Oscillator (http://www.herley.com/index.cfm?act=app_notes&notes=oscillators) notes by Herley General Microwave
8. Sisodia, M. L. (2007). *Microwaves : Introduction To Circuits, Devices And Antennas* (https://books.google.com/books?id=iEvgmwH1esgC&pg=SA1-PA4&dq=microwaves). New Age International. pp. 1.4–1.7. ISBN 8122413382.
9. Liou, Kuo-Nan (2002). *An introduction to atmospheric radiation* (https://books.google.com/?id=6xUpdPOPLckC&pg=PR13&dq=The+sun+also+emits+microwave+radiation,+and+most+of+it+is+blocked+by+Earth%27s+atmosphere.&q=microwaves%20from%20Sun). Academic Press. p. 2. ISBN 0-12-451451-0. Retrieved 12 July 2010.
10. "IEEE 802.20: Mobile Broadband Wireless Access (MBWA)" (http://grouper.ieee.org/groups/802/20/). *Official web site*. Retrieved August 20, 2011.
11. "ALMA website" (http://www.almaobservatory.org/en). Retrieved 2011-09-21.
12. "Welcome to ALMA!" (http://www.eso.org/sci/facilities/alma/). Retrieved 2011-05-25.
13. Wright, E.L. (2004). "Theoretical Overview of Cosmic Microwave Background Anisotropy". In W.L. Freedman. *Measuring and Modeling the Universe*. Carnegie Observatories Astrophysics Series. Cambridge University Press. p. 291. arXiv:astro-ph/0305591 (https://arxiv.org/abs/astro-ph/0305591). Bibcode:2004mmu..symp..291W (http://adsabs.harvard.edu/abs/2004mmu..symp..291W). ISBN 0-521-75576-X.
14. "The way to new energy" (http://www.iter.org/default.aspx). ITER. 2011-11-04. Retrieved 2011-11-08.
15. "Electron Cyclotron Resonance Heating (ECRH)" (http://www.ipp.mpg.de/ippcms/eng/for/bereiche/technologie/projekte/ecrh.html). Ipp.mpg.de. Retrieved 2011-11-08.
16. Silent Guardian Protection System. Less-than-Lethal Directed Energy Protection (https://web.archive.org/web/20070128014922/http://www.raytheon.com/products/stellent/groups/public/documents/content/cms04_017939.pdf). raytheon.com
17. "eEngineer – Radio Frequency Band Designations" (http://www.radioing.com/eengineer/bands.html). Radioing.com. Retrieved 2011-11-08.
18. PC Mojo – Webs with MOJO from Cave Creek, AZ (2008-04-25). "Frequency Letter bands – Microwave Encyclopedia" (http://www.microwaves101.com/encyclopedia/letterbands.cfm). Microwaves101.com. Retrieved 2011-11-08.
19. For other definitions see Letter Designations of Microwave Bands (http://www.jneuhaus.com/fccindex/letter.html).
20. Skolnik, Merrill I. (2001) *Introduction to Radar Systems*, Third Ed., p. 522, McGraw Hill. 1962 Edition full text (https://archive.org/details/IntroductionToRadarSystems)
21. Nave, Rod. "Interaction of Radiation with Matter" (http://hyperphysics.phy-astr.gsu.edu/hbase/mod3.html). *HyperPhysics*. Retrieved 20 October 2014.
22. Goldsmith, JR (December 1997). "Epidemiologic evidence relevant to radar (microwave) effects" (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1469943). *Environmental Health Perspectives*. **105** (Suppl. 6): 1579–1587. doi:10.2307/3433674 (https://doi.org/10.2307%2F3433674). JSTOR 3433674 (https://www.jstor.org/stable/3433674). PMC 1469943 (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1469943). PMID 9467086 (https://www.ncbi.nlm.nih.gov/pubmed/9467086).
23. Philip L. Stocklin, U.S. Patent 4,858,612 (https://www.google.com/patents/US4858612), December 19, 1983
24. Andjus, R.K.; Lovelock, J.E. (1955). "Reanimation of rats from body temperatures between 0 and 1 °C by microwave diathermy" (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1365902). *The Journal of Physiology*. **128** (3): 541–546. doi:10.1113/jphysiol.1955.sp005323 (https://doi.org/10.1113%2Fjphysiol.1955.sp005323). PMC 1365902 (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1365902). PMID 13243347 (https://www.ncbi.nlm.nih.gov/pubmed/13243347).
25. "Resources for You (Radiation-Emitting Products)" (http://www.fda.gov/radiation-emittingproducts/resourcesforyouradiationemittingproducts/ucm252762.htm#Microwave_Ovens_and_Health). *US Food and Drug Administration home page*. U.S. Food and Drug Administration. Retrieved 20 October 2014.
26. Emerson, D.T. (February 1998). "The work of Jagdish Chandra Bose: 100 years of MM-wave research" (http://www.tuc.nrao.edu/~demerson/bose/bose.html). National Radio Astronomy Observatory.

External links

- EM Talk, Microwave Engineering Tutorials and Tools
- Millimeter Wave and Microwave Waveguide dimension chart.

WIKIPEDIA

Washing machine

A **washing machine** (**laundry machine**, **clothes washer**, or **washer**) is a device used to wash laundry. The term is mostly applied to machines that use water as opposed to dry cleaning (which uses alternative cleaning fluids, and is performed by specialist businesses) or ultrasonic cleaners. Laundry detergent is added to the wash water, and is sold in either powdered or liquid form.

A typical front-loader washing machine

Contents

Washing by hand

Laundering by hand involves soaking, beating, scrubbing, and rinsing dirty textiles. Before indoor plumbing, the washerwoman (laundress) or housewife also had to carry all the water used for washing, boiling, and rinsing the laundry; according to an 1886 calculation, women fetched water eight to ten times every day from a pump, well, or spring.[1] Water for the laundry would be hand carried, heated on a fire for washing, then poured into the tub. That made the warm soapy water precious; it would be reused, first to wash the least soiled clothing, then to wash progressively dirtier laundry.

Play media

Irreler Bauerntradition shows an early Miele washing machine at the Roscheider Hof Open Air Museum

Removal of soap and water from the clothing after washing was a separate process. First, soap would be rinsed out with clear water. After rinsing, the soaking wet clothing would be formed into a roll and twisted by hand to extract water. The entire process often occupied an entire day of hard work, plus drying and ironing.

Washing by machine

Clothes washer technology developed as a way to reduce the manual labor spent, providing an open basin or sealed container with paddles or fingers to automatically agitate the clothing. The earliest machines were hand-operated and constructed from wood, while later machines made of metal permitted a fire to burn below the washtub, keeping the water warm throughout the day's washing.

1930 electric wringer/mangle washing machine.

The earliest special-purpose mechanical washing device was the washboard, invented in 1797 by Nathaniel Briggs of New Hampshire.[2][3]

By the mid-1850s steam-driven commercial laundry machinery were on sale in the UK and US.[4] Technological advances in machinery for commercial and institutional washers proceeded faster than domestic washer design for several decades, especially in the UK. In the United States there was more emphasis on developing machines for washing at home, though machines for commercial laundry services were widely used in the late 19th and early 20th centuries.[5] The rotary washing machine was patented by Hamilton Smith in 1858.[3] As electricity was not commonly available until at least 1930, some early washing machines were operated by a low-speed, single-cylinder hit-and-miss gasoline engine.

Wringing by machine

After the items were washed and rinsed, water had to be removed by twisting. To help reduce this labor, the wringer/mangle machine was developed. As implied by the term "mangle," these early machines were quite dangerous, especially if powered and not hand-driven. A user's fingers, hand, arm, or hair could become entangled in the laundry being squeezed, resulting in horrific injuries; unwary bystanders, such as children, could also be caught and hurt. Safer mechanisms were developed over time, and the more hazardous designs were eventually outlawed.

The mangle used two rollers under spring tension to squeeze water out of clothing and household linen. Each laundry item would be fed through the wringer separately. The first wringers were hand-cranked, but were eventually included as a powered attachment above the washer tub. The wringer would be swung over the wash tub so that extracted wash water would fall back into the tub to be reused for the next load.

The modern process of water removal by spinning did not come into use until electric motors were developed. Spinning requires a constant high-speed power source, and was originally done in a separate device known as an "extractor". A load of washed laundry would be transferred from the wash tub to the extractor basket, and the water spun out in a separate operation.[6][7] These early extractors were often dangerous to use, since unevenly distributed loads would cause the machine to shake violently. Many efforts were made to counteract the shaking of unstable loads, such as mounting the spinning basket on a free-floating shock-absorbing frame to absorb minor imbalances, and a bump switch to detect severe movement and stop the machine so that the load could be manually redistributed.

Combined processes

What is now referred to as an automatic washer was at one time referred to as a "washer/extractor", which combined the features of these two devices into a single machine, plus the ability to fill and drain water by itself. It is possible to take this a step further, and to also merge the automatic washing machine and clothes dryer into a single device, called a combo washer dryer.

History

Early machines

19th-century Metropolitan washing machine

The first English patent under the category of Washing machines was issued in 1791.[8] A drawing of an early washing machine appeared in the January 1752 issue of *The Gentlemen's Magazine*, a British publication. Jacob Christian Schäffer's washing machine design was published 1767 in Germany.[9] In 1782, Henry Sidgier issued a British patent for a rotating drum washer, and in the 1790s Edward Beetham sold numerous "patent washing mills" in England.[10] One of the first innovations in washing machine technology was the use of enclosed containers or basins that had grooves, fingers, or paddles to help with the scrubbing and rubbing of the clothes. The person using the washer would use a stick to press and rotate the clothes along the textured sides of the basin or container, agitating the clothes to remove dirt and mud.[11] This crude agitator technology was hand-powered, but still more effective than actually hand-washing the clothes.

A vintage German model

More advancements were made to washing machine technology in the form of the rotative drum design. Basically, these early design patents consisted of a drum washer that was hand-cranked to make the wooden drums rotate. While the technology was simple enough, it was a milestone in the history of washing machines, as it introduced the idea of "powered" washing drums. As metal drums started to replace the traditional wooden drums, it allowed for the drum to turn above an open fire or an enclosed fire chamber, raising the water temperature for more effective washes.

It would not be until the 19th century when steam power would be used in washing machine designs.[12]

In 1862, a patented "compound rotary washing machine, with rollers for wringing or mangling" by Richard Lansdale of Pendleton, Manchester, was shown at the 1862 London Exhibition.[13]

The first United States Patent titled "Clothes Washing" was granted to Nathaniel Briggs of New Hampshire in 1797. Because of the Patent Office fire in 1836, no description of the device survives. Invention of a washing machine is also attributed to Watervliet Shaker Village, as a patent was issued to an Amos Larcom of Watervliet, New York, in 1829, but it is not certain that Larcom was a Shaker.[14] A device that combined a washing machine with a wringer mechanism did not appear until 1843, when Canadian John E. Turnbull of Saint John, New Brunswick patented a "Clothes Washer With Wringer Rolls."[15] During the 1850s, Nicholas Bennett from the Mount Lebanon Shaker Society at New Lebanon, New York, invented a "wash mill", but in 1858 he assigned the patent to David Parker of the Canterbury Shaker Village, where it was registered as the "Improved Washing Machine".[16][17]

Margaret Colvin invented the Triumph Rotary Washer, which was exhibited in the Women's Pavilion at the Centennial International Exhibition of 1876 in Philadelphia.[18][19] At the same Exhibition, the Shakers won a gold medal for their machine.[14][17]

A 1876 advertisement published in Argentina.

Electric washing machines were advertised and discussed in newspapers as early as 1904.[20] Alva J. Fisher has been incorrectly credited with the invention of the electric washer. The US Patent Office shows at least one patent issued before Fisher's US patent number 966677 (e.g. Woodrow's US patent number 921195). The "inventor" of the electric washing machine remains unknown.

US electric washing machine sales reached 913,000 units in 1928. However, high unemployment rates in the Depression years reduced sales; by 1932 the number of units shipped was down to about 600,000.

It is presumed that the first laundromat opened in Fort Worth, Texas in 1934.[21] It was run by Andrew Clein. Patrons used coin-in-the-slot facilities to rent washing machines. The term "laundromat" can be found in newspapers as early as 1884 and they were widespread during the Depression. England established public wash rooms for laundry along with bath houses throughout the 19th century.[22]

Washer design improved during the 1930s. The mechanism was now enclosed within a cabinet, and more attention was paid to electrical and mechanical safety. Spin dryers were introduced to replace the dangerous power mangle/wringers of the day.

By 1940, 60% of the 25,000,000 wired homes in the United States had an electric washing machine. Many of these machines featured a power wringer, although built-in spin dryers were not uncommon.

Automatic machines

The Washing Machine Museum in Mineral Wells, Texas

Bendix Home Appliances, a subsidiary of Avco, introduced the first domestic automatic washing machine in 1937,[23] having applied for a patent in the same year.[24] Avco had licensed the name from Bendix Corporation, an otherwise unrelated company. In appearance and mechanical detail, this first machine was not unlike the front loading automatic washers produced today. Although it included many of today's basic features, the machine lacked any drum suspension and therefore had to be anchored to the floor to prevent "walking". Because of the components required, the machine was also very expensive. For instance, the Bendix Home Laundry Service Manual (published November 1, 1946) shows that the drum speed change was facilitated by a 2-speed gearbox built to a heavy duty standard (not unlike a car automatic gearbox, albeit at a smaller size). The timer was also probably fairly costly, because miniature electric motors were expensive to produce.

Early automatic washing machines were usually connected to a water supply via temporary slip-on connectors to sink taps. Later, permanent connections to both the hot and cold water supplies became the norm, as dedicated laundry water hookups became common. Most modern front-loading European machines now only have a cold water connection (called "cold fill") and rely completely on internal electric heaters to raise the water temperature.[25]

Many of the early automatic machines had coin-in-the-slot facilities and were installed in the basement laundry rooms of apartment houses.

World War II and after

A classic Bendix washing machine

After the attack on Pearl Harbor, US domestic washer production was suspended for the duration of World War II in favor of manufacturing war material. However, numerous US appliance manufacturers were given permission to undertake the research and development of washers during the war years. Many took the opportunity to develop automatic machines, realizing that these represented the future for the industry.[26]

A large number of US manufacturers introduced competing automatic machines (mainly of the top-loading type) in the late 1940s and early 1950s. An improved front-loading automatic model, the Bendix Deluxe (which retailed at $249.50/£162.40, $2687.04 in 2016 dollars[27]), was introduced in 1947. General Electric also introduced its first top loading automatic model in 1947. This machine had many of the features that are incorporated into modern machines. Another early form of automatic washing machine manufactured by The Hoover Company used cartridges to program different wash cycles. This system, called the "Keymatic", used plastic cartridges with key-like slots and ridges around the edges. The cartridge was inserted into a slot on the machine and a mechanical reader operated the machine accordingly.

A 1950s model Constructa

Several manufacturers produced semi-automatic machines, requiring the user to intervene at one or two points in the wash cycle. A common semi-automatic type (available from Hoover in the UK until at least the 1970s) included two tubs: one with an agitator or impeller for washing, plus another smaller tub for water extraction or centrifugal rinsing.

Since their introduction, automatic washing machines have relied on electromechanical timers to sequence the washing and extraction process. Electromechanical timers consist of a series of cams on a common shaft driven by a small electric motor via a reduction gearbox. At the appropriate time in the wash cycle, each cam actuates a switch to engage or disengage a particular part of the machinery (for example, the drain pump motor). One of the first was invented in 1957 by Winston L. Shelton and Gresham N. Jennings, then both General Electric engineers. The device was granted US Patent 2870278.[28]

On the early electromechanical timers, the motor ran at a constant speed throughout the wash cycle, although it was possible for the user to truncate parts of the program by manually advancing the control dial. However, by the 1950s demand for greater flexibility in the wash cycle led to the introduction of more sophisticated electrical timers to supplement the electromechanical timer. These newer timers enabled greater variation in functions such as the wash time. With this arrangement, the electric timer motor is periodically switched off to permit the clothing to soak, and is only re-energized just prior to a micro-switch being engaged or disengaged for the next stage of the process. Fully electronic timers did not become widespread until decades later.

Despite the high cost of automatic washers, manufacturers had difficulty in meeting the demand. Although there were material shortages during the Korean War, by 1953 automatic washing machine sales in the US exceeded those of wringer-type electric machines.

In the UK and in most of Europe, electric washing machines did not become popular until the 1950s. This was largely because of the economic impact of World War II on the consumer market, which did not properly recover until the late 1950s. The early electric washers were single-tub, wringer-type machines, as fully automatic washing machines were extremely expensive. During the 1960s, twin tub machines briefly became very popular, helped by the low price of the Rolls Razor washers. Some machines had the ability to pump used wash water into a separate tub for temporary storage, and to later pump it back for re-use. This was done not to save water or soap, but because heated water was expensive and time-consuming to produce. Automatic washing machines did not become dominant in the UK until well into the 1970s and by then were almost exclusively of the front-loader design.

In early automatic washing machines, any changes in impeller/drum speed were achieved by mechanical means or by a rheostat on the motor power supply. However, since the 1970s electronic control of motor speed has become a common feature on the more expensive models.

Modern washers

Over time manufacturers of automatic washers have gone to great lengths to reduce cost. For instance, expensive gearboxes are no longer required, since motor speed can be controlled electronically

Even on some expensive washers, the outer drum of front loading machines is often made of plastic. This makes changing the main bearings difficult, as the plastic drum usually cannot be separated into two halves to enable the inner drum to be removed to gain access to the bearing.

Some machines now use a direct drive motor, a low aspect ratio device, where the stator assembly is attached to the rear of the outer drum, whilst the co-axial rotor is mounted on the shaft of the inner drum.[29] Direct drive eliminates the need for a pulley, belt and belt tensioner.

In the early 1990s, upmarket machines incorporated microcontrollers for the timing process. These proved reliable and cost-effective, so many cheaper machines now also incorporate microcontrollers rather than electromechanical timers.


A see-through Bosch machine at the IFA 2010 in Berlin shows off its internal components

In 1994, Staber Industries released the System 2000 washing machine, which is the only top-loading, horizontal-axis washer to be manufactured in the United States. The hexagonal tub spins like a front-loading machine, using only about one third as much water as conventional top-loaders. This factor has led to an Energy Star rating for its high efficiency.

In 1998, New Zealand-based company Fisher & Paykel introduced its SmartDrive washing machine line in the US. This washing machine uses a computer-controlled system to determine certain factors such as load size and automatically adjusts the wash cycle to match. It also used a mixed system of washing, first with the "Eco-Active" wash, using a low level of recirculated water being sprayed on the load followed by a more traditional style wash. The SmartDrive also included direct drive brushless DC electric motor, which simplified the bowl and agitator drive by doing away with the need for a gearbox system.

In 2000, the British inventor James Dyson launched the CR01 ContraRotator, a type of washing machine with two cylinders rotating in opposite directions. It was claimed that this design reduced the wash time and produced cleaner washing than a single cylinder machine. In 2004 there was the launch of the CR02, which was the first washing machine to gain the British Allergy Foundation Seal of Approval. However, neither of the ContraRotator machines are now in production as they were too expensive to manufacture.[30]

In 2001, Whirlpool Corporation introduced the Calypso, the first vertical-axis high efficiency washing machine to be top-loading. A washplate in the bottom of the tub nutated (a special wobbling motion) to bounce, shake, and toss the laundry around. Simultaneously, water containing detergent was sprayed on to the laundry. The machine proved to be good at cleaning, but gained a bad reputation due to frequent breakdowns and destruction of laundry. The washer was recalled with a class-action lawsuit and pulled off the market.

In 2003, Maytag introduced their top-loading Neptune washer. Instead of an agitator, the machine had two washplates, perpendicular to each other and at a 45 degree angle from the bottom of the tub. The machine would fill with only a small amount of water and the two washplates would tumble the load within it, mimicking the action of a front-loading washer in a vertical axis design.

In 2007, Sanyo introduced the first drum type washing machine with "Air Wash" function.[31] This washing machine uses only 50 L (11.0 imp gal; 13.2 US gal) of water in the recycle mode.

In 2008, the University of Leeds created a concept washing machine that uses only a cup (less than 300 ml) of water and 20 kg of re-usable plastic beads to carry out a full wash.[32] The machine leaves clothes virtually dry and uses less than 2 % of the water and energy otherwise used by a conventional machine. As such, it could save billions of liters of water each year. The concept is being developed as the Xeros Washing Machine.

A Beko washing machine, modern machines start at 5 kg (11 lb) capacity, ideal for smaller households and spans to 12 kg (26 lb) load capacity

Approximately in 2012, eco indicators were introduced, capable of predicting the energy demand based on the customer settings in terms of program and temperature.[33]

Features available in most modern consumer washing machines:

- Delayed execution: a timer to delay the start of the laundry cycle
- Predefined programs for different laundry types
- Rotation speed settings
- Variable temperatures, including cold wash

Additionally some of the modern machines feature:

- Child lock
- Steam
- Time remaining indication

Production by country

Country	Number[34]	Date of information
China	30,355,000	2005
Italy	9,680,000	2004
USA	9,531,000	2003
South Korea	4,977,000	2003
Germany	4,856,000	2003
France	3,618,000	2004
Japan	2,622,000	2005
Turkey	2,471,000	2003
Brazil	2,266,000	2003
Mexico	1,547,000	2003
Poland	1,481,000	2005
Ukraine	322,000	2005
Sweden	124,000	2003
Kazakhstan	72,800	2005
Sri Lanka	70,500	2014
Belarus	36,700	2005
Republic of Moldova	36,200	2005
Romania	25,000	2005
Uzbekistan	700	2005

Top-loading

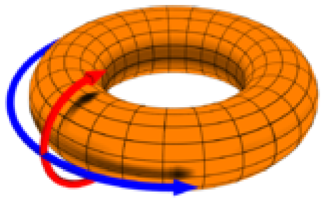
This design places the clothes in a vertically mounted perforated basket that is contained within a water-retaining tub, with a finned water-pumping agitator in the center of the bottom of the basket. Clothes are loaded through the top of the machine, which is usually but not always covered with a hinged door

General Electric Filter-Flo top loading, vertical axis machines in laundromat. The pans on the inside of the lid are placed atop the agitator, and wash water is pumped through the perforated pans to collect lint. (California)

During the wash cycle, the outer tub is filled with water sufficient to fully immerse and suspend the clothing freely in the basket. The movement of the agitator pushes water outward between the paddles towards the edge of the tub. The water then moves outward, up the sides of the basket, towards the center, and then down towards the agitator to repeat the process, in a circulation pattern similar to the shape of a torus. The agitator direction is periodically reversed, because continuous motion in one direction would just lead to the water spinning around the basket with the agitator rather than the water being pumped in the torus-shaped motion. Some washers supplement the water-pumping action of the agitator with a large rotating screw on the shaft above the agitator, to help move water downwards in the center of the basket.

Since the agitator and the drum are separate and distinct in a top-loading washing machine, the mechanism of a top-loader is inherently more complicated than a front-loading machine. Manufacturers have devised several ways to control the motion of the agitator during wash and rinse separately from the high speed rotation of the drum required for the spin cycle.

While a top-loading washing machine could use a universal motor or DC brushless motor, it is conventional for top-loading washing machines to use more expensive, heavy, and more electrically efficient and reliable induction motors. The action of a front-loading washing machine is better suited to a motor capable of reversing direction with every reversal of the wash basket; a universal motor is noisier, less efficient, doesn't last as long, but is better suited to the task of reversing direction every few seconds.



In a top-loading washer, water circulates primarily along the poloidal axis during the wash cycle, as indicated by the red arrow in this illustration of a torus.

An alternative to the oscillating agitator design is the impeller type washtub pioneered by Hoover on its long running *Hoovermatic* series of top loading machines. Here, an impeller (trademarked by Hoover as a "Pulsator") mounted on the side of the tub spins in a constant direction, and creates a fast moving current of water in the tub which drags the clothes through the water along a toroidal path. The impeller design has the advantage of its mechanical simplicity - a single speed motor with belt drive is all that is required to drive the Pulsator with no need for gearboxes or complex electrical controls, but has the disadvantage of lower load capacity in relation to tub size. Hoovermatic machines were made mostly in twin tub format for the European market - (where they competed with Hotpoint's *Supermatic* line which used the oscillating agitator design) until the early 1990s. Some industrial garment testing machines still use the Hoover wash action.

The many different ways different manufacturers have solved the same problem over the years is a good example of many different ways to solve the same engineering problem with different goals, different manufacturing capabilities and expertise, and different patent encumbrances.

Reversible motor

In most current top-loading washers, if the motor spins in one direction, the gearbox drives the agitator; if the motor spins the other way, the gearbox locks the agitator and spins the basket and agitator together. Similarly, if the pump motor rotates one way it recirculates the sudsy water; in the other direction it pumps water from the machine during the spin cycle. Mechanically, this system is very simple.

Mode-changing transmission

In some top loaders, the motor runs only in one direction. During agitation, the transmission converts the rotation into the alternating motion driving the agitator During the spin cycle, the timer turns on a solenoid which engages a clutch locking the motor's rotation to the wash basket, providing a spin cycle. General Electric's very popular line of Filter-Flo (seen to the right) used a variant of this design where the motor reversed only to pump water out of the machine. The same clutch which allows the heavy tub full of wet clothes to "slip" as it comes up to the motor's speed, is also allowed to "slip" during agitation to engage a Gentle Cycle for delicate clothes.

Whirlpool (Kenmore) created a popular design demonstrating the complex mechanisms which could be used to produce different motions from a single motor with the so-called "wig wag" mechanism, which was used for decades until modern controls rendered it obsolete. In the Whirlpool mechanism, a protruding moving piece oscillates in time with the agitation motion. Two solenoids are mounted to this protruding moving piece, with wires attaching them to the timer. During the cycle, the motor operates continuously, and the solenoids on the "wig wag" engage agitation or spin. Despite the wires controlling the solenoids being subject to abrasion and broken connections due to their constant motion and the solenoids operating in a damp environment where corrosion could damage them, these machines were surprisingly reliable.

Reversible motor with mode-changing transmission

Some top-loaders, especially compact apartment-sized washers, use a hybrid mechanism. The motor reverses direction every few seconds, often with a pause between direction changes, to perform the agitation. Spin cycle is accomplished by engaging a clutch in the transmission. A separate motorized pump is generally used to drain this style of machine. These machines could easily be implemented with universal motors or more modern DC brushless motors, but older ones tend to use a capacitor-start induction motor with a pause between reversals of agitation.

Top-load advantages

The top-loader's spin cycle between washing and rinsing allows an extremely simple passive fabric softener dispenser, which operates through centrifugal force and gravity. Fabric softener, vinegar, or any other liquid rinse agent, is placed in a cup at the top of the agitator. It "rides along" during the wash cycle. When the spin cycle is engaged, the fabric softener is pulled up by a tapered cup and centrifugal force, where it collects in the top of the spinning agitator. Once the spin cycle is completed, centrifugal force no longer suspends the fabric softener and it falls through the center of the agitator to join the rinse water coming into the tub. The same objective must be accomplished by a solenoid valve or a pump, and associated timer controls and wiring, on a front loader.

A lint trap can also be built into the center of the agitator, passively collecting lint from water forced through the agitator. Front-loaders tend to require separate pumps and plumbing to provide lint filters which are often mounted behind covers on the bottom of the machine.

Another advantage to the top loading design is the reliance on gravity to contain the water, rather than potentially trouble-prone or short-lived front door seals. Top loaders may require less periodic maintenance, since there is no need to clean a door seal or bellows, although a plastic tub may still require a periodic "maintenance wash" cycle (described below).

As with front-loading washers, clothing should not be packed tightly into a top-loading washer. Although wet fabric usually fits into a smaller space than dry fabric, a dense wad of fabric can restrict water circulation, resulting in poor soap distribution and incomplete rinsing. Extremely overloaded top-loading washers can either jam the motion of the agitator, overloading or damaging the motor or gearbox, burning drive belts, or tearing fabrics - many Whirlpool/Kenmore machines even have a mechanical "fuse" designed to break before the expensive motor is damaged. Extreme overloading can also push fabrics into the small gap between the underside of the agitator and the bottom of the wash basket, resulting in fabrics wrapped around the agitator shaft, possibly requiring agitator removal to unjam.

Some top-loading machines use mechanisms very similar to front-loading drum machines, and are described below.

Front-loading

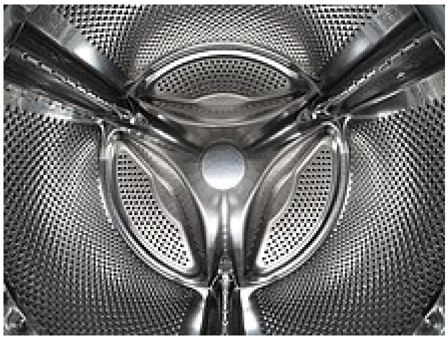
The front-loading or horizontal-axis clothes washer is the dominant design in Europe. In the U.S. and elsewhere, most "high-end" washing machines are of this type. In addition, most commercial and industrial clothes washers around the world are of the horizontal-axis design.

Arctic BE1200A+ is a front loading budget model sold in 2008 with 6-kilogram (13 lb) load, LCD indicator, 1200 RPM

This layout mounts the inner basket and outer tub horizontally, and loading is through a door at the front of the machine. The door often but not always contains a transparent window. Agitation is supplied by the back-and-forth rotation of the cylinder and by gravity. The clothes are lifted up by paddles on the inside wall of the drum and then dropped. This motion flexes the weave of the fabric and forces water and detergent solution through the clothes load. Because the wash action does not require the clothing be freely suspended in water, only enough water is needed to moisten the fabric. Because less water is required, front-loaders typically use less soap, and the repeated dropping and folding action of the tumbling can easily produce large amounts of foam or suds.

Front-loaders control water usage through the surface tension of water, and the capillary wicking action this creates in the fabric weave. A front-loader washer always fills to the same low water level, but a large pile of dry clothing standing in water will soak up the moisture, causing the water level to drop. The washer then refills to maintain the original water level.

Because it takes time for this water absorption to occur with a motionless pile of fabric, nearly all front-loaders begin the washing process by slowly tumbling the clothing under the stream of water entering and filling the drum, to rapidly saturate the clothes with water.



Modern drum of front-loading washing machine (Bosch Maxx WFO 2440)

Front-loading washers are mechanically simple compared to top-loaders, with the main motor (a universal motor or variable-frequency drive motor) normally being connected to the drum via a grooved pulley belt and large pulley wheel, without the need for a gearbox, clutch or crank. But front-load washers suffer from their own technical problems, due to the drum lying sideways. For example, a top loading washer keeps water inside the tub merely through the force of gravity pulling down on the water, while a front-loader must tightly seal the door shut with a gasket to prevent water dripping onto the floor during the wash cycle. This access door is locked shut during the entire wash cycle, since opening the door with the machine in use could result in water gushing out onto the floor. For front-loaders without viewing windows on the door, it is possible to accidentally pinch fabric between the door and the drum, resulting in tearing and damage to the pinched clothing during tumbling and spinning.

Nearly all front-loader washers for the consumer market must also use a folded flexible bellows assembly around the door opening, to keep clothing contained inside the basket during the tumbling wash cycle. If this bellows assembly were not used, small articles of clothing such as socks could slip out of the wash basket near the door, and fall down the narrow slot between the outer tub and basket, plugging the drain and possibly jamming rotation of the inner basket. Retrieving lost items from between the outer tub and inner basket can require complete disassembly of the front of the washer and pulling out the entire inner wash basket. Commercial and industrial front-loaders used by businesses (described below) usually do not use the bellows, and instead require all small objects to be placed in a mesh bag to prevent loss near the basket opening.

The bellows assembly around the door is a potential source of problems for the consumer front-loader. The bellows has a large number of flexible folds to permit the tub to move separately from the door during the high speed extraction cycle. On many machines, these folds can collect lint, dirt, and moisture, resulting in mold and mildew growth, and a foul odor. Some front-loading washer operating instructions say the bellows should be wiped down monthly with a strong bleach solution, while others offer a special "freshening" cycle where the machine is run empty with a strong dosing of bleach.

The inherent mechanical weak spot of the front loader design is the cantilevered mounting of the inner drum within the outer tub. The drum bearing has to support the entire weight of the drum, the laundry, and the dynamic loads created by the sloshing of the water and of the imbalance of the load during the spin cycle. The drum bearing eventually wears out, and usually requires extensive dismantling of the machine to replace, which often results in the machine being written off due to the failure of a relatively inexpensive component that is labor-intensive to renew. Some manufacturers have compounded this problem by "overmolding" the drum bearing into the outer tub to reduce manufacturing costs, but this makes the bearing impossible to renew without replacing the entire outer tub - which usually forces owners to scrap the entire machine - this may be viewed as an implementation of built-in obsolescence.

Compared to top-loading washers, clothing can be packed more tightly in a front loader, up to the full drum volume if using a cottons wash cycle. This is because wet cloth usually fits into a smaller space than dry cloth, and front loaders are able to self-regulate the water needed to achieve correct washing and rinsing. Extreme overloading of front-loading washers pushes fabrics towards the small gap between the loading door and the front of the wash basket, potentially resulting in fabrics lost between the basket and outer tub, and in severe cases, tearing of clothing and jamming the motion of the basket.

Variant and hybrid designs

There are many variations of the two general designs. Top-loading machines in Asia use impellers instead of agitators. Impellers are similar to agitators except that they do not have the center post extending up in the middle of the wash tub basket.

Some machines which actually load from the top are otherwise much more similar to front-loading horizontal-axis drum machines. They have a drum rotating around a horizontal axis, as a front-loader, but there is no front door; instead there is a liftable lid which provides access to the drum, which has a hatch which can be latched shut. Clothes are loaded, the hatch and lid are closed, and the machine operates and spins just like a front-loader. These machines are narrower but usually taller than front-loaders, usually have a lower capacity, and are intended for use where only a narrow space is available, as is sometimes the case in Europe. They have incidental advantages: they can be loaded without bending down; they do not require a perishable rubber bellows seal; and instead of the drum having a single bearing on one side, it has a pair of symmetrical bearings, one on each side, avoiding asymmetrical bearing loading and potentially increasing life.


European top loader with horizontal axis rotating drum (2008)

There are also combo washer dryer machines that combine washing cycles and a full drying cycle in the same drum, eliminating the need to transfer wet clothes from a washer to a dryer machine. In principle, these machines are convenient for overnight cleaning (the combined cycle is considerably longer), but the effective capacity for cleaning larger batches of laundry is drastically reduced. The drying process tends to use much more energy than using two separate devices, because a combo washer dryer not only must dry the clothing, but also needs to dry out the wash chamber itself. These machines are used more in Europe, because they can be fitted into small spaces, and many can be operated without dedicated utility connections.

Comparison

True front-loaders, and top-loading machines with horizontal-axis drum as described above, can be compared with top-loaders on a number of aspects:

- Efficient cleaning: Front-loaders usually use less energy, water, and detergent compared to the best top-loaders.[35] "High Efficiency" washers use 20% to 60% of the detergent, water and energy of "standard" washers. They usually take somewhat longer (20–110 minutes) to wash a load, but are often computer controlled with additional sensors, to adapt the wash cycle to the needs of each load. As this technology improves, the human interface will also improve, to make it easier to understand and control the many different cleaning options.
- Water usage: Front-loaders usually use less water than top-loading residential clothes washers. Estimates are that front-loaders use from one third[36] to one half[37] as much water as top-loaders.
- Spin-dry effectiveness: Front-loaders (and European horizontal axis top loaders) offer much higher maximum spin speeds of up to 2000 RPM, although home machines tend to be in the 1000 to 1400 RPM range, while top-loaders (with agitators) do not exceed 1140 RPM. High-efficiency top-loaders with a wash plate (instead of an agitator) can spin up to 1100 RPM, as their center of gravity is lower. Higher spin speeds, along with the diameter of the drum, determine the g-force, and a higher g-force removes more residual water, making clothes dry faster. This also reduces energy consumption if clothes are dried in a clothes dryer.
- Cycle length: Top-loaders have tended to have shorter cycle times, in part because their design has traditionally emphasized simplicity and speed of operation more than resource conservation.
- Wear and abrasion: Top-loaders require an agitator or impeller mechanism to force enough water through clothes to clean them effectively, which greatly increases mechanical wear and tear on fabrics. Front-loaders use paddles in the drum to repeatedly pick up and drop clothes into water for cleaning; this gentler action causes less wear. The amount of clothes wear can be roughly gauged by the amount of accumulation in a clothes dryer lint filter, since the lint largely consists of stray fibers detached from textiles during washing and drying.
- Difficult items: Top-loaders may have trouble cleaning large items, such as sleeping bags or pillows, which tend to float on top of the wash water rather than circulate within it. In addition, vigorous top-loader agitator motions may damage delicate fabrics.
- Noise: Front-loaders tend to operate more quietly than top-loaders because the door seal helps contain noise, and because there is less of a tendency to imbalance. Top-loaders usually need a mechanical transmission, which can generate more noise than the rubber belt or direct drive found in most front loaders.
- Compactness: True front-loading machines may be installed underneath counter-height work surfaces. A front-loading washing machine, in a fully fitted kitchen, may even be disguised as a kitchen cabinet. These models can also be convenient in homes with limited floor area, since the clothes dryer may be installed directly above the washer ("stacked" configuration).
- Water leakage: Top-loading machines are less prone to leakage, because simple gravity can reliably keep water from spilling out the loading door on top. True front-loading machines require a flexible seal or gasket on the front door, and the front door must be locked during operation to prevent opening, lest large amounts of water spill out.

This seal may leak and require replacement. However, many current front-loaders use so little water that they can be stopped mid-cycle for addition or removal of laundry, while keeping the water level in the horizontal tub below the door level. Best practice installations of either type of machine will include a floor drain or an overflow catch tray with a drain connection, since neither design is immune to leakage or a solenoid valve getting stuck in the open position.

- Maintenance and reliability: Top-loading washers are more tolerant of maintenance neglect, and may not need a regular "freshening" cycle to clean door seals and bellows. During the spin cycle, a top-loading tub is free to move about inside the cabinet of the machine, using only a lip around the top of the inner basket and outer tub to keep the spinning water and clothing from spraying out over the edge. Therefore, the potentially problematic door-sealing and door-locking mechanisms used by true front-loaders are not needed. On the other hand, top-loaders use mechanical gearboxes that are more vulnerable to wear than simpler front-load motor drives.
- Accessibility and ergonomics: Front-loaders are more convenient for very short people and those with paraplegia, as the controls are front-mounted and the horizontal drum eliminates the need for standing or climbing. Risers, also referred to as pedestals, often with storage drawers underneath, can be used to raise the door of a true front-loader closer to the user's level.
- Initial cost: In countries where top-loaders are popular, front-loaders tend to be more expensive to buy than top-loaders, though their lower operating costs can ultimately lead to lower total cost of ownership, especially if energy, detergent, or water are expensive. On the other hand, in countries with a large front-loader user base, top-loaders are usually seen as alternatives and more expensive than basic off-brand front loaders, although without many differences in total cost of ownership apart from design-originated ones. In addition, manufacturers have tended to include more advanced features such as internal water heating, automatic dirt sensors, and high-speed emptying on front-loaders, although some of these features could be implemented on top-loaders.

Wash cycles

The earliest washing machines simply carried out a washing action when loaded with clothes and soap, filled with hot water, and started. Over time machines became more and more automated, first with very complex electromechanical controllers, then fully electronic controllers; users put clothes into the machine, select a suitable program via a switch, start the machine, and come back to remove clean and slightly damp clothes at the end of the cycle. The controller starts and stops many different processes including pumps and valves to fill and empty the drum with water, heating, and rotating at different speeds, with different combinations of settings for different fabrics.

German laundry centrifuge to extract water from laundry. The advent of automatic washing machines with spin cycles made such specialized appliances largely obsolete by the 1970s.

Washing

Many front loading machines have internal electrical heating elements to heat the wash water, to near boiling if desired. The rate of chemical cleaning action of the detergent and other laundry chemicals increases greatly with temperature, in accordance with the Arrhenius equation. Washing machines with internal heaters can use special detergents formulated to release different chemical ingredients at different temperatures, allowing different type of stains and soils to be cleaned from the clothes as the wash water is heated up by the electrical heater.

However, higher-temperature washing uses more energy, and many fabrics and elastics are damaged at higher temperatures. Temperatures exceeding 40 °C (104 °F) have the undesirable effect of inactivating the enzymes when using biological detergent.

Many machines are cold-fill, connected to cold water only, which they heat to operating temperature. Where water can be heated more cheaply or with less carbon dioxide emission than by electricity, cold-fill operation is inefficient.

Front loaders need to use low-sudsing detergents because the tumbling action of the drum folds air into the clothes load that can cause over-sudsing and overflows. However, due to efficient use of water and detergent, the sudsing issue with front-loaders can be controlled by simply using less detergent, without lessening cleaning action.

Rinsing

Washing machines perform several rinses after the main wash to remove most of the detergent. Modern washing machines use less water due to environmental concerns; however, this has led to the problem of poor rinsing on many washing machines on the market,[38] which can be a problem to people who are sensitive to detergents. The Allergy UK website suggests re-running the rinse cycle, or rerunning the entire wash cycle without detergent. [39]

In response to complaints, many washing machines allow the user to select additional rinse cycles, at the expense of higher water usage and longer cycle time.

Spinning

Higher spin speeds, along with larger tub diameters, remove more water, leading to faster drying. If a heated clothes-dryer is used after the wash and spin, energy use is reduced if more water has been removed from clothes. However, faster spinning can crease clothes more. Also, mechanical wear on bearings increases rapidly with rotational speed, reducing life. Early machines would spin at only 300 rpm and, because of lack of any mechanical suspension, would often shake and vibrate.

In 1976, most front loading washing machines spun at around 700 rpm, or less.

Separate spin-driers, without washing functionality, are available for specialized applications. For example, a small high-speed centrifuge machine may be provided in locker rooms of communal swimming pools to allow wet swimsuits to be substantially dried to a slightly damp condition after daily use.

Washing machines can spin in either a clockwise or counter-clockwise direction, depending on the manufacturer.

Maintenance wash

Many home washing machines use a plastic, rather than metal, outer shell to contain the wash water; residue can build up on the plastic tub over time. Some manufacturers advise users to perform a regular maintenance or "freshening" wash to clean the inside of the washing machine of any mold, bacteria, encrusted detergent, and unspecified dirt more effectively than with a normal wash.

A maintenance wash is performed without any laundry, on the hottest wash program,[40] adding substances such as white vinegar, 100 grams of citric acid, a detergent with bleaching properties, or a proprietary washing machine cleaner. The first injection of water goes into the sump[41] so the machine can be allowed to fill for about 30 seconds before adding cleaning substances.

Efficiency and standards

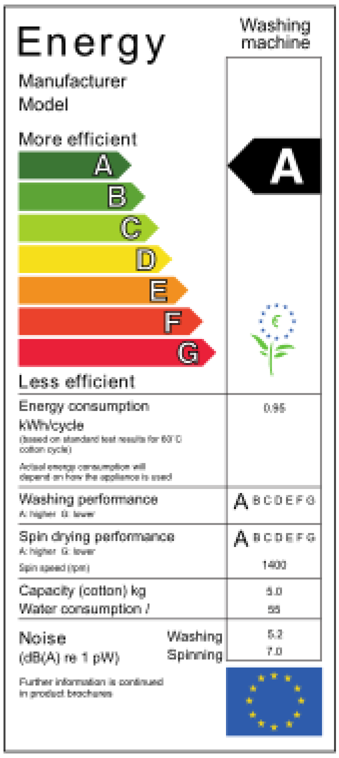
Capacity and cost are both considerations when purchasing a washing machine. All else being equal, a machine of higher capacity will cost more to buy, but will be more convenient if large amounts of laundry must be cleaned. Fewer runs of a machine of larger capacity may have lower running costs and better energy and water efficiency than frequent use of a smaller machine, particularly for large families. Running a large machine with small loads is wasteful.

For many years energy and water efficiency were not regulated, and little attention was paid to them. From the last part of the twentieth century increasing attention was paid to efficiency, with regulations enforcing some standards, and efficiency being a selling point, both to save on running costs and to reduce carbon dioxide emissions associated with energy generation, and waste of water.

As energy and water efficiency were regulated, and a selling point, but effectiveness of rinsing was not, manufacturers tended to reduce the degree of rinsing after washing, saving water and motor energy. This had the side-effect of leaving more detergent residue in clothes. Insufficient rinsing can leave enough detergent in clothes to affect people with allergies or sensitivity.[38]

Europe

Washing machines display an EU Energy Label with grades for energy efficiency, washing performance and spin efficiency. Grades for energy efficiency run from A+++ to G (best to worst), providing a simple method for judging running costs. Washing performance and spin efficiency are graded in the range A to G. However, all machines for sale must have washing performance A, such that manufacturers cannot compromise washing performance in order to improve the energy efficiency. This labeling has had the desired effect of driving customers toward more efficient washing machines and away from less efficient ones.



The EU requires washing machines carry an efficiency label

The TopTenEU and other national TopTen European organizations provide independent recommendations for high eficient washing machines.[42]

According to newer regulations, each washing machine is equipped with a waste water filter. There are two reasons for that. On one hand it has to be ensured that no hazardous chemical substances are disposed of improperly through the waste water channel; on the other hand it must also be ensured that in case of a backwards shear in the waste water channel that is possible in case of technical problems, the feces and other waste could not enter the washing machine.[16]

United States

Top-loading and front-loading clothes washers are covered by a single Federal Standard regulating energy consumption. The old Federal Standard applicable until January 1, 2011 included no restriction on water consumption; washer manufacturers faced no legal restriction on how much unheated rinse water could be used.[43] Energy consumption for clothes washers is quantified using the energy factor.

But after new mandatory Federal Standards were introduced, many US washers were manufactured to be more energy- and water-efficient than required by the federal standard, or even certified by the more stringent Energy Star standard.[44] Manufacturers were found to be motivated to exceed mandatory standards by a program of direct-to-manufacturer tax credits.[45]

In North America, the Energy Star program compares and lists energy efficient clothes washers. Certified Energy Star units can be compared by their Modified Enegy Factor (MEF) and Water Factor (WF) coefficients.

The MEF tells us how many cubic feet of clothes are washed per kWh (kilowatt hour) and is closely related to the configuration of the washer (top-loading, front-loading), its spin speed and the temperatures and the amount of water used in the rinse and wash cycles.

Energy Star residential clothes washers have a MEF of at least 2.0 (the higher the better), but the best machines may reach 3.5. Energy Star washers have also a WF of less than 6.0 (the lower the better).[46]

Commercial use

A commercial washing machine is intended for more frequent use than a consumer washing machine. Durability and functionality is more important than style; most commercial washers are bulky and heavy, often with more expensive stainless steel construction to minimize corrosion in a constantly moist environment. They are built with large easy-to-open service covers, and washers are designed not to require access to the underside for service. Often commercial washers are installed in long rows with a wide access passageway behind all the machines to allow maintenance without moving the heavy machines.

Laundromat machines

Many commercial washers are built for use by the general public, and are installed in publicly accessible laundromats or laundrettes, operated by money accepting devices or card readers. The features of a commercial laundromat washer are more limited than a consumer washer, usually offering just two or three basic wash programs and an option to choose wash cycle temperatures.


Commercial washing machines and dryers (at left) in a self-service laundry (Paris, France)

The common front-loading commercial washing machine also differs from consumer models in its expulsion of wash and rinse water. While the consumer models pump used washer water out, allowing the waste line to be located above the washer, front loading commercial machines generally use only gravity to expel used water. A drain in the rear, at the bottom of the machine opens at the appointed time during the cycle and water flows out. This creates the need for a drainage trough behind machines, which leads to a filter and drain. The trough is usually part of a cement platform built for the purpose of raising the machines to a convenient height, and can be seen behind washers at most laundromats.


Commercial washing machines in a self-service laundromat (Toronto, Canada)

Most laundromat machines are horizontal-axis front-loading models, because of their lower operating costs (notably lower consumption of expensive hot water).

Industrial washers

By contrast, commercial washers for *internal* business operations (still often referred to as "washer/extractor" machines) may include features absent from domestic machines. Many commercial washers offer an option for automatic injection of five or more different chemical types, so that the operator does not have to deal with constantly measuring out soap products and fabric softeners for each load by hand. Instead, a precise metering system draws the detergents and wash additives directly from large liquid-chemical storage barrels and injects them as needed into the various wash and rinse cycles. Some computer-controlled commercial washers offer the operator control over the various wash and rinse cycles, allowing the operator to program custom washing cycles.


A 1980s Belgian 90 kg load industrial washer (horizontal axis, front load)

Most large-scale industrial washers are horizontal-axis machines, but may have front-, side-, or top-load doors. Some industrial clothes washers can batch-process up to 800 pounds (360 kg) of textiles at once, and can be used for extremely machine-abusive washing tasks such as stone washing or fabric bleaching and dyeing.

An industrial washer can be mounted on heavy-duty shock absorbers and attached to a concrete floor, so that it can extract water from even the most severely out-of-balance and heavy wash loads. Noise and vibration is not as unacceptable as in a domestic machine. It may be mounted on hydraulic cylinders, permitting the entire washer to be lifted and tilted so that fabrics can be automatically dumped from the wash drum onto a conveyor belt once the cycle is complete.

One special type of continuous-processing washer is known as the tunnel washer. This specialized high-capacity machine does not have a drum where everything being washed undergoes distinct wash and rinse cycles, but moves the laundry slowly and continuously through a long, large-diameter horizontal-axis rotating tube in the manner of an assembly line, with different processes at different positions.[47]

Social impact

The historically laborious process of washing clothes (a task which often had a whole day set aside to perform) has at times been labelled 'woman's work'. The spread of the washing machine has been seen to be a force behind the improvement of women's position in society. In 2009 the Italian newspaper *L'Osservatore Romano* published a controversial article on International Women's Day arguing that the washing machine had done more for the liberation of women than the contraceptive pill and abortion rights.[48] A study from Université de Montréal, Canada presented a similar point of view, adding fridges as well.[49] The following year, Swedish statistician Hans Rosling suggested that the positive effect the washing machine had on the liberation of women, makes it "the greatest invention of the industrial revolution".[50] It has been argued that washing machines are an example of labour saving technology, which does not decrease employment because households can internalize the gains of the innovation.[51] Historian Frances Finnegan credits the rise of this technology in helping undercut the economic viability of the Magdalene Asylums in Ireland, later revealed to be inhumanly abusive prisons for women, by supplanting their laundry businesses and prompting the eventual closure of the institutions as a whole.[52]

"Woman's Friend" machine (c. 1890)

Before the advent of the washing machine, laundry was done first at watercourses and then in public washhouses known as lavoirs. Camille Paglia and others argue that the washing machine led to a type of social isolation of women,[53] as a communal activity became a solitary one.

In India, *dhobis*, a caste group specialized in washing clothes, are slowly adapting to modern technology, but even with access to washing machines, many still handwash garments as well.[54] Since most modern homes are equipped with a washing machine, many Indians have dispensed with the services of the *dhobiwallahs*.[55]

Environmental impact

Due to the increasing cost of repairs relative to the price of a washing machine, there has been a major increase in the number of defective washing machines being discarded, to the detriment of the environment. The cost of repair and the expected life of the machine may make the purchase of a new machine seem like the better option.[56]

Different washing machine models vary widely in their use of water, detergent, and energy. The energy required for heating is large compared to that used by lighting, electric motors, and electronic devices. Because of their use of hot water, washing machines are among the largest consumers of energy in a typical modern home

Manufacturers and brands

Notable brands include:

- Alliance Laundry Systems[57] including the brand names Cissell, D'Hooge, Huebsch, IPSO, Speed Queen, UniMac and Primus
- Arçelik: including the brand names Arçelik, Beko, Blomberg, Grundig, Arctic, Altus, Flavel, Elektra Bregenz, Leisure
- Brandt France
- BSH: including the brand names Siemens (German), Bosch (German)
- Candy: including brand names Baumatic, Candy, Hoover (Europe), Zerowatt, Helkama, Grepa, Vyatka, Jinling
- Electrolux: including the brand names Electrolux, Frigidaire, Kenmore, Arthur Martin,[58] Zanussi, AEG (German), and White-Westinghouse (until 2006)
- Fagor
- Fisher & Paykel (New Zealand)
- GE: including brand name Hotpoint (North America)
- Girbau (Spain)
- Gorenje
- Haier (China)
- IFB (India)

- Indesit: including the brand names Indesit, Ariston, Hotpoint (Europe), Scholtes
- LG including GoldStar and Kenmore
- Mabe (Mexico)
- Maharaja (India)
- Miele (German)
- Panasonic (*company formerly Matsushita Electric*; included "National" brand)
- SMEG: including brand White-Westinghouse (Europe)
- Samsung including Kenmore
- Sharp
- Toshiba
- Vestel: Vestel, Regal, Vestfrost
- Videocon (India)
- Whirlpool: including the brand names Acros, Admiral, Amana, Bauknecht, Estate, Inglis, Kenmore, Laden, Maytag, Magic Chef, Kirkland, Roper & Philips, Brastemp and Consul (Brazilian market)

See also

- Centrifugation
- Clothes dryer
- Combo washer dryer
- Detergent
- Drying cabinet
- Energetic efficiency
- Home appliance
- Ironing
- Laundry detergent
- Laundry symbols
- List of home appliances
- Major appliance
- Silver Nano
- Standpipe
- L'Increvable

Notes

1. Mintz, Steven. "Housework out here in london in Late 19th Century America". Digital History
2. "On March 28, 1797, Nathaniel Briggs of New Hampshire..." (http://articles.chicagotribune.com/2001-03-28/news/0103280211_1_brady-bill-istanbul-and-ankara-worst-commercial-nuclear-accident). *tribunedigital-chicagotribune*. Retrieved 13 February 2016.
3. "History of Washing Machines" (http://inventors.about.com/od/wstartinventions/a/washingmachines.htm). About.com Inventors. Retrieved 2012-05-24.
4. Arwen Mohun, Steam Laundries: Gender, Technology, and Work, Johns Hopkins University Press, 1999, p28
5. Arwen Mohun, Steam Laundries: Gender, Technology, and Work, Johns Hopkins University Press, 1999
6. Illustration of a 1919 line shaft-driven commercial horizontal washer with a separate large vertical extractor behind it – "Don't Waste Waste", *Popular Science* monthly, January 1919, page 73, Scanned by Google Books: "Archived copy" (https://books.google.com/books?id%3DHykDAAAAMBAJ%26pg%3DPA73). Archived (https://web.archive.org/web/20160428103443/https://books.google.com/books?id=HykDAAAAMBAJ&pg=PA73) from the original on 2016-04-28. Retrieved 2015-12-12.
7. "New Devices that Ought to Make Housekeeping Easy (https://books.google.com/books?id=7igDAAAAMBAJ&pg=PA62) Archived (https://web.archive.org/web/20160509161718/https://books.google.com/books?id=7igDAAAAMBAJ&pg=PA62) May 9, 2016, at the Wayback Machine.", *Popular Science*, Feb 1919
8. *Mothers and Daughters of Invention: Notes for a Revised History of Technology*, Autumn Stanley, Rutgers University Press, 1995, p. 301

9. "Deutsches Museum: Schäfer" (http://www.deutsches-museum.de/bibliothek/unsere-schaetze/technikgeschichte/schaeffer-waschmaschine/). Deutsches-museum.de. Retrieved 2011-12-12.
10. "History of Washing Machines up to 1800" (http://www.oldandinteresting.com/history-washing-machines.aspx). Oldandinteresting.com. 2011-04-14. Retrieved 2012-06-01.
11. *Washing Machine - MSN Encarta* (https://www.webcitation.org/5kwRD4hzo?url=http://encarta.msn.com/encyclopedia_761590288/Washing_Machine.html). Archived from the original (http://encarta.msn.com/encyclopedia_761590288/Washing_Machine.html) on 2009-10-31.
12. "Washing Machine Facts, information, pictures | Encyclopedia.com articles about Washing Machine" (http://www.encyclopedia.com/doc/1G2-2896500105.html). Encyclopedia.com. Retrieved 2012-06-01.
13. "1862 London Exhibition: Catalogue: Class VIII.: Richard Lansdale" (http://www.gracesguide.co.uk/1862_London_Exhibition:_Catalogue:_Class_VIII.:_Richard_Lansdale). GracesGuide.co.uk. Retrieved 2010-06-19.
14. Andrews, Edward Deming; Andrews, Faith (1974-01-01). *Work and Worship Among the Shakers: Their Craftsmanship and Economic Order* (https://books.google.com/books?id=Yh18lhH-ytwC). Courier Corporation. p. 157. ISBN 9780486243825.
15. Mario Theriault, *Great Maritime Inventions 1833–1950*, Goose Lane, 2001, p. 28
16. Tilley, E., Ulrich, L., Lüthi, C., Reymond, Ph., Zurbrügg, C. *Compendium of Sanitation Systems and Technologies – (2nd Revised Edition)* (http://www.eawag.ch/forschung/sandec/publikationen/compendium_e/index_EN). Swiss Federal Institute of Aquatic Science and Technology (Eawag), Duebendorf, Switzerland. p. 147. ISBN 978-3-906484-57-0.
17. shakerml (2016-07-20). "The Shaker Improved Washing Machine" (https://shakerml.wordpress.com/2016/07/20/the-shaker-improved-washing-machine/). *Shaker Museum | Mount Lebanon*. Retrieved 2016-10-10.
18. *Womanlist – Marjorie P. K. Weiser, Jean S. Arbeiter – Google Books* (https://books.google.com/books?id=FDwpAAAAYAAJ&q=%22margaret+colvin%22+rotary&dq=%22margaret+colvin%22+rotary&hl=en&ei=MdHPT-3dAcS36QHEvrySDA&sa=X&oi=book_result&ct=book-thumbnail&resnum=6&ved=0CGAQ6wEwBQ). Books.google.com. Retrieved 2012-10-14.
19. *Women, Aging, and Ageism – Evelyn R Rosenthal – Google Books* (https://books.google.com/books?id=KmOWvTzjegUC&pg=PA146&dq=%22margaret+colvin's+triumph+rotary%22&hl=en&ei=vNLPT7bcAcHX6gGzlN2ZDA&sa=X&oi=book_result&ct=book-thumbnail&resnum=1&ved=0CDwQ6wEwAA#v=onepage&q=%22margaret%20colvin's%20triumph%20rotary%22&f=false). Books.google.com. Retrieved 2012-10-14.
20. "Electric Washing Machine the Latest. Housewives can do Washing in one-third the Time", *Des Moines Daily Capitol*, November 12, 1904, p. 13.
21. David John Cole, Eve Browning, Fred E. H. Schroeder, Encyclopedia of Modern Everyday Inventions, Greenwood 2003
22. New York Times, April 13, 1884; New London Journal, July 22, 1917
23. "LIFE" (https://books.google.com/books?id=oUkEAAAAMBAJ&pg=PA119&dq=Bendix+washer&hl=en&ei=ttAqT64BcT3sgbbrYGkDA&sa=X&oi=book_result&ct=result&redir_esc=y#v=onepage&q=Bendix%20washer&f=false). Retrieved 13 February 2016.
24. US 2165884 (https://worldwide.espacenet.com/textdoc?DB=EPODOC&IDX=US2165884)
25. "Test & Vergleich" (http://www.trocknerland.com/waermepumpentrockner). Archived (https://www.webcitation.org/6g4mbniew?url=http://www.trocknerland.com/waermepumpentrockner) from the original on March 17, 2016. Retrieved March 17, 2016.
26. A. S. Campbell Co. "Your Next Washing Machine (or is it?), advertisement for Campbell wartime production" (http://gogd.tjs-labs.com/show-picture?id=1129064419). Retrieved 13 September 2012.
27. bls inflation calculator (http://data.bls.gov/cgi-bin/cpicalc.pl?cost1=249&year1=1947&year2=2016) Archived (https://web.archive.org/web/20161002030133/http://data.bls.gov/cgi-bin/cpicalc.pl?cost1=249&year1=1947&year2=2016) October 2, 2016, at the Wayback Machine.
28. "Timing mechanism for conducting a selected one of a plurality of sequences of operation" (http://www.google.la/patents/US2870278). Retrieved 2 November 2017.
29. https://www.youtube.com/watch?v=ObgjjDMyCxM
30. Dyson, James. "Inside Dyson: CR01" (http://content.dyson.co.uk/insideDyson/article.asp?aID=cr01&disType=nonFlash&dir=&cp=&hf=1&js=1). dyson.co.uk. Retrieved 13 July 2012.
31. "SANYO Announces the World-First*1 Drum Type Washing Machine with 'Air Wash' Function" (http://www.sanyo.com/news/2007/03/27-2.html). Sanyo.com. Retrieved 2012-06-01.

32. Poulter, Sean (9 June 2008). "Spin dry: The washing machine that needs just one cup of water" (http://www.dailymail.co.uk/sciencetech/article-1025043/Spin-dry-The-washing-machine-needs-just-cup-water.html?ITO=1490). *Daily Mail*.
33. "Whirlpool's Eco Monitor guarantees energy optimisation - The KBzine" (https://www.thekbzine.com/pages/4580/whirlpools_eco_monitor_guarantees_energy_optimisation/). *www.thekbzine.com*. Retrieved 2016-07-03.
34. "Production. Household washing machines — Country Comparisons - world map" (http://statinfo.biz/Geomap.aspx?region=world&act=6133&lang=2). *statinfo.biz*. Retrieved 19 January 2015.
35. "Laundry Products Research" (http://www.lanfaxlabs.com.au/washing_machines.htm). March 2008.
36. "About.com" (http://housewares.about.com/lw/Home-Garden/Home-improvement-renovation/Top-Loading-vs-Front-Loading-Washers-Which-is-Better-.htm)
37. "Consumer Energy Center" (http://www.consumerenergycenter.org/home/appliances/washers.html)
38. "Why can't modern washing machines rinse properly?" (http://www.whitegoodshelp.co.uk/wordpress/why-cant-modern-washing-machines-rinse-properly/). Whitegoodshelp.co.uk. Retrieved 2010-02-16.
39. "Allergy Tips and Advice for Household Cleaning" (http://www.allergyuk.org/fs_handyhints.aspx). Allergyuk.org. Retrieved 2010-02-16.
40. "Washing machine usage (part 2)" (http://www.washerhelp.co.uk/usage_2.html). Washerhelp.co.uk. Retrieved 2010-02-16.
41. "DIY washing machine repairs (Part 4)" (http://www.washerhelp.co.uk/diy-repair-help_4.html). Washerhelp.co.uk. Retrieved 2010-02-16.
42. "Selection criteria washing machines" (http://www.topten.eu/english/criteria/washing-machines-2.html&fromid=) Archived (https://web.archive.org/web/20160425102236/http://www.topten.eu/english/criteria/washing-machines-2.html%26fromid%3D) April 25, 2016, at the Wayback Machine.. TopTenEU
43. "Clothes Washers Key Product Criteria" (http://www.energystar.gov/index.cfm?c=clotheswash.pr_crit_clothes_washers). Energystar.gov. Retrieved 2012-06-01.
44. "ENERGY STAR Qualified Clothes Washers" (http://www.energystar.gov/index.cfm?c=clotheswash.search_clotheswashers). Energystar.gov. 2011-01-01. Retrieved 2012-06-01.
45. "Tax Incentives Assistance Project" (http://energytaxincentives.org/builders/appliances.php). Energytaxincentives.org. Retrieved 2012-06-01.
46. "Clothes Washers Key Product Criteria" (http://www.energystar.gov/index.cfm?c=clotheswash.pr_crit_clothes_washers) Archived (https://web.archive.org/web/20151109211645/http://www.energystar.gov/index.cfm?c=clotheswash.pr_crit_clothes_washers) November 9, 2015, at the Wayback Machine.. Energy Star
47. https://www.isopasse.com.br/dicas/lavadora-de-roupas-melhor-marca/
48. Galeotti, Giulia (8 March 2009). "Metti il detersivo, chiudi il coperchio e rilassati" (http://www.vatican.va/news_services/or/or_quo/cultura/056q05a1.html). *L'Osservatore Romano* (in Italian). Retrieved 25 July 2011.
49. "Fridges And Washing Machines Liberated Women, Study Suggests" (http://www.sciencedaily.com/releases/2009/03/090312150735.htm). Sciencedaily.com. 2009-03-12. Retrieved 2012-06-01.
50. "Hans Rosling and the magic washing machine" (http://www.ted.com/talks/hans_rosling_and_the_magic_washing_machine.html). TED Conferences. December 2010. Retrieved 17 November 2011.
51. E McGaughey, 'Will Robots Automate Your Job Away? Full Employment, Basic Income, and Economic Democracy' (2018) SSRN, part 3(4) (https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3044448)
52. Finnegan, Frances (2004). *Do Penance or Perish: Magdalen Asylums in Ireland*. Oxford University Press.
53. "As mulheres sufocam os homens". Revista Veja, issue 2,363, 5 March 2014 (in Portuguese). "Archived copy" (http://veja.abril.com.br/acervodigital/home.aspx). Archived (https://web.archive.org/web/20160402113729/http://veja.abril.com.br/acervodigital/home.aspx) from the original on 2016-04-02. Retrieved 2014-04-03..
54. Rebecca Bundhun. "Dhobi tradition far from washed up" (http://www.thenational.ae/business/industry-insights/economics/dhobi-tradition-far-from-washed-up). *thenational.ae*. Retrieved 19 January 2015.
55. Photos (19 January 2015). "Indian laundry men spin out decades-old tradition" (http://photoblog.nbcnews.com/_news/2012/12/20/16053402-indian-laundry-men-spin-out-decades-old-tradition?lite). *NBC News*. Retrieved 19 January 2015.
56. "Are new washing machines only built to last 5 years?" (http://www.washerhelp.co.uk/buying-advice2.html). Washerhelp.co.uk. Retrieved 2012-06-01.
57. "Alliance website" (http://www.alliancelaundry.com). Retrieved 2013-11-05.

58. "Archived copy" (http://www.arthurmartin.fr). Archived (https://web.archive.org/web/20081111113120/http://www.arthurmartin.fr/) from the original on 2008-11-11. Retrieved 2012-07-04.

References

- E McGaughey, 'Will Robots Automate Your Job Away? Full Employment, Basic Income, and Economic Democracy' (2018) SSRN, part 3(4) on washing machines

External links

- Preservation and also exhibition of vintage washing machines
- Washing Machines at the Canada Science and Technology Museum
- How Washing Machines Work Article by HowStuffWorks.com
- Washing Machine Museum

Washing machine using fuzzy logic

1. Introduction

Fuzzy logic is a concept which helps computers in making decisions in a way which resembles human behaviors. It helps industry in increasing productivity, creates the opportunity to make production more convenient and most importantly it helps industries in economical terms.

The concept of fuzzy logic was first proposed by Professor Lotfi A. Zadeh in 1965. It was presented in one of his research papers under the name Fuzzy logic or Fuzzy sets [1, 2].

The first fuzzy logic based control experiment was conducted by Mamdani [3] in 1974 who designed the fuzzy logic for a steam engine. With his experiment, Mamdani showed how easy it is for a computer to process linguistic statements which was proposed by Zadeh.

After 1980 the use of fuzzy logic based control system becomes common in vacuum cleaners, washing machines, elevators, metro and company operations. Advancements in engineering in recent years have allowed fuzzy logic to be used in many fields [4].

Nowadays fuzzy logic has found its application in several fields like electronic control systems, automotive industries, breaking systems and home electronics etc.

Everyday many home appliances are being upgraded using fuzzy logic to save time and to conserve electricity [5].

Many necessary home appliances like washing machines, dish washers; vacuum cleaners etc. are based on fuzzy logic nowadays. Tiryaki and Kazan's dish washer using fuzzy logic and Alhanjouri and Alhaddad's optimize wash time of washing machine using fuzzy logic are one of few studies which are based on fuzzy logic [5,6].

Alhanjouri and Alhaddad's washing machine takes dirt type and degree of dirtiness as inputs while wash time is the only output of the system [6].

Agarwal controlling the washing time using fuzzy logic control. Type of dirt, dirtness of clothes were selected as input [7].

Also aim to reduce wasting of electric and water. The washing machine fuzzy controller neural network is researched deeply, which is based on fuzzy logic, neural network and its learning algorithm [8-9].

Kumar and Haider aim to reduce washing time. Quantity and dirtiness were selected as input [10].

The device which is being presented in this study has 4 different inputs depending on which 5 different outputs are being controlled by using fuzzy logic.

In contrast to the previous studies, the washing machine discussed in this paper has more inputs and outputs for example depending on the sensitivity and the quantity of cloths, washing machine will automatically adjust its washing speed, amount of detergent, hotness of water and water level. It will help us in conserving water and detergent while washing our cloths.

In this paper, fuzzy logic control for a very common household, i.e. washing machine, has been developed. The modeling of washing machine has been based on the parameters regarding washing of cloths.

2. Fuzzy Logic

In crisp logic, classifications are definite, i.e. a member is either a part of group or not. It can't be both. In short, crisp logic has two values 0 and 1. In contrast, fuzzy logic can work in complex conditions similar to humans.

If we consider solving a problem regarding human age by using both the crisp and fuzzy logic we can understand the difference between them. Figure 1 shows crisp logic while fuzzy logic can be seen in figure 2.

According to figure 1, people in between 0-30 years will be considered young; 30-50 years old will be considered middle aged and above 50 will be considered old.

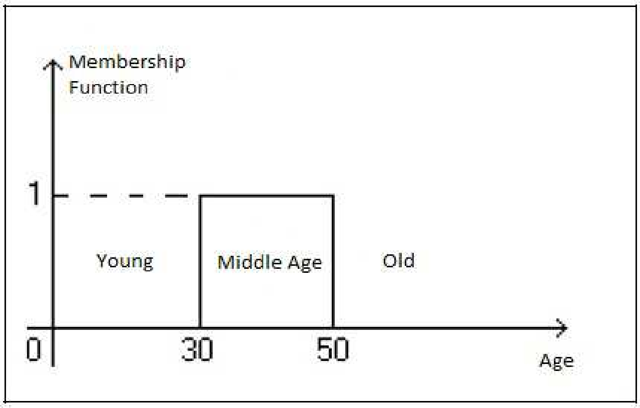


Figure 1. *Crisp Logic [11]*

According to those laws, a 31 years old person will be considered middle age while a 29 years old will be considered young.

If we examine this condition using fuzzy logic then a 30 years old person, in an appropriate proportion, will be considered both young and middle age (figure 2). Unlike Crisp logic, Fuzzy logic doesn't have only 0 and 1. It is more flexible thus a more realistic approach can be applied [12].

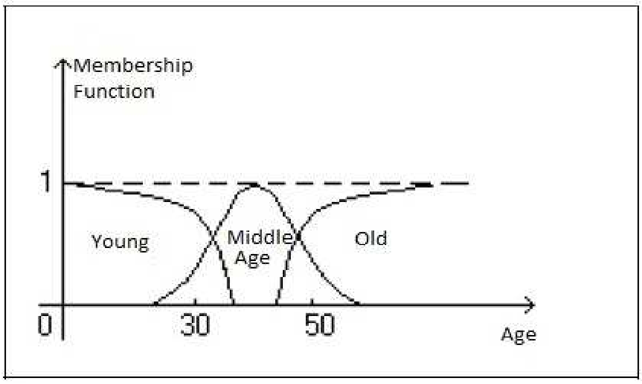


Figure 2. *Fuzzy Logic [11]*

2.1. Fuzzy Logic System Structure

The basic elements of fuzzy logic; Fuzzy inputs, outputs, rules and defuzzification; are shown in figure 3. [13-14]

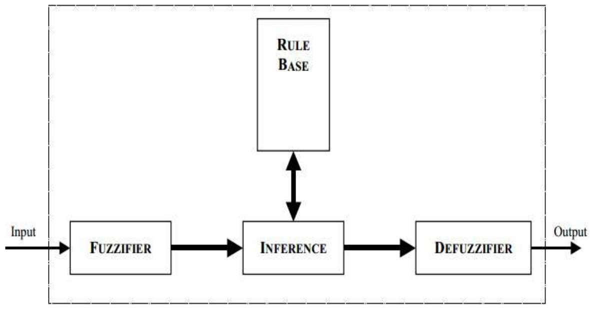


Figure 3. *Structure of a fuzzy logic system [12, 13]*

Fuzzy take the information from a system; which is in normal language; and converts it to values. The values of input quantities, which are associated with of membership functions, are given in form of words such as small, smallest [2].

Input and output variables of fuzzy system are determined and their values i.e. less, much, hot and cold etc. are being selected. Afterwards, rules are being developed and by using those rules input and output relationship is developed.

Outputs are being produced by using fuzzified inputs and rules which are being determined. Those fuzzified outputs must be converted to real values so that they can be used in real systems. This whole process is known is defuzzification. [13].

3. Fuzzy Logic Modeling of Washing Machine

To model a system using fuzzy logic, the first step is to determine the inputs and outputs of it. A washing machine's most important duty is to clean the cloths without damaging them. In order to achieve it, the output parameters of fuzzy logic, which are related to washing, must be paid importance. Inputs and outputs of fuzzy logic system are shown in figure 4.

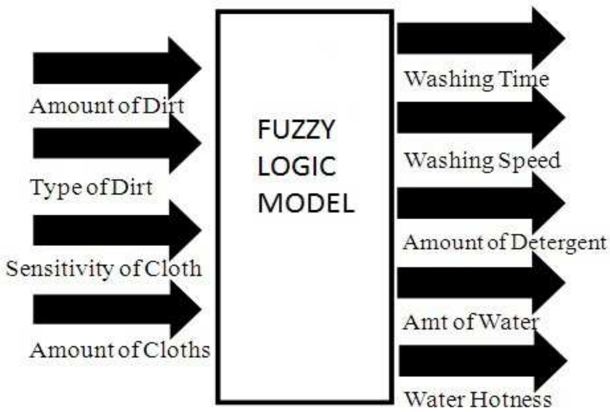


Figure 4. *Inputs and Outputs of the System*

Using fuzzy logic, input parameters such as Amount of dirt, type of dirt, sensitivity of cloth and amount of cloths, will help washing machine to achieve economical wash.

The input and output parameter's membership function values, names, upper and lower limits are being set based on a given problem. The membership functions, with upper and lower limits, of input and output parameter's are shown in figure 5 and 6 respectively. Figure 5 and figure 6 show membership functions of input and output respectively and also their upper and lower limits.

After determining the membership functions and their upper and lower limits required for the modeling of necessary parameters, a total of 81 rules have been established to define relationship among those parameters.

In order to apply fuzzy logic to washing, it is necessary to establish fuzzy logic rules. These rules can be seen in Table 1.

Input Parameters:

1. Amount of Dirt
2. Type of Dirt
3. Sensitivity of Cloth
4. Amount of Cloths

Output Parameters:

1. Washing Time
2. Washing Speed
3. Amount of Detergent
4. Amount of Water
5. Water Hotness

Table 1. *Fuzzy Logic Rule Table*

	INPUTS				OUTPUTS				
	1	2	3	4	1	2	3	4	5
1	S	NG	LS	S	S	LW	LT	LT	LW
2	S	G	LS	L	LG	M	MN	MN	H
3	S	NG	NS	M	M	M	LT	LT	LW
4	M	M	NS	M	M	M	N	N	N
5	M	M	LS	S	S	M	N	N	N
6	M	M	LS	L	LG	H	MN	MN	N
7	M	M	VS	M	S	M	N	N	N
8	L	G	VS	L	VL	VH	MN	MN	H
9	L	G	LS	M	LG	H	MN	MN	H
10	L	NG	NS	L	VL	H	N	N	LW

S = Small, M = Medium, L = Large, NG = Not Greasy, G = Greasy, LS = Less Sensitive, NS = Normal Sensitive, VS = Very Sensitive, S = Short, LG = Long, VL = Very Long, LW = Low, H = High, VH = Very High, LT = Little, N = Normal, MN = Many.

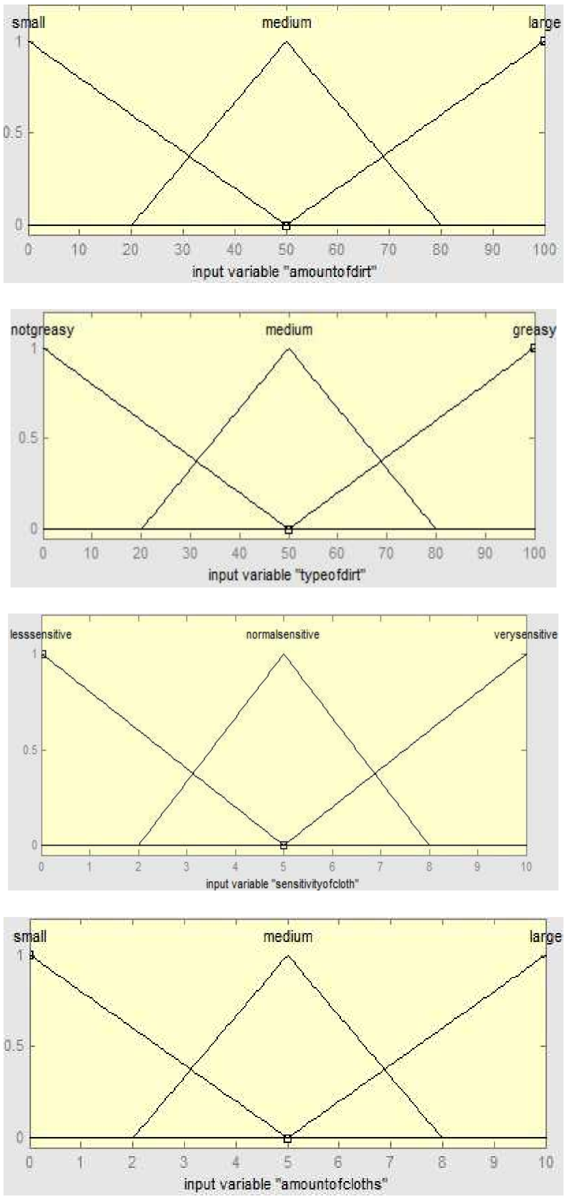
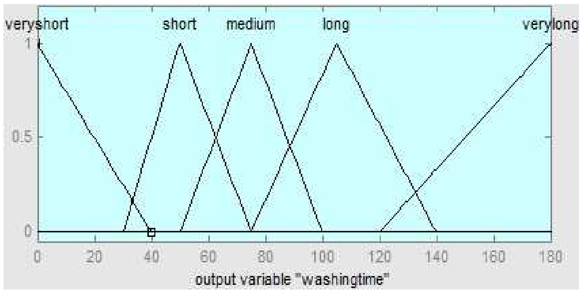


Figure 5. *Fuzzy logic input membership functions*



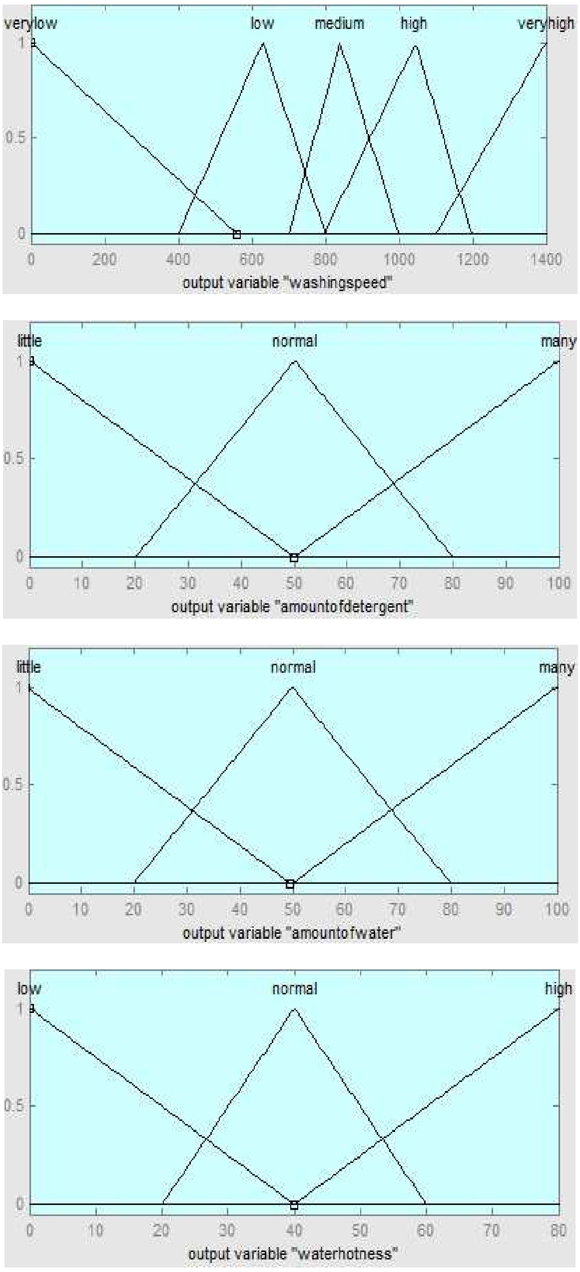


Figure 6. *Fuzzy logic output membership functions*

Fuzzy rules have been established for the modeling of washing machine. The whole system has been developed by using MATLAB's fuzzy logic toolbox.

The results of those rules, which have been determined by applying Min-Max operator, are illustrated in the form of 3D graphs in figure 7, 8, 9, 10, 11, 12. These figures show the relationship between input and output parameters.

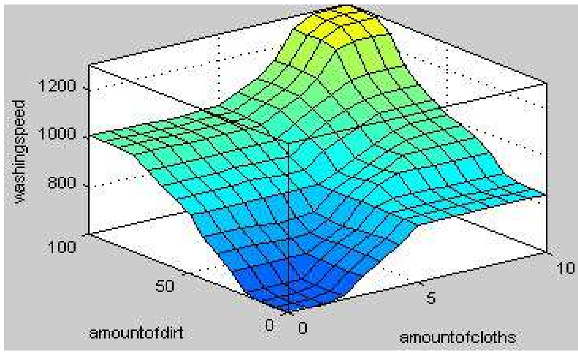


Figure 7. *Amount of cloths and amount of dirt affects the washing speed*

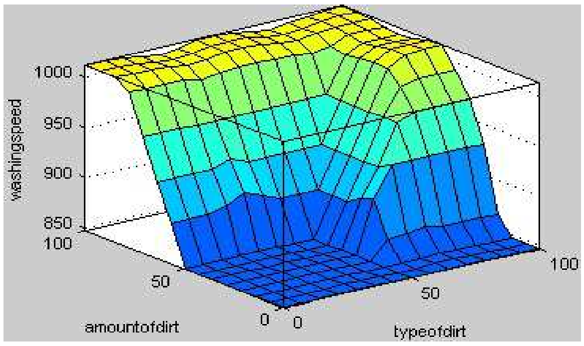


Figure 8. *Type of dirt and amount of dirt affects the washing speed*

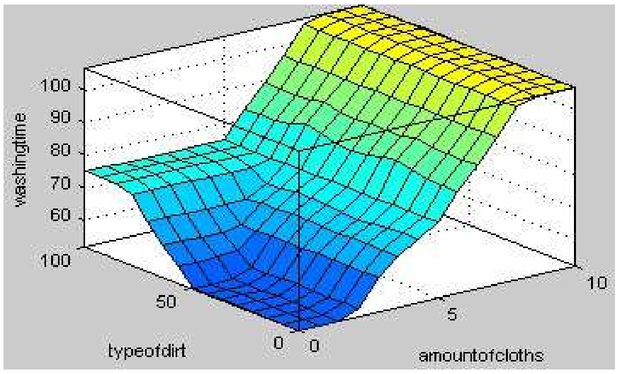


Figure 9. *Amount of cloths and type of dirt affects the washing time*

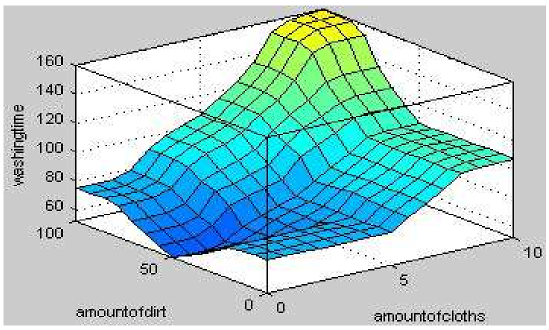


Figure 10. *Amount of dirt and amount of cloths affects the washing time*

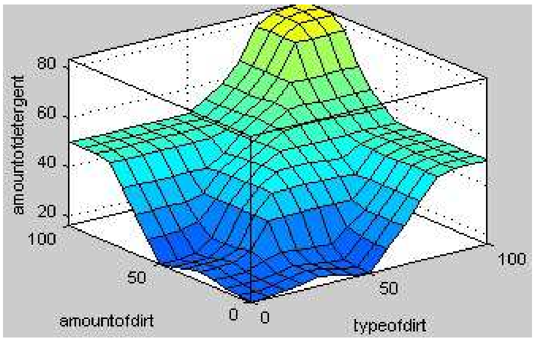


Figure 11. *Type of dirt and amount of dirt affects the amount of detergent*

As can be seen in figure 7, washing speed isn't affected much by the amount of cloths. Amount of dirt and sensitivity of cloth are the most important factors which regulate the washing speed.

Figure 9 shows that washing time is directly proportional to the amount of cloths.

Figure 12 tells us that water hotness is very much affected by the type of dirt present in the cloths.

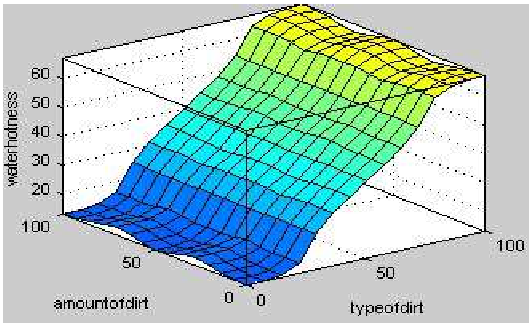


Figure 12. *Type of dirt and amount of dirt affects the water hotness*

Table 2. *Fuzzy logic outputs in response to the inputs*

INPUTS				OUTPUTS				
Amount of Dirt	**Type of Dirt**	**Sensitivity of cloth**	**Amount of Cloths**	**Washing Time**	**Washing Speed**	**Amount of detergent**	**Amount of Water**	**Water Hotness**
%50	%50	5	5	95 d	1000d/d	% 45,8	% 48,5	60 °C
%88.7	%82.2	1.8	7.67	140 d	1200d/d	% 60,5	% 60	70°C
%62	%66.4	3.67	6.2	128 d	1100d/d	% 52	% 55,8	65°C
%24.7	%20.4	7.27	3.27	60 d	700d/d	% 30,5	% 35	40°C
%11.3	%11.2	8.73	1.93	40 d	400d/d	% 20,5	% 30	30°C

Table 2 describes the variation in the output parameters, in response to the given inputs, of the washing machine.

4. Conclusion

In this paper, rule based fuzzy logic for washing machine has been developed. It will help in achieving economical washing procedure by sensing amount of dirt, type of dirt, sensitivity of cloth and amount of cloths. Based on input parameters, i.e. amount of dirt, type of dirt, sensitivity of cloth and amount of cloths; washing speed, washing time, water hotness and amount of detergent will be regulated on the output. Due to this adjustment of output parameters, cloths will come out cleaner and it will also make the whole washing process economical by reducing the amount of water, detergent, electricity and time.

Results of this simulation based study are pretty good which is clearly shown in the graphs. When we compare the results we have gotten with the expected results, it shows that this model, which has been developed in this paper, is extremely useable.

MATLAB/Fuzzy logic toolbox has been used to materialize this study. It can be practically implemented by using necessary mechanical and electronics engineering concepts.

References

[1] Zadeh, L.A., "Fuzzy Sets", Information and Control,8,338-353, 1965.

[2] Elmas, C., "Bulanik Mantik Denetleyicileri", ISBN 975-347-613-2, 2003

[3] Mamdani, E.H., "Application of Fuzzy Algorithms for Control of Simple Dynamic Plant", Proc. IEEE, 121(12), 1585-1588, 1974.

[4] Şen Z., "Bulanık (Fuzzy) Mantık Ve Modelleme İlkeleri", Bilge Sanat Yapım Yayınevi, İstanbul, 2001.

[5] Tiryaki, A.E., Kazan, R., "Bulasik Makinesinin Bulanik Mantik ile Nodellenmesi", Muhendis ve Makina Dergisi, Cilt:48, Sayi:565, Sakarya.

[6] Alhanjouri, M. and A. Alhaddad, A., "Optimize Wash Time of Washing Machine Using Fuzzy Logic", Islamic University of Gaza.

[7] Agarwal, M. (2007). Fuzzy logic control of washing machines.URL:http://softcomputing.tripod.com/sample_ter mpater:pdf.

[8] Zhen. A. and Feng R. G., "The design of neural network fuzzy controller in washing machine," in Proc. 2012 International Conference on Computing, Measurement, Control and Sensor Network (CMCSN), Shanxi, China, 136-139, 2012.

[9] Virkhare N., Jasutkar R.W., Neuro-Fuzzy Controller Based Washing Machine, International Journal of Engineering Science Invention, 3(1), 48-51, 2014.

[10] Kumar D., Haider Y., Fuzzy Logic Based Control System for Washing Machines, International Journal of Computer Science and Technology, 4(2), 198-200, 2013.

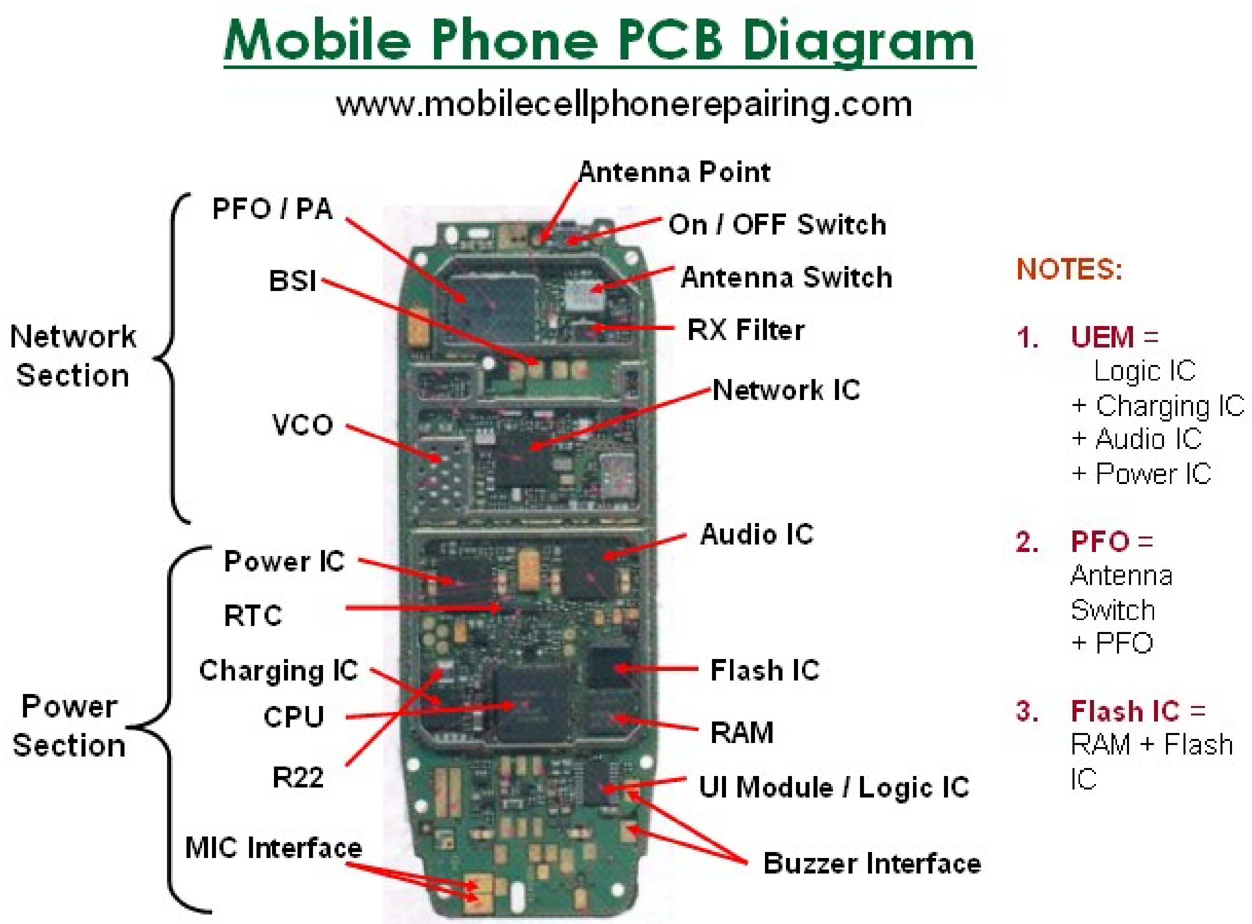
[11] Ozek, A., Sinecen, M., "Klima Sistem Kontrolunun Bulanik Mantik ile Modellenmesi", Pamukkale Universitesi Muhendislik Fak. Muhendislik Bilimleri Dergisi, 10(3), 353-358, 2004.

[12] Tuncer, S. 1999. "Değişken Hızlı Sürücü Sistemleri İçin Fuzzy Denetleyicili Yeni Bir Algoritmanın Geliştirilmesi ve Uygulaması" , F. Ü., Fen Bilimleri Enstitüsü, Yüksek Lisans Tezi.

[13] Dadone, P., "Design Optimization of Fuzzy Logic Systems", Doctor of Philosophy in Electrical Engineering, Virginia Polytechnic Institute and State University, 2001.

[14] Mendel, J.M., "Fuzzy Logic Systems for Engineering: A Tutorial", Proceedings of the IEEE, 83(3), 1995.

Mobile Phone Sections – A Mobile Phone PCB is Divided into 3 Main Sections – (1) Network Section; (2) Power Section; and (3) Audio Section (*in Android Smartphone and iPhone*). This is applicable to all Mobile Phones and Smartphones of All Brands including – Samsung, Nokia, LG, Motorola, Sony Ericsson, Acer, Alcatel, Apple, Amoi, Asus, BenQ, Siemens, Bird, Blackberry, Blu, Celkon, Dell, Gigabyte, Haier, HTC, Huawai, Micromax, Panasonic, Philips, Sagem, Spice, Toshiba, ZTE Etc.



As mentioned above, there a Mobile Phone or Smartphone PCB can be Broadly Divided into 3 Main Sections – ***Network Section, Power Section*** and ***Audio Section***. Now, these Broad Sections can again be Divided in Several Small Sections for Easy of Understanding. Let us Understand these All These Sections in Detail and Electronic Components and IC Parts Present in these Sections and Their Function.

1. Keyboard or Keypad Section

The keyboard section of any mobile cell phone is directly connected with the CPU. This means that rows and columns of keys are directly connected with the CPU. Protector IC or Interface IC or Varactor diode is connected in the row or column line for the protection of key section. In modern mobile cell phones which have qwerty keys, a separate control IC is connected with the CPU for extra protection to the keys. In Latest Android Smartphones and Apple iPhone, there is No Physical Keypad. The Keys are Displayed and Controlled by the Operating System (*OS*) and Apps. These Virtual Keys on the Display are Controlled by a Touch Screen Connected Separately to the PCB / Logic Board.

2. Display Section

The display section is directly connected with the CPU to receive following signals – LCD Data Signal, LCD Reset Signal, LCD WR Signal, LCD RD Signal, LCD FLM Signal, LCD HSYN Signal etc. These signals are given to the LCD Module through the CPU. 2.8V power supply or 1.8V power supply is given to the LCD for functioning. LCD signal interface filter are connected in many mobile cell phones for interfacing these signals of LCD Module.

3. SIM Card Section

The SIM Card Interface section is directly connected with the CPU in most mobile cell phones. If there is no power supply in a mobile phone then the SIM section is connected with the CPU through the Power IC. Mainly V-SIM (*3.0V*), SIM-RST (*2.85V*), SIM CLK, SIM-Data (*2.5V*), and SIM GND are made in the SIM Section. These four pins (*Beside SIM GND*) are directly connected with the SIM interface / control section and V-SIM volt are given to the SIM data pin from V-SIM pin through the 10-18 Kilo Ohms Resistance.

4. Memory Card Section

Now mostly Micro SD Card is connected in most mobile cell phones which is connected with micro card section through a 8 pin socket. Memory card section is made inside the CPU.

Description of these 8 pins are as follows:

1. MMC-Data-2
2. MMC Data
3. MMC CMD (*Command*)
4. VMMC / VSD (*Positive Supply Pin*)
5. MMC-CLK
6. GND
7. MMC-Dta0
8. MMC Data-1

2.8 Volt Power is supplied to Pin Number 4 from Power Supply for functioning of the MMC Card and connection the 50 tp 100 Kilo Ohms resistance in this power supply. This power supply is given to Pin Numbers – 1,2,3,7,8 of MMC Socket. One MMC detector switch or pin is made in MMC socket at which, if there is no MMC Card then 1.8 V power is continuously received and after the MMC is connected, it becomes zero.

5. MIC Interface Section

MIC interface section is directly connected with the CPU in most mobile phones. Working voltage (*MIC Bios*) (*1.8 to 2.8 V*) is supplied from the CPU or the Power Supply Section for functioning of the MIC and MIC Positive and Negative Volt are input through two SMD Capacitors.

6. Ear Speaker Section

In most modern mobile cell phones, in which there is a separate ear speaker, it is directly related to the CPU. It receives sound via signals directly from the CPU or from the audio section inbuilt within the CPU. In some mobile phones, these sound signals are received via SMD Coil / SMD Resistance. Some mobile phones have audio IC in the audio section. Some mobile phones have audio amplifier.

7. Speaker / Ringer Section

Ringer, Buzzer or Speaker in most mobile phones are connected with the audio amplifier IC to obtain loud sound. The amplifier IC amplifies the sound or audio signal received from the CPU of the audio section.

8. Key Backlight Section

LED Lights are connected according to the parallel circuit in the key backlight section. Anode ends of all the LEDs are connected to each other and all the cathode ends are connected to each other. 3 to 3.3 V is supplied for the functioning of these Key LED Lights. This power supply is given to the cathode ends of LEDs from the ground ends. Power supply to the anode ends of LED Lights is controlled bu using LED-Driver or PNR IC.

9. LCD Backlight Section

LCD Backlight in mobile cell phones is made according to the series circuit. A Boost Voltage Generator Section is built for the supply of high voltage (*10 to 18V*) for the functioning of the LCD LED. Boost coil, Boost Volt Driver IC, Rectifier Diode etc are present in this section.

10. Vibrator Motor Section

Positive power supply is given to this section directly from the positive end of the battery. Negative power supply is given through a NPN transistor or from the ground of any circuit.

11. Network Section

Antenna, External Antenna Socket, RX-Band Pass Filter, RF Crystal, FEM, PFO, TX-Band Pass Filter, RF IC, CPU are connected in the Network Section. Signal received at the antenna during the RX is given to the antenna switch or FEM through the antenna socket where the next processing is completed by selecting a frequency of proper band and is passed on to the RF IC through RX-Band Pass Filter. RF Signal out from the RF IC during TX is given to the FEM or PFO to amplify the signal. After the Band Selection Process the signal is passed through the antenna.

12. Battery Charging Section

Charger and system interface connector is made together in most modern mobile cell phones. Regulator section is made separately for the battery charging section. In some mobile phones, the battery charging section is made inside the Power IC.

13. FM Radio Section

FM Radio Driver IC, FM Antenna, Signal and Supply Components are made in the FM Radio Section.

14. Bluetooth Section

Bluetooth Antenna, Bluetooth RF Signal Filter, Bluetooth Driver IC, Supply and Signal Components are made in this section. The Bluetooth sections functions like the Network Section. RF-CLK signal is given to the Bluetooth driver IC during signal processing.

15. Set Power ON

Power IC, CPU (UCP), Flash IC, RF-CLK, Crystal, RF-IF, PWR Ket etc components are present this section. Battery positive supply is given to the power IC and connecting the battery (3.7V) from 2.87 to 3.0 Power ON Volts are received at one tip of the Power Key. Supply is given to the CPU, Flash IC, RF-CLK, Generator Section (RF Crystal, RF IC) by which the mobile phone gets switched ON.

16. Hands-free / Earphone Section

Mainly hands free jack, hands free MIC, speaker signal component and hands free audio amplifier are present in this section. Hands free symbol is displayed after connection the Handsfree jack.

SOCIALIGHT

An Introduction To Mobile Technologies and Services

by Michael Sharon, Co-founder / CTO, Socialight

Overview

1. **What does “mobile” mean?**
   - Components
   - Typical device features
2. **The state of the industry**
   - Operators, Devices, Openness, Ease of development
3. **Mobile development options**
   - Types of devices
   - OSes, languages, platforms
   - Applications

1. What does **“mobile”** mean?

Mobile

From the Latin *mobilis - “to move”*

“able to move freely or easily”

“able or willing to move freely or easily between occupations, places of residence and social classes”

Device, state of being, industry

Mobile device

Mobile, *wireless or cellular* phone - a portable, handheld communications device connected to a wireless network that allows users to make voice calls, send text messages and run applications.

AKA *keitai*, personal handy phone

WARNING: Jargon & Acronym laden

Multimedia
Computer

NOKIA
Connecting People

Reinvented
Phone

Many devices. Many manufacturers.
Many formats.


NOKIA
NOKIA
SAMSUNG
NOKIA
NOKIA

Motorola

RIM

Samsung

Kyocera

Palm

Nokia

BenQ

Fujitsu

Mobile device manufacturers

Sanyo

Sharp

LG

SonyEricsson

Apple

	Feature phones	Smart phones	PDAs/ handheld
Price	$	$$	$$$
OS	Proprietary, Series40	S60, Windows Mobile, Linux	PalmOS, PocketPC
Applications	Java or BREW	Any	Any
			

Mobile development ecosystem

Publishing

Certification

Air interface

Mobile operator

Data bearer

Mobile UI

Deployment

Mobile OS

Packaging

Platform

Language

why mobile?

- one handed use
- limited (input, processing, battery life)
- rich (sensors, usage)
- small!
- truly ubiquitous

Mobile phone capabilities

Bluetooth WAP

WiFi

GPS

TDMA PTT GPRS EDGE

GSM CDMA UMTS W-CDMA

ringtones NFC

monochrome colour RFID

voice text graphics images WiMax

speaker cameras

microphone

1990 2000 2007

Mobile evolution (briefly)

G - 1/2/3/4 G

G refers to the different generations of mobile devices.

First generation (**1G**) cellphones were analog devices. Second generation (**2G**) devices were digital, and third generation (**3G**) allows for voice, data and advanced services.

0G

1946-1980’s

Early mobile phones

- Expensive
- In cars/trucks/briefcases
- Voice only

1G

1980's-now

- First generation cellular networks
- Radio signals = analog
- Technologies - AMPS / DataTac
- First Blackberry (850)
- Voice + Limited data

2G

1990's-now

- Second generation cellular networks
- Digital. Voice + SMS + Circuit switched data
- GSM, iDEN, CDMA, TDMA

2.5G

1990's-now

- Marketing term
- GPRS, HSCSD, WiDEN
- Also EDGE, CDMA2000 1x-RTT

GSM

Global System for Mobile Communications

GSM is the most popular standard for mobile phones worldwide used by 2.2 billion people on over 210 networks.*

US Operators = T-Mobile, Cingular

* according to this http://en.wikipedia.org/wiki/GSM

GPRS

General Packet Radio Services

A mobile data service for use on GSM networks.

Part of the 2.5G standards family

iDEN

Integrated Digital Enhanced Network

A second generation (2G) mobile telecommunications standard developed entirely by Motorola.

US Operators = Sprint-Nextel / Boost

CDMA

Code Division Multiple Access

A second generation (2G) standard for mobile phones.

US Operators = Sprint, Verizon

3G
2004-now

- Third generation cellular networks
- Broadband data + voice, streaming video!
- W-CDMA (UMTS, FOMA), 1xEV-DO

4G
the future!

- “high-speed broadband for data- and visual- centric information”
- Transmits data at 100mbps while moving and 1Gbs while standing still

some refreshing statistics

- **3.2m** Blackberries
- **50m** PDAs
- **70m** iPods
- **190m** Gameboys
- **820m** PCs
- **1.5bn** TV sets
- **2bn+** Mobile phones*

Source: Charlie Schick's blog - http://cognections.typepad.com/lifeblog/2006/08/eh_kinda_quiet_.html

2. The State of the Industry

Operators in the US

Service	Cingular	Verizon	Sprint	T-Mobile
Subscribers	61m	59.1m	53.1m	25m
Technology	GSM	CDMA	CDMA/ iDEN	GSM
Platform	J2ME	BREW	J2ME	J2ME
Openness	Open	Semi-Walled	Open	Semi-Walled
Network	2.5G/3G	2.5G/3G	2.5G/3G	2.5G/3G
Location	TDOA (no access)	A-GPS	A-GPS	TDOA (no access)

Sprint (Nextel + Boost), T-Mobile & Cingular* support J2ME

* 3 out of the 4 largest carriers
(but who's counting anyway?)

3. Mobile Development Options

Mobile Development in 2007
is kinda like the web in 1997

Anybody remember <blink> ? <marquee>?

This is worse

1997	2007
Netscape vs Microsoft	Symbian vs Flash Lite vs Java ME vs Python vs BREW vs .NET vs WAP vs Palm
Proprietary features vs standards <blink> vs <marquee>	Platform features / standards OEM APIs (Java)
Free environment	$$ environment (contracts)
Free development tools	Mostly free development tools (except for BREW)
Clear development / deployment process	Convoluted development & painful deployment process

Java ME / J2ME

Java ME (formerly known as Java 2 Platform, Micro Edition or J2ME), is a **collection** of Java APIs for developing software on resource constrained devices such as PDAs, cell phones and other consumer appliances.

Flash Lite

Flash Lite is a development platform created by Macromedia, based on their hugely successful Flash web application platform.

v1.1 - most widely deployed, limited

v2.x - improved experience, language

Symbian

Operating system based on original PDAs from Psion. Largest installed base. Multiple versions customized for different manufacturers. Language = C++

UIQ - SonyEricsson
Series 60 - Nokia
MOAP - NTT Docomo FOMA

Python for Series 60

Open source scripting language ported by Nokia

Only on Series 60 smartphones

Python wrappers around low-level APIs, easy access to native OS features

BREW

Binary **R**untime **E**nvironment **W**ireless

Proprietary mobile device platform developed by Qualcomm.Development language is C with C++ interfaces. Certification and development process is expensive.

WAP

Wireless **A**pplication **P**rotocol

Originally used to describe lightweight protocol which used **W**ireless **M**arkup **L**anguage (WML).

Currently used to refer to Mobile Web, which uses XHTML MP/Basic + CSS.

Platform	Overview
Java ME	Second best reach, best overall development
Flash Lite	Good for graphics-heavy applications in supported markets
Symbian	Strong support from Nokia, best access to hardware
.NET	PocketPC + Windows Mobile Devices
BREW	The only option for CDMA networks
Python	Great for quick prototypes, still immature
WAP	Largest overall reach, lightweight functionality

sources: http://www.biskero.org/?p=430, http://alindh.iki.fi/2006/06/27/mobile-platform-statistics/, http://en.wikipedia.org/wiki/Mobile_development

Platform	Language	X-Platform	Learning Curve	Emulator	Availability
Java ME	Java	Average	Average	Free	~1.5bn
Flash Lite	AS	Excellent	Average	With IDE	77-115m
Symbian	C++	Average	STEEP!	Free	120m
.NET	C#, C++, VB.NET	WM	STEEP!	IDE	4.5m
BREW	C++	CDMA only	STEEP!	Simulator	????
Python	Python	FREE	Gentle	Add-on	Nokia-only
WAP / Mobile Web	XHTML, WML	FREE	Gentle	Free	2bn+

sources: http://www.biskero.org/?p=430, http://alindh.iki.fi/2006/06/27/mobile-platform-statistics/, http://en.wikipedia.org/wiki/Mobile_development

Platform	GUI	Functionality	Phone Data Access	Developer Community
Java ME	2D/3D, Many widgets, Visual Form Builder	Varies by handset, no CellID, high res pics	Varies by handset, Optional APIs	Extensive
Flash Lite	2D/3D, Many widgets, Visual IDE	Partial through API	None	Extensive
Symbian	2D/3D, Many widgets, Visual Form Builder	No restriction	Simulator	Extensive
.NET	2D/3D, Many widgets, Visual Form Builder	Limited audio	Full	MSDN
BREW	2D/3D, Many widgets, uiOne	Operator dependent	Full	Limited
Python	2D Graphics, some widgets	Partial through API	Partial	Small, but growing
WAP / Mobile Web	Basic forms. Inconsistencies	Limited to browser	None	Extensive

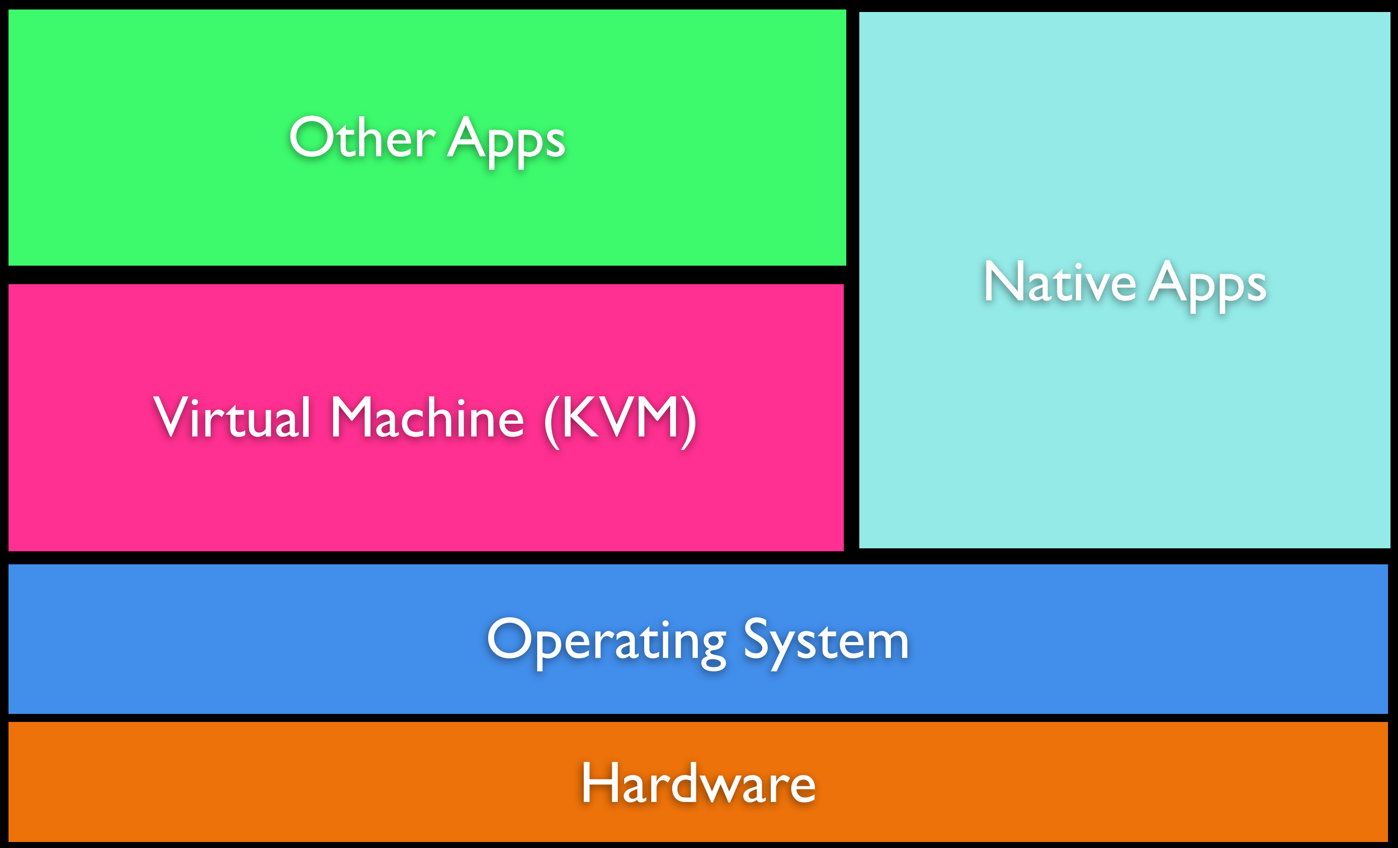
sources: http://www.biskero.org/?p=430, http://alindh.iki.fi/2006/06/27/mobile-platform-statistics/, http://en.wikipedia.org/wiki/Mobile_development

Java ME (J2ME)

Java Sources

- Java Community Process - http://jcp.org
  - JSR specification requests
  - reference implementations
- Sun - http://java.sun.com
  - SDK, tools, community
- Manufacturer
  - SDKs, community, device emulators

Java VM


Other Apps
Native Apps
Virtual Machine (KVM)
Operating System
Hardware

A typical Java ME stack

1. Configurations

- specifies minimum Java technology that we can expect for certain devices
- Includes language, virtual machine features, core libraries

2. Profiles

- layer defining APIs and specifications for a particular device or market - MIDP, FP
- MIDlets

3. Optional Packages

- includes additional functionality only supported by certain devices - e.g. Bluetooth API, Location API

1. Configurations: CLDC

Connected Limited Device Configuration

- specifies environment for mobile phone, pagers
- 160-512k of memory for Java
- limited power / batteries
- intermittent, low-bandwidth connectivity

CLDC 1.0
- May 2000, JSR 30
- java.lang

CLDC 1.1
- Dec 2002, JSR 139
- adds floating point support
- bug fixes

2. Profiles: MIDP

Mobile Information Device Profile

MIDP 1.0

- December 2000, JSR 37
- java.microedition.midlet
- java.microedition.rms
- java.microedition.lcdui
- java.microedition.io.HttpConnection

MIDP 2.0

- Nov 2002, JSR 118
- java.microedition.media
- java.microedition.lcdui.game

MIDP 3.0

- Q3 2006? No! Sometime 2007...

3. Optional Packages

Bluetooth API (JSR 82)
- communication with Bluetooth devices

Wireless Messaging API (JSR 120, JSR 205)
- SMS, MMS, multi-part messages

Mobile Media API (JSR 135)
- audio, video and multimedia

Location API (JSR 179)
- interface to location services

MIDP 3.0

AKA “The Future”

- **Background MIDlets (remember TSRs?)**
- **Drawing to secondary displays**
- **Improved large screen support**
- **Auto-start MIDlets**
- **And much more... to forget about for the moment**

MIDlets

MIDlets are like Java applets for mobile devices.

Has a lifecycle with four stages, created, started, paused, destroyed.

Applications

Games
Pang
The Sims2

Mapping
Google Maps
mGmaps
uLocate

Photos
Mobup
Shozu
Zonetag

Web
Opera Mini
GCalSync

Mapping
Wayfinder

Art
Balldroppings

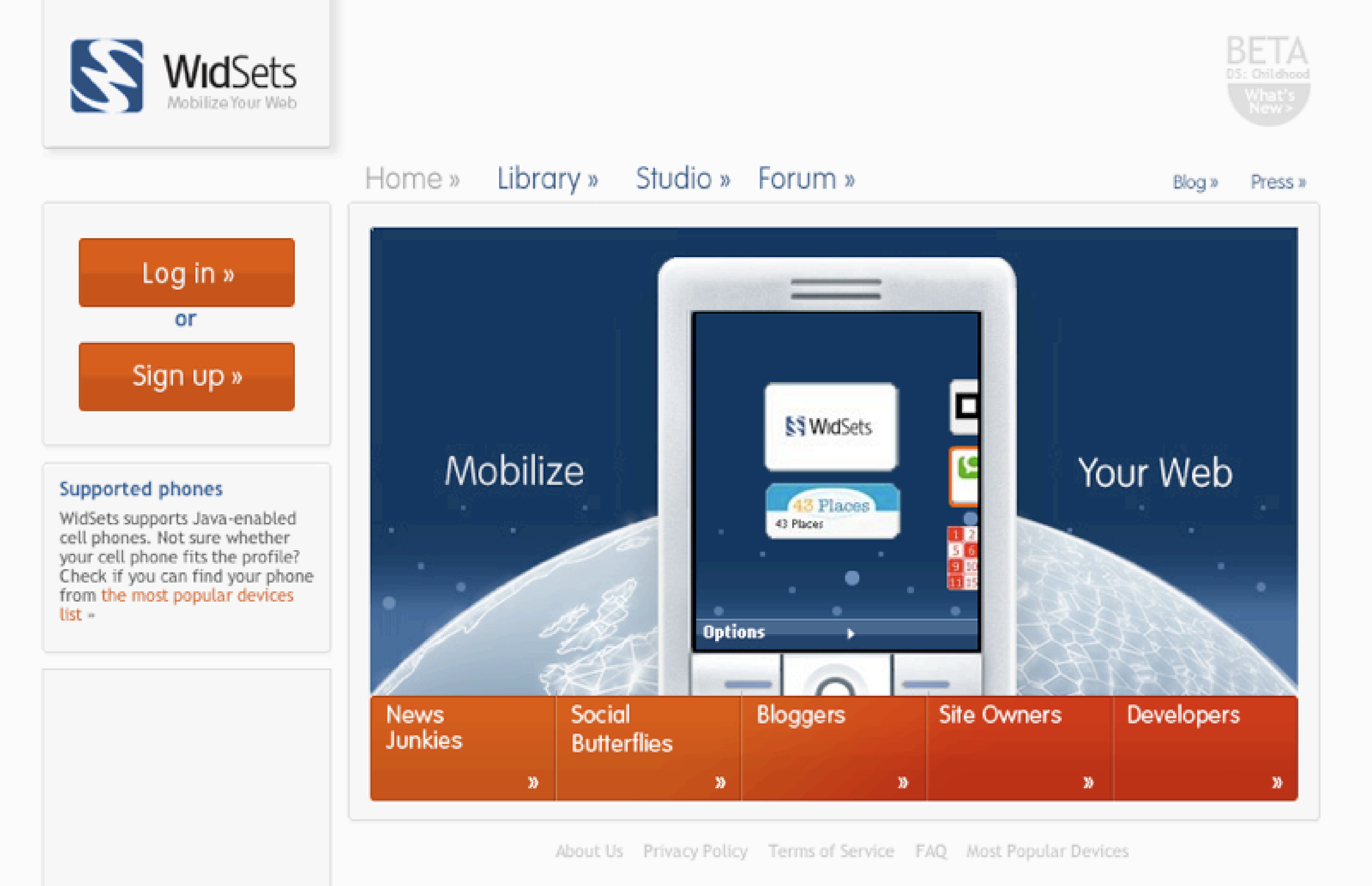
Social
BEDD
Flirtomatic
Loopt

RSS
Widsets
MobileGlu

Hybrids
MogiMogi
Socialight
Yahoo Go!

http://www.mogimogi.com/

http://www.wayfinder.com/



http://www.wayfinder.com/

GCALSYNC

SYNCHRONIZE YOUR PHONE WITH GOOGLE CALENDAR

Carry your Google Calendar in your pocket! GCalSync is an open source application that lets you do a two-way synchronization between Google Calendar and your phone's built-in calendar. Download events to your phone, or add an event on your phone and upload it to Google Calendar.

To install, visit http://wap.gcalsync.com with your phone's browser

You can also download the files here if you prefer to install via USB, Bluetooth or infrared (see your phone's manual for how to do this).

gcalsync.jad gcalsync.jar signed version - for most phones

gcalsync.jad gcalsync.jar unsigned version - try this if your phone will not let you install the signed version

gcalsync.jad gcalsync.cod for Blackberry

NEW: Version 1.1.1 released, a bug fix to the first version after I open sourced GCalSync. Source code is available on SourceForge. New in version 1.1:

- Time zone options: you can specify an offest if you have problems with events being a couple of hours off.
- Download/upload options: choose if you want to just download events from GCal, just upload evnets from the phone, or both.

Known problems:

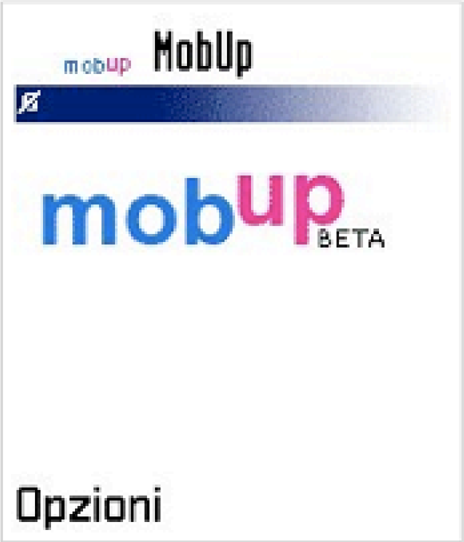
- Changes and deleteions on the phone are not uploaded. I am getting error messages from GCal when I do this so it is disabled for now.

http://www.gcalsync.com

mobup beta

http://www.mobup.org

Installing Mobup | Supported devices | Licensing | Version history | Developers | Blog



Flickr from your mobile device built using the Flickr APIs. Once installed it gives you the possibility to shoot your photo and add **title, tags** and **description**, manage **sets** and groups from the same applications with optimal user experience and to **post the shooted photo on your blog.**

Mobup is being developed as by the CT|DND **team and a bunch of** other programmers;
Mobup is actually in public beta: thanks to the group of volunteers that
daily apply for testing (if you want to be included just send us an email
specifying your Java phone model).

Download mobup for FREE

Download source code

Mobup **source code is now available for free** under GNU General Public License and is **hosted on Sourceforge**, the world's largest Open Source software development web site. (Visit developer section for more infos)

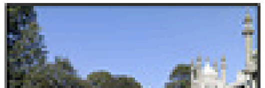
Installing Mobup

Mobup activation on Flickr

1. Go to the activation page
   1. If necessary log in
   2. Click *OK, I'LL ALLOW IT*
   3. Write down the 9 numbers code xxx-xxx-xxx (Token) .
2. End of this procedure

Mobup phone configuration

Latest Mobupped shots



Python for Series 60

What is Python?

- **Created 1990 by Guido van Rossum**
- **Interpreted, object oriented programming language**
- **Very powerful language + terse syntax.**
- **Modules, classes, exceptions, dynamic typing**

Java	Python
statically typed *String blah = “”;*	dynamically (“duck”) typed *blah = “string”* *blah = 1*
verbose	concise

`public class HelloWorld`
`{`
`   public static void main (String[] args)`
`   {`
`      System.out.println("Hello, world!");`
`   }`
`}`
	print “Hello World”

Java ME	Python S60
freshly open source	open source
broad manufacturer support	Symbian Series60
complex, multiple APIs (High Level, Low Level), confusing exception model, runs in sandbox	extremely terse. no checked exceptions. uses Python standard library. simpler APIs, C++ wrapper

Capabilities of PyS60

- GUI: Menu, Forms, Listboxes, Input fields, Dialogs, Notes
- Graphics: - color, font and style attributes, - direct-screen drawing, - displaying images and icons
- Key-down and key-up events
- Sockets: **TCP/IP, Bluetooth** (RFCOMM, OBEX)
- Messaging (**SMS**) + accessing the Inbox
- Networking (**HTTP**, **FTP**, …)
- Access to file system, file reading, XML, RSS
- Access to camera, telephone
- Access to calendar, contacts, sysinfo
- Location (cell-id)
- Content handler (download + open videos..)
- Python extensions can be written in C++
- Package scripts into standalone applications - (using SIS files)

WAP

The birth of WAP

- The end of the 1990's:
- Data service bearers available: CSD (circuit switched data/dialup)/CDPD
- Date connnection speeds: CSD=9.6kbs/ CDPD=14.4kbs
- Light weight protocol needed to transfer data.

1G

1980's-now

- First generation cellular networks
- Radio signals = analog
- Technologies - AMPS / DataTac
- First Blackberry (850)
- Voice + Limited data

Enter, WAP

- Enter, WAP, a light weight protocol stage left.
- Good for data speed at that time
- WAP = Wireless Application Protocol
- Like HTTP with extra bits stripped out
- WAP Gateway (GW) handles translation
- Limited markup language resulted in
  - HDML - Handheld Device Markup Language
  - WML (established by the WAP Forum)

2G

1990's-now

- Second generation cellular networks
- Digital. Voice + SMS + Circuit switched data
- GSM, iDEN, CDMA, TDMA

2.5G

1990's-now

- Marketing term
- GPRS, HSCSD, WiDEN
- Also EDGE, CDMA2000 1x-RTT

WAP 2.0 (circa 2002)

- Data service bearers available: GPRS (54kbs)
- Development of 3G networks leads to enhancement of languges
- WAP 2.0 and XHTML-MP released by the WAP forum.
- Smarter phones + faster data (3G).
- WAP GW resembles typical Proxy Server
- WAP GW is largely for legacy device support (WAP 1.1 devices)

3G

2004-now

- Third generation cellular networks
- Broadband data + voice, streaming video!
- W-CDMA (UMTS, FOMA), 1xEV-DO

4G

the future!

- “high-speed broadband for data- and visual- centric information”
- Transmits data at 100mbps while moving and 1Gbs while standing still

WML vs XHTML

	WML 1.x	XHTML-MP
Standards Body	WAP Forum (defunct)	W3C + OMA
Content displaying	Content + layout in same document. Tailored separately for different devices.	Content + layout separate. Can be rendered separately.
Content Encoding	Binary	No encoding required
Document Layout control	Basic	Advanced layout with CSS
Colour control Support	Only colour images, no colour control for fonts, backgrounds, borders etc.	Full support with CSS, fonts, backgrounds, borders
Data bearer	WAP	Wireless profile - TCP/IP

Java	WAP
Complex syntax, powerful language	Simple syntax, not so powerful
Download apps	Use built in browser (no download necessary)

public class HelloWorld
{
public static void main (String[] args)
{
System.out.println("Hello, world!");
}
}
	Hello, WAP

Mobile application development can be challenging.

Start small, keep it simple, add constraints

Choose your platform wisely

Thanks!

SOCIALIGHT

Questions? Comments? Suggestions?

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WIKIPEDIA

Fax

A fax machine from the late 1990s

Fax (short for **facsimile**), sometimes called **telecopying** or **telefax** (the latter short for **telefacsimile**), is the telephonic transmission of scanned printed material (both text and images), normally to a telephone number connected to a printer or other output device. The original document is scanned with a **fax machine** (or a **telecopier**), which processes the contents (text or images) as a single fixed graphic image, converting it into a bitmap, and then transmitting it through the telephone system in the form of audio-frequency tones. The receiving fax machine interprets the tones and reconstructs the image, printing a paper copy.[1] Early systems used direct conversions of image darkness to audio tone in a continuous or analog manner. Since the 1980s, most machines modulate the transmitted audio frequencies using a digital representation of the page which is compressed to quickly transmit areas which are all-white or all-black.

Contents

History

Wire transmission

Scottish inventor Alexander Bain worked on chemical mechanical fax type devices and in 1846 was able to reproduce graphic signs in laboratory experiments. He received British patent 9745 on May 27, 1843 for his "Electric Printing Telegraph."[2] Frederick Bakewell made several improvements on Bain's design and demonstrated a telefax machine. The Pantelegraph was invented by the Italian physicist Giovanni Caselli. He introduced the first commercial telefax service between Paris and Lyon in 1865, some 11 years before the invention of the telephone.[3][4]

In 1880, English inventor Shelford Bidwell constructed the *scanning phototelegraph* that was the first telefax machine to scan any two-dimensional original, not requiring manual plotting or drawing. Around 1900, German physicist Arthur Korn invented the *Bildtelegraph*, widespread in continental Europe especially, since a widely noticed transmission of a wanted-person photograph from Paris to London in 1908, used until the wider distribution of the radiofax. Its main competitors were the *Bélinographe* by Édouard Belin first, then since the 1930s the *Hellschreiber*, invented in 1929 by German inventor Rudolf Hell, a pioneer in mechanical image scanning and transmission.

The 1888 invention of the telautograph by Elisha Gray marked a further development in fax technology, allowing users to send signatures over long distances, thus allowing the verification of identification or ownership over long distances.[5]

On May 19, 1924, scientists of the AT&T Corporation "by a new process of transmitting pictures by electricity" sent 15 photographs by telephone from Cleveland to New York City, such photos suitable for newspaper reproduction. Previously, photographs had been sent over the radio using this process.[6]

The Western Union "Deskfax" fax machine, announced in 1948, was a compact machine that fit comfortably on a desktop, using special spark printer paper.[7]

Wireless transmission

As a designer for the Radio Corporation of America (RCA), in 1924, Richard H. Ranger invented the wireless photoradiogram, or transoceanic radio facsimile, the forerunner of today's "fax" machines. A photograph of President Calvin Coolidge sent from New York to London on November 29, 1924 became the first photo picture reproduced by transoceanic radio facsimile. Commercial use of Ranger's product began two years later. Also in 1924, Herbert E. Ives of AT&T transmitted and reconstructed the first color facsimile, a natural-color photograph of silent film star Rudolph Valentino in period costume, using red, green and blue color separations.[8]

Beginning in the late 1930s, the Finch Facsimile system was used to transmit a "radio newspaper" to private homes via commercial AM radio stations and ordinary radio receivers equipped with Finch's printer, which used thermal paper. Sensing a new and potentially golden opportunity, competitors soon entered the field, but the printer and special paper were expensive luxuries, AM radio transmission was very slow and vulnerable to static, and the newspaper was too small. After more than ten years of repeated attempts by Finch and others to establish such a service as a viable business, the public, apparently quite content with its cheaper and much more substantial home-delivered daily newspapers, and with conventional spoken radio bulletins to provide any "hot" news, still showed only a passing curiosity about the new medium.[9]

By the late 1940s, radiofax receivers were sufficiently miniaturized to be fitted beneath the dashboard of Western Union's "Telecar" telegram delivery vehicles.[7]

In the 1960s, the United States Army transmitted the first photograph via satellite facsimile to Puerto Rico from the Deal Test Site using the Courier satellite.

Radio fax is still in limited use today for transmitting weather charts and information to ships at sea.

Telephone transmission

In 1964, Xerox Corporation introduced (and patented) what many consider to be the first commercialized version of the modern fax machine, under the name (LDX) or Long Distance Xerography. This model was superseded two years later with a unit that would truly set the standard for fax machines for years to come. Up until this point facsimile machines were very expensive and hard to operate. In 1966, Xerox released the Magnafax Telecopiers, a smaller, 46-pound facsimile machine. This unit was far easier to operate and could be connected to any standard telephone line. This machine was capable of transmitting a letter-sized document in about six minutes. The first sub-minute, digital fax machine was developed by Dacom, which built on digital data compression technology originally developed at Lockheed for satellite communication.[10][11]

By the late 1970s, many companies around the world (especially Japan) entered the fax market. Very shortly after a new wave of more compact, faster and efficient fax machines would hit the market. Xerox continued to refine the fax machine for years after their ground-breaking first machine. In later years it would be combined with copier equipment to create the hybrid machines we have today that copy, scan and fax. Some of the lesser known capabilities of the Xerox fax technologies included their Ethernet enabled Fax Services on their 8000 workstations in the early 1980s.

Prior to the introduction of the ubiquitous fax machine, one of the first being the Exxon Qwip[12] in the mid-1970s, facsimile machines worked by optical scanning of a document or drawing spinning on a drum. The reflected light, varying in intensity according to the light and dark areas of the document, was focused on a photocell so that the current in a circuit varied with the amount of light. This current was used to control a tone generator (a modulator), the current determining the frequency of the tone produced. This audio tone was then transmitted using an acoustic coupler (a speaker, in this case) attached to the microphone of a common telephone handset. At the receiving end, a handset's speaker was attached to an acoustic coupler (a microphone), and a demodulator converted the varying tone into a variable current that controlled the mechanical movement of a pen or pencil to reproduce the image on a blank sheet of paper on an identical drum rotating at the same rate.

Computer facsimile interface

In 1985, Hank Magnuski, founder of GammaLink, produced the first computer fax board, called GammaFax. Such boards could provide voice telephony via Analog Expansion Bus[13]

Fax in the 21st century

Although businesses usually maintain some kind of fax capability, the technology has faced increasing competition from Internet-based alternatives. In some countries, because electronic signatures on contracts are not yet recognized by law, while faxed contracts with copies of signatures are, fax machines enjoy continuing support in business.[14] In Japan, faxes are still used extensively for cultural and graphemic reasons and are available for sending to both domestic and international recipients from over 81% of all convenience stores nationwide. Convenience-store fax machines commonly print the slightly re-sized content of the sent fax in the electronic confirmation-slip, in A4 paper size.[15][16][17]

In many corporate environments, freestanding fax machines have been replaced by fax servers and other computerized systems capable of receiving and storing incoming faxes electronically, and then routing them to users on paper or via an email (which may be secured). Such systems have the advantage of reducing costs by eliminating unnecessary printouts and reducing the number of inbound analog phone lines needed by an office.

The once ubiquitous fax machine has also begun to disappear from the small office and home office environments. Remotely hosted fax-server services are widely available from VoIP and e-mail providers allowing users to send and receive faxes using their existing e-mail accounts without the need for any hardware or dedicated fax lines. Personal computers have also long been able to handle incoming and outgoing faxes using analog modems or ISDN, eliminating the need for a stand-alone fax machine. These solutions are often ideally suited for users who only very occasionally need to use fax services. In July 2017 the NHS was said to be the world's largest purchaser of fax machines because the digital revolution has largely bypassed it.[18]

Capabilities

There are several indicators of fax capabilities: group, class, data transmission rate, and conformance with ITU-T (formerly CCITT) recommendations. Since the 1968 Carterphone decision, most fax machines have been designed to connect to standard PSTN lines and telephone numbers.

Group

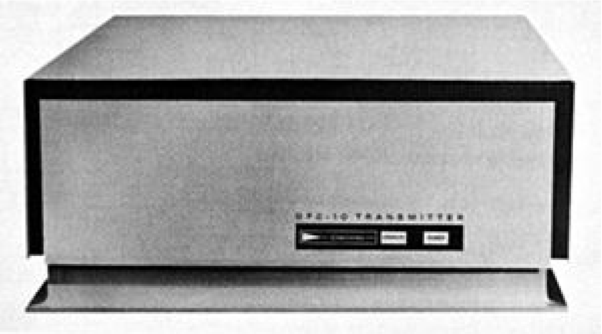
Analog

Group 1 and 2 faxes are sent in the same manner as a frame of analog television, with each scanned line transmitted as a continuous analog signal. Horizontal resolution depended upon the quality of the scanner, transmission line, and the printer. Analog fax machines are obsolete and no longer manufactured. ITU-T Recommendations T.2 and T.3 were withdrawn as obsolete in July 1996.

- Group 1 faxes conform to the ITU-T Recommendation T.2. Group 1 faxes take six minutes to transmit a single page, with a vertical resolution of 96 scan lines per inch. Group 1 fax machines are obsolete and no longer manufactured.
- Group 2 faxes conform to the ITU-T Recommendations T.3 and T.30. Group 2 faxes take three minutes to transmit a single page, with a vertical resolution of 96 scan lines per inch. Group 2 fax machines are almost obsolete, and are no longer manufactured. Group 2 fax machines can interoperate with Group 3 fax machines.

Digital

A major breakthrough in the development of the modern facsimile system was the result of digital technology, where the analog signal from scanners was digitized and then compressed, resulting in the ability to transmit high rates of data across standard phone lines. The first digital fax machine was the Dacom Rapidfax first sold in late 1960s, which incorporated digital data compression technology developed by Lockheed for transmission of images from satellites.[10][11]



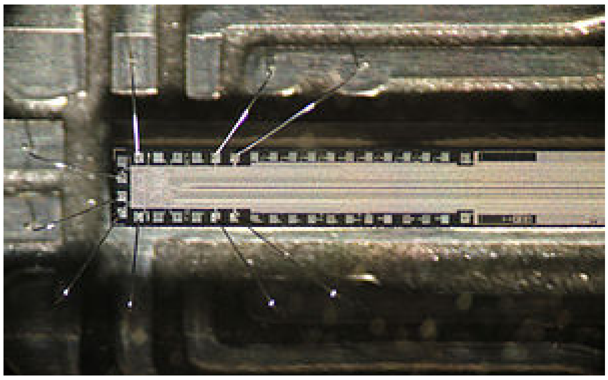
The Dacom DFC-10—the first digital fax machine.[10]

Group 3 and 4 faxes are digital formats, and take advantage of digital compression methods to greatly reduce transmission times.

- Group 3 faxes conform to the ITU-T Recommendations T.30 and T.4. Group 3 faxes take between six and fifteen seconds to transmit a single page (not including the initial time for the fax machines to handshake and synchronize). The horizontal and vertical resolutions are allowed by the T.4 standard to vary among a set of fixed resolutions:
  - Horizontal: 100 scan lines per inch
    - Vertical: 100 scan lines per inch ("Basic")
  - Horizontal: 200 or 204 scan lines per inch
    - Vertical: 100 or 98 scan lines per inch ("Standard")
    - Vertical: 200 or 196 scan lines per inch ("Fine")
    - Vertical: 400 or 391 (note not 392) scan lines per inch ("Superfine")
  - Horizontal: 300 scan lines per inch

- Vertical: 300 scan lines per inch
- Horizontal: 400 or 408 scan lines per inch
  - Vertical: 400 or 391 scan lines per inch ("Ultrafine")
- Group 4 faxes conform to the ITU-T Recommendations T.563, T.503, T.521, T.6, T.62, T.70, T.411 to T.417. They are designed to operate over 64 kbit/s digital ISDN circuits. The allowed resolutions, a superset of those in the T.4 recommendation, are specified in the T.6 recommendation.[19]

Fax Over IP (FoIP) can transmit and receive pre-digitized documents at near realtime speeds using ITU-T recommendation T.38 to send digitised images over an IP network using JPEG compression. T.38 is designed to work with VoIP services and often supported by analog telephone adapters used by legacy fax machines that need to connect through a VoIP service. Scanned documents are limited to the amount of time the user takes to load the document in a scanner and for the device to process a digital file. The resolution can vary from as little as 150 DPI to 9600 DPI or more. This type of faxing is not related to the e-mail to fax service that still uses fax modems at least one way



The chip in a fax machine. Only about one quarter of the length is shown. The thin line in the middle consists of photosensitive pixels. The read-out circuit is at left.

CCD MN8051 Matsushita CCD side, monochrome 2048-bit linear sensor +cm (centimeters)

Class

Computer modems are often designated by a particular fax class, which indicates how much processing is offloaded from the computer's CPU to the fax modem.

- Class 1 fax devices do fax data transfer where the T.4/T.6 data compression and T.30 session management are performed by software on a controlling computer. This is described in ITU-T recommendation T.31.[20]
- Class 2 fax devices perform T.30 session management themselves, but the T.4/T.6 data compression is performed by software on a controlling computer. The relevant ITU-T recommendation is T.32.[20]
- Class 2.0 is different from Class 2.
- Class 2.1 is an improvement of Class 2.0. Class 2.1 fax devices are referred to as "super G3"; they seem to be a little faster than Class 1/2/2.0.
- Class 3 fax devices are responsible for virtually the entire fax session, given little more than a phone number and the text to send (including rendering ASCII text as a raster image). These devices are not common.

Data transmission rate

Several different telephone line modulation techniques are used by fax machines. They are negotiated during the fax-modem handshake, and the fax devices will use the highest data rate that both fax devices support, usually a minimum of 14.4 kbit/s for Group 3 fax.

ITU Standard	Released Date	Data Rates (bit/s)	Modulation Method
V.27	1988	4800, 2400	PSK
V.29	1988	9600, 7200, 4800	QAM
V.17	1991	14,400; 12,000; 9600; 7200	TCM
V.34	1994	28,800	QAM
V.34bis	1998	33,600	QAM
ISDN	1986	64,000	digital

Note that "Super Group 3" faxes use V.34bis modulation that allows a data rate of up to 33.6 kbit/s.

Compression

As well as specifying the resolution (and allowable physical size of the image being faxed), the ITU-T T.4 recommendation specifies two compression methods for decreasing the amount of data that needs to be transmitted between the fax machines to transfer the image. The two methods defined in T.4 are:[21]

- Modified Huffman (MH), and
- Modified READ (MR) (*Relative Element Address Designate*[22]), optional

An additional method is specified in T.6:[19]

- Modified Modified READ (MMR)

Later, other compression techniques were added as options to ITU-T recommendation T.30, such as the more efficient JBIG (T.82, T.85) for bi-level content, and JPEG (T.81), T.43, MRC (T.44), and T.45 for grayscale, palette, and colour content.[23] Fax machines can negotiate at the start of the T.30 session to use the best technique implemented on both sides.

Modified Huffman

Modified Huffman (MH), specified in T.4 as the one-dimensional coding scheme, is a codebook-based run-length encoding scheme optimised to efficiently compress whitespace.[21] As most faxes consist mostly of white space, this minimises the transmission time of most faxes. Each line scanned is compressed independently of its predecessor and successor.[21]

Modified READ

Modified READ (MR), specified as an optional two-dimensional coding scheme in T.4, encodes the first scanned line using MH.[21] The next line is compared to the first, the differences determined, and then the differences are encoded and transmitted.[21] This is effective as most lines differ little from their predecessor. This is not continued to the end of the fax transmission, but only for a limited number of lines until the process is reset and a new 'first line' encoded with MH is produced. This limited number of lines is to prevent errors propagating throughout the whole fax, as the standard does not provide for error-correction. MR is an optional facility, and some fax machines do not use MR in order to minimise the amount of computation required by the machine. The limited number of lines is two for 'Standard' resolution faxes, and four for 'Fine' resolution faxes.

Modified Modified READ

The ITU-T T.6 recommendation adds a further compression type of Modified Modified READ (MMR), which simply allows for a greater number of lines to be coded by MR than in T.4.[19] This is because T.6 makes the assumption that the transmission is over a circuit with a low number of line errors such as digital ISDN. In this case, there is no maximum number of lines for which the differences are encoded.

JBIG

In 1999, ITU-T recommendation T.30 added JBIG (ITU-T T.82) as another lossless bi-level compression algorithm, or more precisely a "fax profile" subset of JBIG (ITU-T T.85). JBIG-compressed pages result in 20% to 50% faster transmission than MMR-compressed pages, and up to 30-times faster transmission if the page includes halftone images.

JBIG performs adaptive compression, that is both the encoder and decoder collect statistical information about the transmitted image from the pixels transmitted so far, in order to predict the probability for each next pixel being either black or white. For each new pixel, JBIG looks at ten nearby, previously transmitted pixels. It counts, how often in the past the next pixel has been black or white in the same neighborhood, and estimates from that the probability distribution of the next pixel. This is fed into an arithmetic coder, which adds only a small fraction of a bit to the output sequence if the more probable pixel is then encountered.

The ITU-T T.85 "fax profile" constrains some optional features of the full JBIG standard, such that codecs do not have to keep data about more than the last three pixel rows of an image in memory at any time. This allows the streaming of "endless" images, where the height of the image may not be known until the last row is transmitted.

ITU-T T.30 allows fax machines to negotiate one of two options of the T.85 "fax profile":

- In "basic mode", the JBIG encoder must split the image into horizontal stripes of 128 lines (parameter L0=128), and restart the arithmetic encoder for each stripe.
- In "option mode", there is no such constraint.

Matsushita Whiteline Skip

A proprietary compression scheme employed on Panasonic fax machines is Matsushita Whiteline Skip (MWS). It can be overlaid on the other compression schemes, but is operative only when two Panasonic machines are communicating with one another. This system detects the blank scanned areas between lines of text, and then compresses several blank scan lines into the data space of a single character. (JBIG implements a similar technique called "typical prediction", if header flag TPBON is set to 1.)

Typical characteristics

Group 3 fax machines transfer one or a few printed or handwritten pages per minute in black-and-white (bitonal) at a resolution of 204×98 (normal) or 204×196 (fine) dots per square inch. The transfer rate is 14.4 kbit/s or higher for modems and some fax machines, but fax machines support speeds beginning with 2400 bit/s and typically operate at 9600 bit/s. The transferred image formats are called ITU-T (formerly CCITT) fax group 3 or 4. Group 3 faxes have the suffix `.g3` and the MIME type `image/g3fax`.

The most basic fax mode transfers in black and white only. The original page is scanned in a resolution of 1728 pixels/line and 1145 lines/page (for A4). The resulting raw data is compressed using a modified Huffman code optimized for written text, achieving average compression factors of around 20. Typically a page needs 10 s for transmission, instead of about 3 minutes for the same uncompressed raw data of 1728×1145 bits at a speed of 9600 bit/s. The compression method uses a Huffman codebook for run lengths of black and white runs in a single scanned line, and it can also use the fact that two adjacent scanlines are usually quite similar, saving bandwidth by encoding only the differences.

Fax classes denote the way fax programs interact with fax hardware. Available classes include Class 1, Class 2, Class 2.0 and 2.1, and Intel CAS. Many modems support at least class 1 and often either Class 2 or Class 2.0. Which is preferable to use depends on factors such as hardware, software, modem firmware, and expected use.

Printing process

Fax machines from the 1970s to the 1990s often used direct thermal printers with rolls of thermal paper as their printing technology, but since the mid-1990s there has been a transition towards plain-paper faxes:- thermal transfer printers, inkjet printers and laser printers.

One of the advantages of inkjet printing is that inkjets can affordably print in color; therefore, many of the inkjet-based fax machines claim to have color fax capability. There is a standard called ITU-T30e (formally ITU-T Recommendation T.30 Annex E [24]) for faxing in color; unfortunately, it is not widely supported, so many of the color fax machines can only fax in color to machines from the same manufacturer.

Stroke speed

Stroke speed in facsimile systems is the rate at which a fixed line perpendicular to the direction of scanning is crossed in one direction by a scanning or recording spot. Stroke speed is usually expressed as a number of strokes per minute. When the fax system scans in both directions, the stroke speed is twice this number. In most conventional 20th century mechanical systems, the stroke speed is equivalent to drum speed.[25]

Fax paper

Paper roll for direct thermal fax machine

As a precaution, thermal fax paper is typically not accepted in archives or as documentary evidence in some courts of law unless photocopied. This is because the image-forming coating is eradicable and brittle, and it tends to detach from the medium after a long time in storage.[26]

Internet fax

One popular alternative is to subscribe to an Internet fax service, allowing users to send and receive faxes from their personal computers using an existing email account. No software, fax server or fax machine is needed. Faxes are received as attached TIFF or PDF files, or in proprietary formats that require the use of the service provider's software. Faxes can be sent or retrieved from anywhere at any time that a user can get Internet access. Some services offer secure faxing to comply with stringent HIPAA and Gramm–Leach–Bliley Act requirements to keep medical information and financial information private and secure. Utilizing a fax service provider does not require paper, a dedicated fax line, or consumable resources.[27]

Another alternative to a physical fax machine is to make use of computer software which allows people to send and receive faxes using their own computers, utilizing fax servers and unified messaging. A virtual (email) fax can be printed out and then signed and scanned back to computer before being emailed. Also the sender can attach a digital signature to the document file.

With the surging popularity of mobile phones, virtual fax machines can now be downloaded as applications for Android and iOS. These applications make use of the phone's internal camera to scan fax documents for upload or they can import from various cloud services.

Related Standards

- T.4 is the umbrella specification for fax. It specifies the standard image sizes, two forms of image-data compression (encoding), the image-data format, and references, T.30 and the various modem standards.
- T.6 specifies a compression scheme that reduces the time required to transmit an image by roughly 50-percent.
- T.30 specifies the procedures that a sending and receiving terminal use to set up a fax call, determine the image size, encoding, and transfer speed, the demarcation between pages, and the termination of the call. T.30 also references the various modem standards.
- V.21, V.27ter, V.29, V.17, V.34: ITU modem standards used in facsimile. The first three were ratified prior to 1980, and were specified in the original T.4 and T.30 standards. V.34 was published for fax in 1994.[28]
- T.37 The ITU standard for sending a fax-image file via e-mail to the intended recipient of a fax.
- G.711 pass through - this is where the T.30 fax call is carried in a VoIP call encoded as audio. This is sensitive to network packet loss, jitter and clock synchronization. When using voice high-compression encoding techniques such as, but not limited to, G.729, some fax tonal signals may not get correctly transported across the packet network.
- RFC 3362 image/t38 MIME-type

See also

- Black fax
- Called subscriber identification (CSID)
- Error correction mode (ECM)
- Fax art
- Fax demodulator
- Fax modem
- Fax server
- Faxlore
- Fultograph
- Internet fax
- Junk fax
- Radiofax—image transmission over HF radio
- Slow-scan television
- T.38 Fax-over-IP

- Telautograph
- Telex
- Teletex
- Transmitting Subscriber Identification (TSID)

References

1. Rouse, Margaret (June 2006). "What is fax?" (http://searchnetworking.techtarget.com/definition/fax) SearchNetworking. Retrieved 25 July 2012.
2. "Mr. Bain's Electric Printing Telegraph," Mechanics' Magazine April 13, 1844, 268–70
3. "Istituto Tecnico Industriale, Italy Italian biography of Giovanni Caselli" (http://www.itisgalileiroma.it/shed/shed0/shed0/caselli.htm). Itisgalileiroma.it. Retrieved 2014-02-16.
4. The Hebrew University of Jerusalem – Giovanni Caselli biography (http://chem.ch.huji.ac.il/history/caselli.html) Archived (https://web.archive.org/web/20080506000000/http://chem.ch.huji.ac.il/history/caselli.html) May 6, 2008, at the Wayback Machine.
5. "The History of Fax – from 1843 to Present Day" (http://faxauthority.com/fax-history/). Fax Authority. Retrieved 25 July 2012.
6. The Montreal Gazette, May 20, 1924, page 10, column 3
7. G. H. Ridings, A Facsimile transceiver for Pickup and Delivery of Telegrams (http://massis.lcs.mit.edu/archives/technical/western-union-tech-review/03-1/p017.htm) Western Union Technical Review, Vol. 3, No. 1 (http://massis.lcs.mit.edu/archives/technical/western-union-tech-review/03-1/readpg.html) (January 1949); page 17-26.
8. Sipley, Louis Walton (1951). *A Half Century of Color*. Macmillan.
9. Schneider, John (2011). "The Newspaper of the Air: Early Experiments with Radio Facsimile" (http://www.theradiohistorian.org/Radiofax/newspaper_of_the_air1.htm). theradiohistorian.org. Retrieved 2017-05-15.
10. *The implementation of a personal computer-based digital facsimile information distribution system* (https://etd.ohiolink.edu/rws_etd/document/get/ohiou1183661772/inline) – Edward C. Chung, Ohio University, November 1991, page 2
11. *Fax: The Principles and Practice of Facsimile Communication*, Daniel M. Costigan, Chilton Book Company, 1971, pages 112–114, 213, 239
12. An Exxon Sale To Harris Unit (https://www.nytimes.com/1985/02/22/business/an-exxon-sale-to-harris-unit-the-exxon-corporation-said.html) – The New York Times, February 22, 1985.
13. Perratore, Ed (September 1992). "GammaFax MLCP-4/AEB: High-End Fax, Long-Range Potential". *Byte*. Vol. 17 no. 9. McGraw-Hill. pp. 82, 84. ISSN 0360-5280 (https://www.worldcat.org/issn/0360-5280).
14. Adams, Ken (7 November 2007). "Enforceability of Fax and Scanned Signature Pages" (http://www.adamsdrafting.com/2007/11/07/fax-and-scanned-signatures/). AdamsDrafting. Retrieved 25 July 2012.
15. "FAXサービス｜サービス｜ローソン" (https://web.archive.org/web/20150210112224/http://www.lawson.co.jp/service/counter/fax.html) (in Japanese). Archived from the original (http://www.lawson.co.jp/service/counter/fax.html) on 2015-02-10.
16. Fackler, Martin (13 February 2013). "In High-Tech Japan, the Fax Machines Roll On" (https://www.nytimes.com/2013/02/14/world/asia/in-japan-the-fax-machine-is-anything-but-a-relic.html?pagewanted=1&_r=0&ref=world). *The New York Times*. Retrieved 14 February 2013.
17. Oi, Mariko (2012-07-31). "BBC News – Japan and the fax: A love affair" (http://www.bbc.co.uk/news/magazine-19045837). Bbc.co.uk. Retrieved 2014-02-16.
18. "Digital doldrums: NHS remains world's largest purchaser of fax machines" (http://www.nationalhealthexecutive.com/Health-Care-News/digital-doldrums-nhs-remains-worlds-largest-purchaser-of-fax-machines). National Health Executive. 5 July 2017. Retrieved 2 September 2017.
19. "T.6: Facsimile coding schemes and coding control functions for Group 4 facsimile apparatus" (http://www.itu.int/rec/T-REC-T.6/en). ITU-T. November 1988. Retrieved 2013-12-28.
20. Peterson, Kerstin Day (2000). *Business telecom systems: a guide to choosing the best technologies and services* (https://books.google.com/books?id=W79R0niNU5wC&pg=PA191). Focal Press. pp. 191–192. ISBN 1578200415. Retrieved 2011-04-02.
21. "T.4: Standardization of Group 3 facsimile terminals for document transmission" (http://www.itu.int/rec/T-REC-T.4/en). ITU-T. 2011-03-14. Retrieved 2013-12-28.

22. *International digital facsimile coding standards* (http://ieeexplore.ieee.org/xpl/login.jsp?tp=&arnumber=1456020&url=http%3A%2F%2Fieeexplore.ieee.org%2Fiel5%2F5%2F31291%2F01456020.pdf%3Farnumber%3D1456020) Hunter, R., and Robinson, A.H., Proceedings of the IEEE Volume 68 Issue 7, pp 854–867, July 1980
23. "T.30: Procedures for document facsimile transmission in the general switched telephone network" (http://www.itu.int/rec/T-REC-T.30). ITU-T. 2014-05-15. Retrieved 2013-12-28.
24. tsbmail. "T.30 : Procedures for document facsimile transmission in the general switched telephone network" (http://www.itu.int/rec/T-REC-T.30-200509-I/en). Itu.int. Retrieved 2014-02-16.
25. This article incorporates public domain material from the General Services Administration document "Federal Standard 1037C" (http://www.its.bldrdoc.gov/fs-1037/fs-1037c.htm) (in support of MIL-STD-188).
26. "4.12 Filing rules: 19.Newspaper extracts or thermal facsimile paper should not be preserved as archives. Such extracts should be photocopied and the copy preserved. The original can then be destroyed." Office of Corporate & Legal Affairs, University College Cork, Ireland
27. "Online Fax vs Traditional Fax" (http://blog.efax.com/blog/online-fax-2/five-reasons-to-adopt-online-fax). eFax. 16 May 2013. Retrieved 8 December 2013.
28. "V.34" (http://www.itwissen.info/definition/lexikon/V34-V-34.html). *www.itwissen.info*.

Further reading

- Coopersmith, Jonathan, *Faxed: The Rise and Fall of the Fax Machine* (Johns Hopkins University Press, 2015) 308 pp.

External links

- Group 3 Facsimile Communication a '97 essay with technical details on compression and error codes, and call establishment and release.
- ITU T.30 Recommendation

Retrieved from "https://en.wikipedia.org/w/index.php?title=Fax&oldid=821938290"

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Photocopier

A **photocopier** (also known as a **copier** or **copy machine**) is a machine that makes paper copies of documents and other visual images quickly and cheaply. Most current photocopiers use a technology called *xerography*, a dry process that uses electrostatic charges on a light-sensitive photoreceptor to first attract and then transfer toner particles (a powder) onto paper in the form of an image. Heat, pressure or a combination of both is then used to fuse the toner onto the paper. (Copiers can also use other technologies such as ink jet, but xerography is standard for office copying.) Earlier versions included the Gestetner stencil duplicator, invented by David Gestetner in 1881.

A Xerox photocopier in 2010

Commercial xerographic office photocopying was introduced by Xerox in 1959,[1][2] and it gradually replaced copies made by Verifax, Photostat, carbon paper, mimeograph machines, and other duplicating machines.

Photocopying is widely used in the business, education, and government sectors. While there have been predictions that photocopiers will eventually become obsolete as information workers increase their use of digital document creation, storage and distribution, and rely less on distributing actual pieces of paper, as of 2015, photocopiers continue to be widely used. In the 2010s, there is a convergence in some high-end machines between the roles of a photocopier, a fax machine, a scanner, and a computer network-connected printer into a multi-function printer. Lower-end machines that can copy and print in color have increasingly dominated the home-office market as their prices fell steadily through 2017. Higher-end color photocopiers capable of handling heavy duty cycles and large-format printing remain a costlier specialty for print and design shops.

Contents

History

Chester Carlson, the inventor of photocopying, was originally a patent attorney, as well as a part-time researcher and inventor. His job at the patent office in New York required him to make a large number of copies of important papers. Carlson, who was arthritic, found this to be a painful and tedious process. This motivated him to conduct experiments with photo conductivity. Carlson used his kitchen for his "electrophotography" experiments, and, in 1938, he applied for a patent for the process. He made the first photocopy using a zinc plate covered with sulfur. The words "10-22-38 Astoria" were written on a microscope slide, which was placed on top of more sulfur and under a bright light. After the slide was removed, a mirror image of the words remained. Carlson tried to sell his invention to some companies, but failed because the process was still underdeveloped. At the time, multiple copies were most commonly made at the point of document origination, using carbon paper or manual duplicating machines, and people did not see the need for an electronic machine. Between 1939 and 1944, Carlson was turned down by over 20 companies, including IBM and General Electric—neither of which believed there was a significant market for copiers.

In 1944, the Battelle Memorial Institute, a non-profit organization in Columbus, Ohio, contracted with Carlson to refine his new process. Over the next five years, the institute conducted experiments to improve the process of electrophotography. In 1947, Haloid Corporation (a small New York-based manufacturer and seller of photographic paper) approached Battelle to obtain a license to develop and market a copying machine based on this technology.[2]

Haloid felt that the word "electrophotography" was too complicated and did not have good recall value. After consulting a professor of classical language at Ohio State University, Haloid and Carlson changed the name of the process to "xerography," which was derived from Greek words that meant "dry writing." Haloid called the new copier machines "Xerox Machines" and, in 1948, the word "Xerox" was trademarked. Haloid eventually changed its name to Xerox Corporation.

In 1949, Xerox Corporation introduced the first xerographic copier called the Model A.[3] Xerox became so successful that, in North America, photocopying came to be popularly known as "xeroxing." Xerox has actively fought to prevent "Xerox" from becoming a genericized trademark. While the word "Xerox" has appeared in some dictionaries as a synonym for photocopying, Xerox Corporation typically requests that such entries be modified, and that people not use the term "Xerox" in this way. Some languages include hybrid terms, such as the widely used Polish term *kserokopia* ("xerocopy"), even though relatively few photocopiers are of the Xerox brand.

In the early 1950s, Radio Corporation of America (RCA) introduced a variation on the process called Electrofax, whereby images are formed directly on specially coated paper and rendered with a toner dispersed in a liquid.

During the 1960s and through the 1980s, Savin Corporation developed and sold a line of liquid-toner copiers that implemented a technology based on patents held by the company.

Before the widespread adoption of xerographic copiers, photo-direct copies produced by machines such as Kodak's Verifax were used. A primary obstacle associated with the pre-xerographic copying technologies was the high cost of supplies: a Verifax print required supplies costing USD $0.15 in 1969, while a Xerox print could be made for USD $0.03 including paper and labor. The coin-operated Photostat machines still found in some public libraries in the late 1960s made letter-size copies for USD $0.25 each, at a time when the minimum wage for a US worker was USD $1.65 per hour; the Xerox machines that replaced them typically charged USD $0.10.

Xerographic copier manufacturers took advantage of a high perceived-value of the 1960s and early 1970s, and marketed paper that was "specially designed" for xerographic output. By the end of the 1970s, paper producers made xerographic "runability" one of the requirements for most of their ofice paper brands.

Some devices sold as photocopiers have replaced the drum-based process with inkjet or transfer film technology.


DADF or Duplex Automatic Document feeder - Canon IR6000

Among the key advantages of photocopiers over earlier copying technologies are their ability:

- to use plain (untreated) ofice paper,
- to implement duplex (or two-sided) printing,
- Able to scan several pages automatically with an ADF, and
- eventually, to sort and/or staple output.

Color photocopiers

Colored toner became available in the 1950s, although full-color copiers were not commercially available until 3M released the *Color-in-Color* copier in 1968, which used a dye sublimation process rather than conventional electrostatic technology. The first electrostatic color copier was released by Xerox (the 6500) in 1973. Color photocopying is a concern to governments, as it facilitates counterfeiting currency and other documents: for more information, see Counterfeiting section.

Digital technology

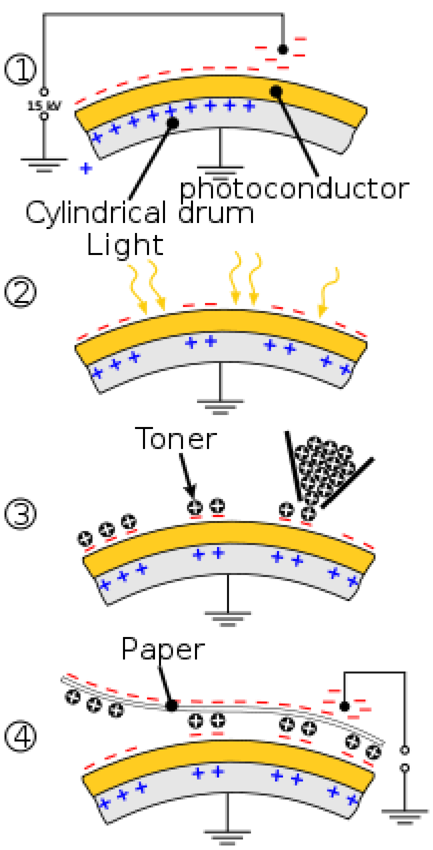
There is an increasing trend for new photocopiers to adopt digital technology, thus replacing the older analog technology. With digital copying, the copier effectively consists of an integrated scanner and laser printer. This design has several advantages, such as automatic image quality enhancement and the ability to "build jobs" (that is, to scan page images independently of the process of printing them). Some digital copiers can function as high-speed scanners; such models typically offer the ability to send documents via email or to make them available on file servers.

A great advantage of digital copier technology is "automatic digital collation." For example, when copying a set of 20 pages 20 times, a digital copier scans each page only once, then uses the stored information to produce 20 sets. In an analog copier, either each page is scanned 20 times (a total of 400 scans), making one set at a time, or 20 separate output trays are used for the 20 sets.

Low-end copiers also use digital technology, but tend to consist of a standard PC scanner coupled to an inkjet or low-end laser printer, both of which are far slower than their counterparts in high-end copiers. However, low-end scanner-inkjets can provide color copying at a lower purchase price but with a much higher cost per copy. The cost of electronics is such that combined scanner-printers sometimes have built-in fax machines. (See Multifunction printer.)

How it works (using xerography)

1. **Charging**: cylindrical drum is electrostatically charged by a high voltage wire called a corona wire or a charge roller. The drum has a coating of a photoconductive material. A photoconductor is a semiconductor that becomes conductive when exposed to light.[4]
2. **Exposure**: A bright lamp illuminates the original document, and the white areas of the original document reflect the light onto the surface of the photoconductive drum. The areas of the drum that are exposed to light become conductive and therefore discharge to the ground. The area of the drum not exposed to light (those areas that correspond to black portions of the original document) remains negatively charged.
3. **Developing**: The toner is positively charged. When it is applied to the drum to develop the image, it is attracted and sticks to the areas that are negatively charged (black areas), just as paper sticks to a balloon with a static charge.
4. **Transfer**: The resulting toner image on the surface of the drum is transferred from the drum onto a piece of paper with a higher negative charge than the drum.
5. **Fusing**: The toner is melted and bonded to the paper by heat and pressure rollers.



Schematic overview of the xerographic photocopying process (step 1-4)

A negative photocopy inverts the colors of the document when creating a photocopy, resulting in letters that appear white on a black background instead of black on a white background. Negative photocopies of old or faded documents sometimes produce documents which have better focus and are easier to read and study

Copyright issues

Photocopying material that is subject to copyright (such as books or scientific papers) is subject to restrictions in most countries. This is common practice, as the cost of purchasing a book for the sake of one article or a few pages can be excessive.

The principle of fair use (in the United States) or fair dealing (in other Berne Convention countries) allows copying for certain specified purposes.

In certain countries, such as Canada, some universities pay royalties from each photocopy made at university copy machines and copy centers to copyright collectives out of the revenues from the photocopying, and these collectives distribute resulting funds to various scholarly publishers. In the United States, photocopied compilations of articles, handouts, graphics, and other information called *readers* are often required texts for college classes. Either the instructor or the copy center is responsible for clearing copyright for every article in the reader, and attribution information must be clearly included in the reader.

Counterfeiting

To counter the risk of people using color copiers to create counterfeit copies of paper currency, some countries have incorporated anti-counterfeiting technologies into their currency. These include watermarks, microprinting, holograms, tiny security strips made of plastic (or other material), and ink that appears to change color as the currency is viewed at an angle. Some photocopying machines contain special software that can prevent copying currency that contains a special pattern.

Color copying also raises concerns regarding the copying and/or forging of other documents as well, such as driver's licenses and university degrees and transcripts. Some driver's licenses are made with embedded holograms so that a police officer can detect a fake copy. Some university and college transcripts have special anti-copying watermarks in the background. If a copy is made, the watermarks will become highly visible, which allows the recipient to determine that they have a copy rather than a genuine original transcript.

Health issues

Exposure to ultraviolet light is a concern. In the early days of photocopiers, the sensitizing light source was filtered green to match the optimal sensitivity of the photoconductive surface. This filtering conveniently removed all ultraviolet.[5] Currently, a variety of light sources are used. As glass transmits ultraviolet rays between 325 and 400 nanometers, copiers with ultraviolet-producing lights such as fluorescent, tungsten halogen, or xenon flash, expose documents to some ultraviolet.[5]

Concerns about emissions from photocopy machines have been expressed by some in connection with the use of selenium and emissions of ozone and fumes from heated toner.[6][7]

Forensic identification

Similar to forensic identification of typewriters, computer printers and copiers can be traced by imperfections in their output. The mechanical tolerances of the toner and paper feed mechanisms cause banding, which can reveal information about the individual device's mechanical properties. It is often possible to identify the manufacturer and brand, and, in some cases, the individual printer can be identified from a set of known printers by comparing their outputs.[8]

Some high-quality color printers and copiers steganographically embed their identification code into the printed pages, as fine and almost invisible patterns of yellow dots. Some sources identify Xerox and Canon as companies doing this.[9][10] The Electronic Frontier Foundation (EFF) has investigated this issue[11] and documented how the Xerox DocuColor printer's serial number, as well as the date and time of the printout, are encoded in a repeating 8×15 dot pattern in the yellow channel. EFF is working to reverse engineer additional printers.[12] The EFF also reports that the US government has asked these companies to implement such a tracking scheme, so that counterfeiting can be traced. The EFF has filed a Freedom of Information Act request in order to look into privacy implications of this tracking.[13]

See also

- List of duplicating processes
- Heliography
- Reprography

- Risograph
- Scanography
- Thermochromatic ink
- Thermofax
- Xerox art
- Gestetner

References

1. "Xerox History: 1950s" (https://www.xerox.com/about-xerox/history-timeline/1950-decade/ensg.html). Retrieved 28 September 2017.
2. "The Story of Xerography" (https://www.xerox.com/downloads/usa/en/s/Storyofxerography.pdf) (PDF). Xerox Corporation. Retrieved 28 September 2017.
3. "Xerox history: 1940s" (https://www.xerox.com/about-xerox/history-timeline/1940-decade/ensg.html). Retrieved 28 September 2017.
4. "Encarta definition of 'photoconductor'" (https://web.archive.org/web/20081211205730/http://encarta.msn.com/dictionary_/photoconductor.html). Archived from the original (http://encarta.msn.com/dictionary_/photoconductor.html) on 2008-12-11. Retrieved 2009-11-20.
5. "Photocopier Hazards and a Conservation Case Study (notes 17,18)" (http://aic.stanford.edu/sg/bpg/annual/v08/bp08-05.html#note17). Retrieved 2009-11-20.
6. "Photocopier and Laser Printer Hazards" (https://web.archive.org/web/20100401010211/http://www.lhc.org.uk/members/pubs/factsht/76fact.pdf) (PDF). London Hazards Centre. 2002. Archived from the original (http://www.lhc.org.uk/members/pubs/factsht/76fact.pdf) (PDF) on 2010-04-01. Retrieved 2009-11-20.
7. "Health and Safety Representatives' Handbook" (https://web.archive.org/web/20110719081216/http://www.nasuwt.org.uk/consum/idcplg?IdcService=GET_FILE&dDocName=NASUWT_000235&RevisionSelectionMethod=latest&allowInterrupt=1). [National Association of Schoolmasters Union of Women Teachers (NASUWT)]. July 27, 2009. Archived from the original (http://www.nasuwt.org.uk/consum/idcplg?IdcService=GET_FILE&dDocName=NASUWT_000235&RevisionSelectionMethod=latest&allowInterrupt=1) (PDF) on July 19, 2011. Retrieved April 30, 2011.
8. "Printer forensics to aid homeland security, tracing counterfeiters" (http://news.uns.purdue.edu/UNS/html4ever/2004/041011.Delp.forensics.html). 2004-10-12. Retrieved 2009-11-20.
9. Jason Tuohey (2004-11-22). "Government Uses Color Laser Printer Technology to Track Documents" (http://www.pcworld.com/article/118664/government_uses_color_laser_printer_technology_to_track_documents.html). Retrieved 2009-11-20.
10. Wilbert de Vries (2004-10-26). "Dutch track counterfeits via printer serial numbers" (http://www.pcworld.idg.com.au/article/8305/dutch_track_counterfeits_via_printer_serial_numbers). Retrieved 2009-11-20.
11. "Is Your Printer Spying On You?" (https://www.eff.org/issues/printers). Electronic Frontier Foundation. Retrieved 2009-11-20.
12. "List of Printers Which Do or Do Not Display Tracking Dots" (https://www.eff.org/Privacy/printers/list.php). Electronic Frontier Foundation. Retrieved 2009-11-20.
13. "Printers" (https://www.eff.org/issues/printers). *Electronic Frontier Foundation*.

Further reading

- R. Schaffert: *Electrophotography*. Focal Press, 1975
- Owen, David (August 2004). *Copies in Seconds : How a Lone Inventor and an Unknown Company Created the Biggest Communication Breakthrough Since Gutenberg: Chester Carlson and the Birth of the Xerox Machine*. New York: Simon & Schuster. ISBN 0-7432-5117-2.

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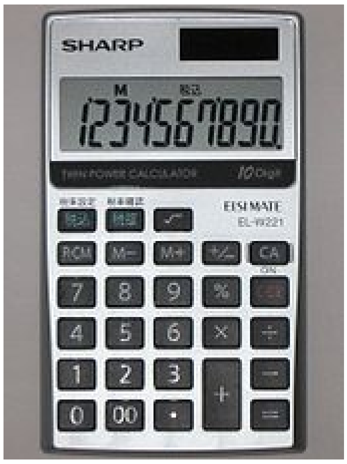
Calculator

An **electronic calculator** is typically a portable electronic device used to perform calculations, ranging from basic arithmetic to complex mathematics.



An electronic pocket calculator with a liquid-crystal display (LCD) seven-segment display, that can perform arithmetic operations

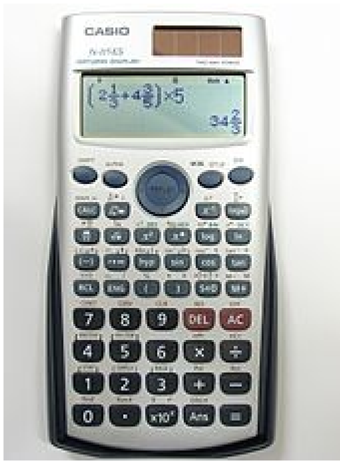
The first solid state electronic calculator was created in the early 1960s.

The pocket sized devices became available in the 1970s, especially after the first microprocessor, the Intel 4004, developed by Intel for the Japanese calculator company Busicom. They later became used commonly within the petroleum industry (oil and gas).

Modern electronic calculators vary: from cheap, give-away, credit-card-sized models to sturdy desktop models with built-in printers. They became popular in the mid-1970s (as integrated circuits made their size and cost small). By the end of that decade, calculator prices had reduced to a point where a basic calculator was affordable to most and they became common in schools.

Computer operating systems as far back as early Unix have included interactive calculator programs such as dc and hoc, and calculator functions are included in almost all personal digital assistant (PDA) type devices (save a few dedicated address book and dictionary devices).

In addition to general purpose calculators, there are those designed for specific markets. For example, there are scientific calculators which include trigonometric and statistical calculations. Some calculators even have the ability to do computer algebra. Graphing calculators can be used to graph functions defined on the real line, or higher-dimensional Euclidean space. As of 2016, basic calculators cost little, but the scientific and graphing models tend to cost more.



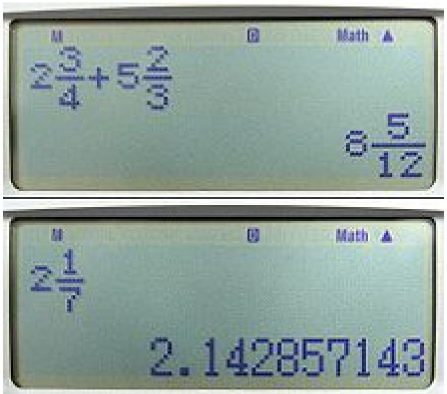
A modern scientific calculator with a dot matrix LCD

In 1986, calculators still represented an estimated 41% of the world's general-purpose hardware capacity to compute information. By 2007, this diminished to less than 0.05%.[1]

Contents

Design

Input



Scientific calculator displays of fractions and decimal equivalents

Electronic calculators contain a keyboard with buttons for digits and arithmetical operations; some even contain "00" and "000" buttons to make larger or smaller numbers easier to enter. Most basic calculators assign only one digit or operation on each button; however, in more specific calculators, a button can perform multi-function working with key combinations.

Display output

Calculators usually have liquid-crystal displays (LCD) as output in place of historical light-emitting diode (LED) displays and vacuum fluorescent displays (VFD); details are provided in the section *Technical improvements*.

Large-sized figures are often used to improve readability; while using decimal separator (usually a point rather than a comma) instead of or in addition to vulgar fractions. Various symbols for function commands may also be shown on the display. Fractions such as $^1⁄_3$ are displayed as decimal approximations, for example rounded to 0.33333333. Also, some fractions (such as $^1⁄_7$, which is 0.14285714285714; to 14 significant figures) can be difficult to recognize in decimal form; as a result, many scientific calculators are able to work in vulgar fractions or mixed numbers.

Memory

Calculators also have the ability to store numbers into computer memory. Basic calculators usually store only one number at a time; more specific types are able to store many numbers represented in variables. The variables can also be used for constructing formulas. Some models have the ability to extend memory capacity to store more numbers; the extended memory address is termed an array index.

Power source

Power sources of calculators are: batteries, solar cells or mains electricity (for old models), turning on with a switch or button. Some models even have no turn-off button but they provide some way to put off (for example, leaving no operation for a moment, covering solar cell exposure, or closing their lid). Crank-powered calculators were also common in the early computer era.

Key layout

The following keys are common to most pocket calculators. While the arrangement of the digits is standard, the positions of other keys vary from model to model; the illustration is an example.

Usual basic pocket calculator layout

MC	MR	M−	M+
C	±	%	√
7	8	9	÷
4	5	6	×
1	2	3	−
0	.	=	+

MC or CM	**M**emory **C**lear
MR, RM, or MRC	**M**emory **R**ecall
M−	**M**emory **Subtraction**
M+	**M**emory **Addition**
C or AC	**A**ll **C**lear
CE	**C**lear (last) **E**ntry; sometimes called CE/C: a first press clears the last entry (CE), a second press clears all (C)
± or CHS	Toggle positive/negative number aka **CH**ange **S**ign
%	Percent
÷	Division
×	Multiplication
−	Subtraction
+	Addition
.	Decimal point
√	Square root
=	Result

Internal workings

In general, a basic electronic calculator consists of the following components:[2]

- Power source (mains electricity, battery and/or solar cell)
- Keypad (input device) – consists of keys used to input numbers and function commands (addition, multiplication, square-root, etc.)
- Display panel (output device) – displays input numbers, commands and results. Liquid-crystal displays (LCDs), vacuum fluorescent displays (VFDs), and light-emitting diode (LED) displays use seven segments to represent each digit in a basic calculator. Advanced calculators may use dot matrix displays.
  - A printing calculator, in addition to a display panel, has a printing unit that prints results in ink onto a roll of paper, using a printing mechanism.
- Processor chip (microprocessor or central processing unit).

Processor chip's contents

Unit	Function
Scanning (Polling) unit	When a calculator is powered on, it scans the keypad waiting to pick up an electrical signal when a key is pressed.
Encoder unit	Converts the numbers and functions into binary code.
X register and Y register	They are number stores where numbers are stored temporarily while doing calculations. All numbers go into the X register first; the number in the X register is shown on the display
Flag register	The function for the calculation is stored here until the calculator needs it.
Permanent memory (ROM)	The instructions for in-built functions (arithmetic operations, square roots, percentages, trigonometry, etc.) are stored here in binary form. These instructions are *programs*, stored permanently, and cannot be erased.
User memory (RAM)	The store where numbers can be stored by the user. User memory contents can be changed or erased by the user.
Arithmetic logic unit (ALU)	The ALU executes all arithmetic and logic instructions, and provides the results in binary coded form.
Binary decoder unit	Converts binary code into *decimal* numbers which can be displayed on the display unit.

Clock rate of a processor chip refers to the frequency at which the central processing unit (CPU) is running. It is used as an indicator of the processor's speed, and is measured in *clock cycles per second* or the SI unit hertz (Hz). For basic calculators, the speed can vary from a few hundred hertz to the kilohertz range.

Example

An office calculating machine with a paper printer

A basic explanation as to how calculations are performed in a simple four-function calculator:

To perform the calculation 25 + 9, one presses keys in the following sequence on most calculators: 2 5 + 9 =.

- When 2 5 is entered, it is picked up by the scanning unit; the number 25 is encoded and sent to the X register;
- Next, when the + key is pressed, the "addition" instruction is also encoded and sent to the flag or status register;
- The second number 9 is encoded and sent to the X register. This "pushes" (shifts) the first number out into the Y register;
- When the = key is pressed, a "message" (signal) from the flag or status register tells the permanent or non-volatile memory that the operation to be done is "addition";
- The numbers in the X and Y registers are then loaded into the ALU and the calculation is carried out following instructions from the permanent or non-volatile memory;
- The answer, 34 is sent (shifted) back to the X register. From there, it is converted by the binary decoder unit into a decimal number (usually binary-coded decimal), and then shown on the display panel.

Other functions are usually performed using repeated additions or subtractions.

Numeric representation

Most pocket calculators do all their calculations in BCD rather than a floating-point representation. BCD is common in electronic systems where a numeric value is to be displayed, especially in systems consisting solely of digital logic, and not containing a microprocessor. By employing BCD, the manipulation of numerical data for display can be greatly simplified by treating each digit as a separate single sub-circuit. This matches much more closely the physical reality of display hardware—a designer might choose to use a series of separate identical seven-segment displays to build a metering circuit, for example. If the numeric quantity were stored and manipulated as pure binary, interfacing to such a display would require complex circuitry. Therefore, in cases where the calculations are relatively simple, working throughout with BCD can lead to a simpler overall system than converting to and from binary.

The same argument applies when hardware of this type uses an embedded microcontroller or other small processor. Often, smaller code results when representing numbers internally in BCD format, since a conversion from or to binary representation can be expensive on such limited processors. For these applications, some small processors feature BCD arithmetic modes, which assist when writing routines that manipulate BCD quantities.[3][4]

Where calculators have added functions (such as square root, or trigonometric functions), software algorithms are required to produce high precision results. Sometimes significant design effort is needed to fit all the desired functions in the limited memory space available in the calculator chip, with acceptable calculation time.[5]

Calculators compared to computers

The fundamental difference between a calculator and computer is that a computer can be programmed in a way that allows the program to take different branches according to intermediate results, while calculators are pre-designed with specific functions (such as addition, multiplication, and logarithms) built in. The distinction is not clear-cut: some devices classed as programmable calculators have programming functions, sometimes with support for programming languages (such as RPL or TI-BASIC).

For instance, instead of a hardware multiplier, a calculator might implement floating point mathematics with code in read-only memory (ROM), and compute trigonometric functions with the CORDIC algorithm because CORDIC does not require much multiplication. Bit serial logic designs are more common in calculators whereas bit parallel designs dominate general-purpose computers, because a bit serial design minimizes chip complexity, but takes many more clock cycles. This distinction blurs with high-end calculators, which use processor chips associated with computer and embedded systems design, more so the Z80, MC68000, and ARM architectures, and some custom designs specialized for the calculator market.

History

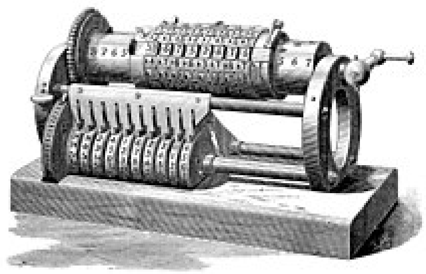
Precursors to the electronic calculator

The first known tools used to aid arithmetic calculations were: bones (used to tally items), pebbles, and counting boards, and the abacus, known to have been used by Sumerians and Egyptians before 2000 BC.[6] Except for the Antikythera mechanism (an "out of the time" astronomical device), development of computing tools arrived near the start of the 17th century: the geometric-military compass (by Galileo), logarithms and Napier bones (by Napier), and the slide rule (by Edmund Gunter).


17th century mechanical calculators

In 1642, the Renaissance saw the invention of the mechanical calculator (by Wilhelm Schickard[7] and several decades later Blaise Pascal[8]), a device that was at times somewhat over-promoted as being able to perform all four arithmetic operations with minimal human intervention.[9] Pascal's Calculator could add and subtract two numbers directly and thus, if the tedium could be borne, multiply and divide by repetition. Schickard's machine, constructed several decades earlier, used a clever set of mechanised multiplication tables to ease the process of multiplication and division with the adding machine as a means of completing this operation. (Because they were different inventions with different aims a debate about whether

Pascal or Schickard should be credited as the "inventor" of the adding machine (or calculating machine) is probably pointless.[10]) Schickard and Pascal were followed by Gottfried Leibniz who spent forty years designing a four-operation mechanical calculator, inventing in the process his leibniz wheel, but who couldn't design a fully operational machine.[11] There were also five unsuccessful attempts to design a calculating clock in the 17th century.[12]



The Grant mechanical calculating machine, 1877

The 18th century saw the arrival of some interesting improvements, first by Poleni with the first fully functional calculating clock and four-operation machine, but these machines were almost always *one of the kind*. It was not until the 19th century and the Industrial Revolution that real developments began to occur. Although machines capable of performing all four arithmetic functions existed prior to the 19th century, the refinement of manufacturing and fabrication processes during the eve of the industrial revolution made large scale production of more compact and modern units possible. The Arithmometer, invented in 1820 as a four-operation mechanical calculator, was released to production in 1851 as an adding machine and became the first commercially successful unit; forty years later, by 1890, about 2,500 arithmometers had been sold[13] plus a few hundreds more from two arithmometer clone makers (Burkhardt, Germany, 1878 and Layton, UK, 1883) and Felt and Tarrant, the only other competitor in true commercial production, had sold 100 comptometers.[14]

It wasn't until 1902 that the familiar push-button user interface was developed, with the introduction of the Dalton Adding Machine, developed by James L. Dalton in the United States.

Patent image of the Clarke graph-based calculator, 1921

In 1921, Edith Clarke invented the "Clarke calculator", a simple graph-based calculator for solving line equations involving hyperbolic functions. This allowed electrical engineers to simplify calculations for inductance and capacitance in power transmission lines.[15]

The Curta calculator was developed in 1948 and, although costly, became popular for its portability. This purely mechanical hand-held device could do addition, subtraction, multiplication and division. By the early 1970s electronic pocket calculators ended manufacture of mechanical calculators, although the Curta remains a popular collectable item.

Development of electronic calculators

The first mainframe computers, using firstly vacuum tubes and later transistors in the logic circuits, appeared in the 1940s and 1950s. This technology was to provide a stepping stone to the development of electronic calculators.

The Casio Computer Company, in Japan, released the Model *14-A* calculator in 1957, which was the world's first all-electric (relatively) compact calculator. It did not use electronic logic but was based on relay technology, and was built into a desk.

Early calculator light-emitting diode (LED) display from the 1970s (USSR)

In October 1961, the world's first *all-electronic desktop* calculator, the British Bell Punch/Sumlock Comptometer ANITA (**A** **N**ew **I**nspiration **T**o **A**rithmetic/**A**ccounting) was announced.[16][17] This machine used vacuum tubes, cold-cathode tubes and Dekatrons in its circuits, with 12 cold-cathode "Nixie" tubes for its display. Two models were displayed, the Mk VII for continental Europe and the Mk VIII for Britain and the rest of the world, both for delivery from early 1962. The Mk VII was a slightly earlier design with a more complicated mode of multiplication, and was soon dropped in favour of the simpler Mark VIII. The ANITA had a full keyboard, similar to mechanical comptometers of the time, a feature that was unique to it and the later Sharp CS-

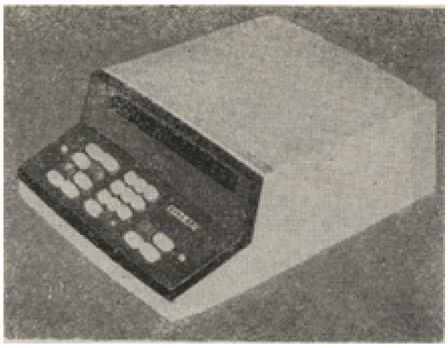
10A among electronic calculators. The ANITA weighed roughly 33 pounds (15 kg) due to its large tube system.[18] Bell Punch had been producing key-driven mechanical calculators of the comptometer type under the names "Plus" and "Sumlock", and had realised in the mid-1950s that the future of calculators lay in electronics. They employed the young graduate Norbert Kitz, who had worked on the early British Pilot ACE computer project, to lead the development. The ANITA sold well since it was the only electronic desktop calculator available, and was silent and quick.

The tube technology of the ANITA was superseded in June 1963 by the U.S. manufactured Friden EC-130, which had an all-transistor design, a stack of four 13-digit numbers displayed on a 5-inch (13 cm) cathode ray tube (CRT), and introduced Reverse Polish Notation (RPN) to the calculator market for a price of $2200, which was about three times the cost of an electromechanical calculator of the time. Like Bell Punch, Friden was a manufacturer of mechanical calculators that had decided that the future lay in electronics. In 1964 more all-transistor electronic calculators were introduced: Sharp introduced the CS-10A, which weighed 25 kilograms (55 lb) and cost 500,000 yen ($4595.89), and Industria Macchine Elettroniche of Italy introduced the IME 84, to which several extra keyboard and display units could be connected so that several people could make use of it (but apparently not at the same time).

There followed a series of electronic calculator models from these and other manufacturers, including Canon, Mathatronics, Olivetti, SCM (Smith-Corona-Marchant), Sony, Toshiba, and Wang. The early calculators used hundreds of germanium transistors, which were cheaper than silicon transistors, on multiple circuit boards. Display types used were CRT, cold-cathode Nixie tubes, and filament lamps. Memory technology was usually based on the delay line memory or the magnetic core memory, though the Toshiba "Toscal" BC-1411 appears to have used an early form of dynamic RAM built from discrete components. Already there was a desire for smaller and less power-hungry machines.

The Olivetti Programma 101 was introduced in late 1965; it was a stored program machine which could read and write magnetic cards and displayed results on its built-in printer. Memory, implemented by an acoustic delay line, could be partitioned between program steps, constants, and data registers. Programming allowed conditional testing and programs could also be overlaid by reading from magnetic cards. It is regarded as the first personal computer produced by a company (that is, a desktop **electronic calculating machine** programmable by non-specialists for personal use). The Olivetti Programma 101 won many industrial design awards.

Another calculator introduced in 1965 was Bulgaria's ELKA 6521,[19][20] developed by the Central Institute for Calculation Technologies and built at the Elektronika factory in Sofia. The name derives from ***EL****ektronen* ***KA****lkulator*, and it weighed around 8 kg (18 lb). It is the first calculator in the world which includes the square root function. Later that same year were released the ELKA 22 (with a luminescent display)[19][21][22] and the ELKA 25, with an in-built printer. Several other models were developed until the first pocket model, the ELKA 101, was released in 1974. The writing on it was in Roman script, and it was exported to western countries.[19][23][24]



The Bulgarian ELKA 22 from 1965

The *Monroe Epic* programmable calculator came on the market in 1967. A large, printing, desk-top unit, with an attached floor-standing logic tower, it could be programmed to perform many computer-like functions. However, the only *branch* instruction was an implied unconditional branch (GOTO) at the end of the operation stack, returning the program to its starting instruction. Thus, it was not possible to include any conditional branch (IF-THEN-ELSE) logic. During this era, the absence of the conditional branch was sometimes used to distinguish a programmable calculator from a computer.

The first handheld calculator was a prototype called "Cal Tech", whose development was led by Jack Kilby at Texas Instruments in 1967. It could add, multiply, subtract, and divide, and its output device was a paper tape.[25][26][27][28][29][30]

1970s to mid-1980s

The electronic calculators of the mid-1960s were large and heavy desktop machines due to their use of hundreds of transistors on several circuit boards with a large power consumption that required an AC power supply. There were great efforts to put the logic required for a calculator into fewer and fewer integrated circuits (chips) and calculator electronics was one of the leading edges of semiconductor development. U.S. semiconductor manufacturers led the world in large scale integration (LSI) semiconductor development, squeezing more and more functions into individual integrated circuits. This led to alliances between Japanese calculatc manufacturers and U.S. semiconductor companies: Canon Inc. with Texas Instruments, Hayakawa Electric (later renamed Sharp Corporation) with North-American Rockwell Microelectronics (later renamed Rockwell International), Busicom with Mostek and Intel, and General Instrument with Sanyo.

Pocket calculators

By 1970, a calculator could be made using just a few chips of low power consumption, allowing portable models powered from rechargeable batteries. The first portable calculators appeared in Japan in 1970, and were soon marketed around the world. These included the Sanyo ICC-0081 "Mini Calculator", the Canon Pocketronic, and the Sharp QT-8B "micro Compet". The Canon Pocketronic was a development of the "Cal-Tech" project which had been started at Texas Instruments in 1965 as a research project to produce a portable calculator. The Pocketronic has no traditional display; numerical output is on thermal paper tape. As a result of the "Cal-Tech" project, Texas Instruments was granted master patents on portable calculators.

Sharp put in great efforts in size and power reduction and introduced in January 1971 the Sharp EL-8, also marketed as the Facit 1111, which was close to being a pocket calculator. It weighed 1.59 pounds (721 grams), had a vacuum fluorescent display, rechargeable NiCad batteries, and initially sold for US $395.

However, the efforts in integrated circuit development culminated in the introduction in early 1971 of the first "calculator on a chip", the MK6010 by Mostek,[31] followed by Texas Instruments later in the year. Although these early hand-held calculators were very costly, these advances in electronics, together with developments in display technology (such as the vacuum fluorescent display, LED, and LCD), led within a few years to the cheap pocket calculator available to all.

In 1971 Pico Electronics.[32] and General Instrument also introduced their first collaboration in ICs, a full single chip calculator IC for the Monroe Royal Digital III calculator. Pico was a spinout by five GI design engineers whose vision was to create single chip calculator ICs. Pico and GI went on to have significant success in the burgeoning handheld calculator market.

The first truly pocket-sized electronic calculator was the Busicom LE-120A "HANDY", which was marketed early in 1971.[33] Made in Japan, this was also the first calculator to use an LED display, the first hand-held calculator to use a single integrated circuit (then proclaimed as a "calculator on a chip"), the Mostek MK6010, and the first electronic calculator to run off replaceable batteries. Using four AA-size cells the LE-120A measures 4.9 by 2.8 by 0.9 inches (124 mm × 71 mm × 23 mm).

The first European-made pocket-sized calculator, DB 800[34][35] is made in May 1971 by Digitron in Buje, Croatia (former Yugoslavia) with four functions and an eight-digit display and special characters for a negative number and a warning that the calculation has too many digits to display.

The first American-made pocket-sized calculator, the Bowmar 901B (popularly termed *The Bowmar Brain*), measuring 5.2 by 3.0 by 1.5 inches (132 mm × 76 mm × 38 mm), came out in the Autumn of 1971, with four functions and an eight-digit red LED display, for $240, while in August 1972 the four-function Sinclair Executive became the first slimline pocket calculator measuring 5.4 by 2.2 by 0.35 inches (137.2 mm × 55.9 mm × 8.9 mm) and weighing 2.5 ounces (71 g). It retailed for around £79 ($106.67). By the end of the decade, similar calculators were priced less than £5 ($6.75).

The first Soviet Union made pocket-sized calculator, the *Elektronika B3-04* was developed by the end of 1973 and sold at the start of 1974.

One of the first low-cost calculators was the Sinclair Cambridge, launched in August 1973. It retailed for £29.95 ($40.44), or £5 ($6.75) less in kit form. The Sinclair calculators were successful because they were far cheaper than the competition; however, their design led to slow and inaccurate computations of transcendental functions.[36]

Meanwhile, Hewlett-Packard (HP) had been developing a pocket calculator. Launched in early 1972, it was unlike the other basic four-function pocket calculators then available in that it was the first pocket calculator with *scientific* functions that could replace a slide rule. The $395 HP-35, along with nearly all later HP engineering calculators, used reverse Polish notation (RPN), also called postfix notation. A calculation like "8 plus 5" is, using RPN, performed by pressing "8", "Enter↑", "5", and "+"; instead of the algebraic infix notation: "8", "+", "5", "=". It had 35 buttons and was based on Mostek Mk6020 chip.

The first Soviet *scientific* pocket-sized calculator the "B3-18" was completed by the end of 1975.

In 1973, Texas Instruments (TI) introduced the SR-10, (*SR* signifying slide rule) an *algebraic entry* pocket calculator using scientific notation for $150. Shortly after the SR-11 featured an added key for entering Pi (π). It was followed the next year by the SR-50 which added log and trig functions to compete with the HP-35, and in 1977 the mass-marketed TI-30 line which is still produced.

In 1978 a new company, Calculated Industries arose which focused on specialized markets. Their first calculator, the Loan Arranger[37] (1978) was a pocket calculator marketed to the Real Estate industry with preprogrammed functions to simplify the process of calculating payments and future values. In 1985, CI launched a calculator for the construction industry called the Construction Master[38] which came preprogrammed with common construction calculations (such as angles, stairs, roofing math, pitch, rise, run, and feet-inch fraction conversions). This would be the first in a line of construction related calculators.

Adler 81S pocket calculator with vacuum fluorescent display (VFD) from the mid-1970s.

The Casio CM-602 Mini electronic calculator provided basic functions in the 1970s.

The 1972 Sinclair Executive pocket calculator.

The HP-35, the world's first scientific pocket calculator by Hewlett Packard (1972).

Programmable calculators

The HP-65, the first programmable pocket calculator (1974)

The first desktop *programmable calculators* were produced in the mid-1960s by Mathatronics and Casio (AL-1000). These machines were very heavy and costly. The first programmable pocket calculator was the HP-65, in 1974; it had a capacity of 100 instructions, and could store and retrieve programs with a built-in magnetic card reader. Two years later the HP-25C introduced *continuous memory*, i.e., programs and data were retained in CMOS memory during power-off. In 1979, HP released the first *alphanumeric*, programmable, *expandable* calculator, the HP-41C. It could be expanded with random access memory (RAM, for memory) and read-only memory (ROM, for software) modules, and peripherals like bar code readers, microcassette and floppy disk drives, paper-roll thermal printers, and miscellaneous communication interfaces (RS-232, HP-IL, HP-IB).

The first Soviet programmable desktop calculator ISKRA 123, powered by the power grid, was released at the start of the 1970s. The first Soviet pocket battery-powered programmable calculator, Elektronika *B3-21*, was developed by the end of 1976 and released at the start of 1977.[39] The successor of B3-21, the Elektronika B3-34 wasn't backward compatible with B3-21, even if it kept the reverse Polish notation (RPN). Thus B3-34 defined a new command set, which later was used in a series of later programmable Soviet calculators. Despite very limited abilities (98 bytes of instruction memory and about 19 stack and addressable registers), people managed to write all kinds of programs for them, including adventure games and libraries of calculus-related functions for engineers. Hundreds, perhaps thousands, of programs were written for these machines, from practical scientific and business software, which were used in real-life offices and labs, to fun games for children. The Elektronika MK-52 calculator (using the extended B3-34 command set, and featuring internal EEPROM memory for storing programs and external interface for EEPROM cards and other periphery) was used in Soviet spacecraft program (for Soyuz TM-7 flight) as a backup of the board computer.

This series of calculators was also noted for a large number of highly counter-intuitive mysterious undocumented features, somewhat similar to "synthetic programming" of the American HP-41, which were exploited by applying normal arithmetic operations to error messages, jumping to nonexistent addresses and other methods. A number of respected monthly publications, including the popular science magazine *Nauka i Zhizn* (*Наука и жизнь*, *Science and Life*), featured special columns, dedicated to optimization methods for calculator programmers and updates on undocumented features for hackers, which grew into a whole esoteric science with many branches, named "yeggogology" ("еггогология"). The error messages on those calculators appear as a Russian word "YEGGOG" ("ЕГГОГ") which, unsurprisingly, is translated to "Error".

A similar hacker culture in the USA revolved around the HP-41, which was also noted for a large number of undocumented features and was much more powerful than B3-34.

Technical improvements

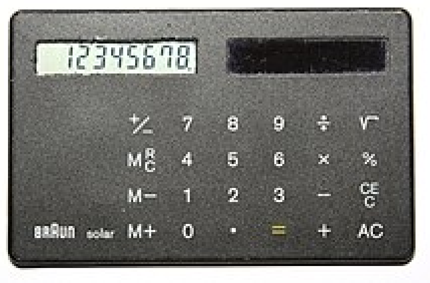
A calculator which runs on solar and battery power

Through the 1970s the hand-held electronic calculator underwent rapid development. The red LED and blue/green vacuum fluorescent displays consumed a lot of power and the calculators either had a short battery life (often measured in hours, so rechargeable nickel-cadmium batteries were common) or were large so that they could take larger, higher capacity batteries. In the early 1970s liquid-crystal displays (LCDs) were in their infancy and there was a great deal of concern that they only had a short operating lifetime. Busicom introduced the Busicom *LE-120A "HANDY"* calculator, the first pocket-sized calculator and the first with an LED display, and announced the Busicom *LC* with LCD. However, there were problems with this display and the calculator never went on sale. The first successful calculators with LCDs were manufactured by Rockwell International and sold from 1972 by other companies under such names as: Dataking *LC-800*, Harden *DT/12*, Ibico *086*, Lloyds *40*, Lloyds *100*, Prismatic *500* (a.k.a. *P500*), Rapid Data *Rapidman 1208LC*. The LCDs were an early form using the *Dynamic Scattering*

Mode DSM with the numbers appearing as bright against a dark background. To present a high-contrast display these models illuminated the LCD using a filament lamp and solid plastic light guide, which negated the low power consumption of the display. These models appear to have been sold only for a year or two.

A more successful series of calculators using a reflective DSM-LCD was launched in 1972 by Sharp Inc with the Sharp *EL-805*, which was a slim pocket calculator. This, and another few similar models, used Sharp's *Calculator On Substrate* (COS) technology. An extension of one glass plate needed for the liquid crystal display was used as a substrate to mount the needed chips based on a new hybrid technology. The COS technology may have been too costly since it was only used in a few models before Sharp reverted to conventional circuit boards.

In the mid-1970s the first calculators appeared with field-effect, *twisted nematic* (TN) LCDs with dark numerals against a grey background, though the early ones often had a yellow filter over them to cut out damaging ultraviolet rays. The advantage of LCDs is that they are passive light modulators reflecting light, which require much less power than light-emitting displays such as LEDs or VFDs. This led the way to the first credit-card-sized calculators, such as the Casio *Mini Card LC-78* of 1978, which could run for months of normal use on button cells.

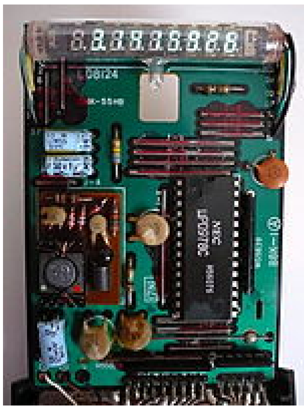


Credit-card-sized, solar-powered calculator by Braun (1987)

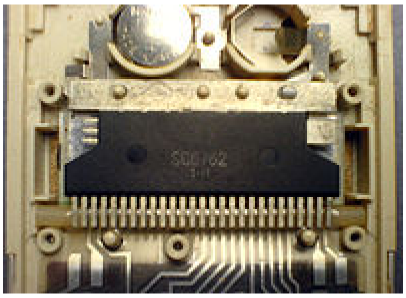
There were also improvements to the electronics inside the calculators. All of the logic functions of a calculator had been squeezed into the first "calculator on a chip" integrated circuits (ICs) in 1971, but this was leading edge technology of the time and yields were low and costs were high. Many calculators continued to use two or more ICs, especially the scientific and the programmable ones, into the late 1970s.

The power consumption of the integrated circuits was also reduced, especially with the introduction of CMOS technology. Appearing in the Sharp "EL-801" in 1972, the transistors in the logic cells of CMOS ICs only used any appreciable power when they changed state. The LED and VFD displays often required added driver transistors or ICs, whereas the LCDs were more amenable to being driven directly by the calculator IC itself.

With this low power consumption came the possibility of using solar cells as the power source, realised around 1978 by calculators such as the Royal *Solar 1*, Sharp *EL-8026*, and Teal *Photon*.

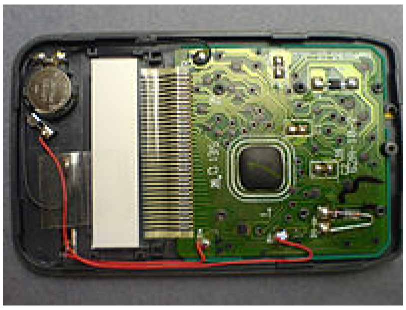


The interior of a Casio fx-20 scientific calculator from the mid-1970s, using a VFD. The processor integrated circuit (IC) is made by NEC. Discrete electronic components like capacitors and resistors and the IC are mounted on a printed circuit board (PCB). This calculator uses a battery pack as a power source.



The processor chip (integrated circuit package) inside a 1981 Sharp pocket calculator, marked SC6762 1•H. An LCD is directly under the chip. This was a PCB-less design. No discrete components are used. The battery compartment at the top can hold two button cells.

Inside a Casio scientific calculator from the mid-1990s, showing the processor chip (small square, top-middle, left), keypad contacts, right (with matching contacts on the left), the back of the LCD (top, marked 4L102E), battery compartment, and other components. The solar cell assembly is under the chip.



The interior of a newer (ca. 2000) pocket calculator. It uses a button battery in combination with a solar cell. The processor is a "Chip on Board" type, covered with darkepoxy.

Mass market phase

At the start of the 1970s, hand-held electronic calculators were very costly, at two or three weeks' wages, and so were a luxury item. The high price was due to their construction requiring many mechanical and electronic components which were costly to produce, and production runs that were too small to exploit economies of scale. Many firms saw that there were good profits to be made in the calculator business with the margin on such high prices. However, the cost of calculators fell as components and their production methods improved, and the efect of economies of scale was felt.

By 1976, the cost of the cheapest four-function pocket calculator had dropped to a few dollars, about 1/20th of the cost five years before. The results of this were that the pocket calculator was affordable, and that it was now difficult for the manufacturers to make a profit from calculators, leading to many firms dropping out of the business or closing down. The firms that survived making calculators tended to be those with high outputs of higher quality calculators, or producing high-specification scientific and programmable calculators.

Mid-1980s to present

The first calculator capable of symbolic computing was the HP-28C, released in 1987. It could, for example, solve quadratic equations symbolically. The first graphing calculator was the Casio fx-7000G released in 1985.

The Elektronika MK-52 was a programmable RPN-style calculator that accepted extension modules; it was manufactured in the Soviet Union from 1985 to 1992

The two leading manufacturers, HP and TI, released increasingly feature-laden calculators during the 1980s and 1990s. At the turn of the millennium, the line between a graphing calculator and a handheld computer was not always clear, as some very advanced calculators such as the TI-89, the Voyage 200 and HP-49G could differentiate and integrate functions, solve differential equations, run word processing and PIM software, and connect by wire or IR to other calculators/computers.

The HP 12c financial calculator is still produced. It was introduced in 1981 and is still being made with few changes. The HP 12c featured the reverse Polish notation mode of data entry. In 2003 several new models were released, including an improved version of the HP 12c, the "HP 12c platinum edition" which added more memory, more built-in functions, and the addition of the algebraic mode of data entry

Calculated Industries competed with the HP 12c in the mortgage and real estate markets by differentiating the key labeling; changing the “I”, “PV”, “FV” to easier labeling terms such as "Int", "Term", "Pmt", and not using the reverse Polish notation. However, CI's more successful calculators involved a line of construction calculators, which evolved and expanded in the 1990s to present. According to Mark Bollman,[40] a mathematics and calculator historian and associate professor of mathematics at Albion College, the "Construction Master is the first in a long and profitable line of CI construction calculators" which carried them through the 1980s, 1990s, and to the present.

Personal computers often come with a calculator utility program that emulates the appearance and functions of a calculator, using the graphical user interface to portray a calculator. One such example is Windows Calculator. Most personal data assistants (PDAs) and smartphones also have such a feature.

Use in education

In most countries, students use calculators for schoolwork. There was some initial resistance to the idea out of fear that basic or elementary arithmetic skills would suffer. There remains disagreement about the importance of the ability to perform calculations *in the head*, with some curricula restricting calculator use until a certain level of proficiency has been obtained, while others concentrate more on teaching estimation methods and problem-solving. Research suggests that inadequate guidance in the use of calculating tools can restrict the kind of mathematical thinking that students engage in.[41] Others have argued that calculator use can even cause core mathematical skills to atrophy, or that such use can prevent understanding of advanced algebraic concepts.[42] In December 2011 the UK's Minister of State for Schools, Nick Gibb, voiced concern that children can become "too dependent" on the use of calculators.[43] As a result, the use of calculators is to be included as part of a review of the Curriculum.[43] In United States, many math educators and boards of education enthusiastically endorsed the National Council of Teachers of Mathematics (NCTM) standards and actively promoted the use of classroom calculators from kindergarten through high school.

See also

- Calculator spelling
- Comparison of HP graphing calculators
- Comparison of Texas Instruments graphing calculators
- Formula calculator
- History of computing hardware
- List of HP calculators
- Scientific calculator
- Software calculator
- Solar-powered calculator
- Photomath

Notes

1. "The World's Technological Capacity to Store, Communicate, and Compute Information" (http://www.sciencemag.org/content/332/6025/60) Archived (https://web.archive.org/web/20130727161911/http://www.sciencemag.org/content/332/6025/60) 2013-07-27 at the Wayback Machine, Martin Hilbert and Priscila López (2011), Science (journal), 332(6025), 60–65; see also "free access to the study" (http://www.martinhilbert.net/WorldInfoCapacity.html) Archived (https://web.archive.org/web/20160414233810/http://www.martinhilbert.net/WorldInfoCapacity.html/) 2016-04-14 at the Wayback Machine.
2. John Lewis, *The Pocket Calculator Book* (London: Usborne, 1982)
3. University of Alicante. "A Cordic-based Architecture for High Performance Decimal Calculations" (http://rua.ua.es/dspace/bitstream/10045/11826/1/VF-016519.pdf) (PDF). IEEE. Archived (https://web.archive.org/web/20160303235832/http://rua.ua.es/dspace/bitstream/10045/11826/1/VF-016519.pdf) (PDF) from the original on 2016-03-03. Retrieved 2015-08-15.
4. "Decimal CORDIC Rotation based on Selection by Rounding: Algorithm and Architecture" (http://faculties.sbu.ac.ir/~jaberipur/Papers/Journals/19.pdf) (PDF). British Computer Society. Retrieved 2015-08-14.
5. "David S. Cochran, "Algorithms and accuracy in the HP35", "Hewlett Packard Journal", June 1972" (http://www.hpl.hp.com/hpjournal/72jun/jun72a2.pdf) (PDF). Archived (https://web.archive.org/web/20131004225515/http://www.hpl.hp.com/hpjournal/72jun/jun72a2.pdf) (PDF) from the original on 2013-10-04. Retrieved 2013-10-03.
6. Ifrah 2001:11
7. See for example, http://calculatorhistory.net
8. Pascal's invention of the calculating machine, Pascal invented his machine just four hundred years ago, as a youth of nineteen. He was spurred to it by sharing the burden of arithmetical labor involved in his father's official work as supervisor of taxes at Rouen. He conceived the idea of doing the work mechanically, and developed a design appropriate for this purpose ; showing herein the same combination of pure science and mechanical genius that characterized his whole life. But it was one thing to conceive and design the machine, and another to get it made and put into use. Here were needed those practical gifts that he displayed later in his inventions....
   In a sense, Pascal's invention was premature, in that the mechanical arts in his time were not sufficiently advanced to enable his machine to be made at an economic price, with the accuracy and strength needed for reasonably long use. This difficulty was not overcome until well on into the nineteenth century, by which time also a renewed stimulus to invention was given by the need for many kinds of calculation more intricate than those considered by Pascal. S. Chapman, Magazine Nature, pp.508,509 (1942)
9. "Pascal and Leibnitz, in the seventeenth century, and Diderot at a later period, endeavored to construct a machine which might serve as a substitute for human intelligence in the combination of figures" The Gentleman's magazine, Volume 202, p.100 (https://books.google.com/books?id=Rf0IAAAAIAAJ&pg=PA100&dq=arithmometer&as_brr=1#v=onepage&q=arithmometer&f=false) Archived (https://web.archive.org/web/20171106145057/https://books.google.com/books?id=Rf0IAAAAIAAJ&pg=PA100&dq=arithmometer&as_brr=1) 2017-11-06 at the Wayback Machine.

10. See Pascal vs Schickard: An empty debate? (http://metastudies.net/pmwiki/pmwiki.php?n=Site.SchicardvsPascal) Archived (https://web.archive.org/web/20140408215848/http://metastudies.net/pmwiki/pmwiki.php?n=Site.SchicardvsPascal) 2014-04-08 at the Wayback Machine.
11. In 1893, the German calculating machine inventor Arthur Burkhardt was asked to put Leibniz machine in operating condition if possible. His report was favorable except for the sequence in the carry. Ginsburg, Jekuthiel (1933). *Scripta Mathematica*. Kessinger Publishing, LLC. p. 149. ISBN 978-0-7661-3835-3.
12. see Mechanical calculator#Calculating clocks: unsuccessful mechanical calculators
13. "(retrieved on 01/02/2012)" (http://www.arithmometre.org/NumerosSerie/PageNumerosSeriePayen.html) (in French). Arithmometre.org. Archived (https://web.archive.org/web/20130521075617/http://www.arithmometre.org/NumerosSerie/PageNumerosSeriePayen.html) from the original on 2013-05-21. Retrieved 2013-10-03.
14. Felt, Dorr E. (1916). *Mechanical arithmetic, or The history of the counting machine* (https://archive.org/details/mechanicalarithm00feltrich). Chicago: Washington Institute. p. 4. Archived (https://web.archive.org/web/20160703013921/https://archive.org/details/mechanicalarithm00feltrich) from the original on 2016-07-03.
15. Lott, Melissa C. "The Engineer Who Foreshadowed the Smart Grid--in 1921" (https://blogs.scientificamerican.com/plugged-in/the-engineer-who-foreshadowed-the-smart-grid-in-1921/). *Plugged In*. Scientific American Blog Network. Archived (https://web.archive.org/web/20170814232626/https://blogs.scientificamerican.com/plugged-in/the-engineer-who-foreshadowed-the-smart-grid-in-1921/) from the original on 14 August 2017. Retrieved 14 August 2017.
16. "Simple and Silent", *Office Magazine*, December 1961, p1244
17. "'Anita' der erste tragbare elektonische Rechenautomat" [trans: "the first portable electronic computer"], *Büromaschinen Mechaniker*, November 1961, p207
18. Ball, Guy; Flamm, Bruce. "The History of Pocket Electronic Calculators" (http://www.vintagecalculators.com/html/history_of_electronic_calculat.html). *vintagecalculators.com*. Vintage Calculators Web Museum. Archived (https://web.archive.org/web/20140703140814/http://vintagecalculators.com/html/history_of_electronic_calculat.html) from the original on 3 July 2014. Retrieved 8 July 2014.
19. The Bulgarian ELKA electronic calculators (http://clockwiser.wordpress.com/2012/01/10/elka-hist/) Archived (https://web.archive.org/web/20131023023224/http://clockwiser.wordpress.com/2012/01/10/elka-hist/) 2013-10-23 at the Wayback Machine., *Clockwiser*. Retrieved Oct 2013.
20. ELKA 6521 (photo) (http://clockwiser.files.wordpress.com/2012/01/elka6521.jpg) Archived (https://web.archive.org/web/20131023023226/http://clockwiser.files.wordpress.com/2012/01/elka6521.jpg) 2013-10-23 at the Wayback Machine.. Retrieved October 2013.
21. ELKA 22 (photo) (http://clockwiser.files.wordpress.com/2012/01/elka22-2.jpg) Archived (https://web.archive.org/web/20131023023227/http://clockwiser.files.wordpress.com/2012/01/elka22-2.jpg) 2013-10-23 at the Wayback Machine.. Retrieved Oct 2013.
22. ELKA 22, Bulgarian Calculator (http://rk86.com/frolov/elka22.htm) Archived (https://web.archive.org/web/20150526055144/http://rk86.com/frolov/elka22.htm) 2015-05-26 at the Wayback Machine., *Soviet digital calculators collection (http://rk86.com/frolov/) Archived (https://web.archive.org/web/20071220022647/http://rk86.com/frolov/) 2007-12-20 at the Wayback Machine*. Retrieved Oct 2013.
23. ELKA 100 series (photos) (http://clockwiser.wordpress.com/2012/01/10/elka-101-135-series/) Archived (https://web.archive.org/web/20131023023222/http://clockwiser.wordpress.com/2012/01/10/elka-101-135-series/) 2013-10-23 at the Wayback Machine., (photo) (http://clockwiser.files.wordpress.com/2012/01/elka100-series.jpg) Archived (https://web.archive.org/web/20131023023229/http://clockwiser.files.wordpress.com/2012/01/elka100-series.jpg) 2013-10-23 at the Wayback Machine., *Clockwiser. Retrieved Oct 2013.*
24. ELKA 101 description (http://www.vintagecalculators.com/html/elka_101.html) Archived (https://web.archive.org/web/20131016092534/http://www.vintagecalculators.com/html/elka_101.html) 2013-10-16 at the Wayback Machine., *Vintage Calculators*. Retrieved Oct 2013.
25. Texas Instruments Celebrates the 35th Anniversary of Its Invention of the Calculator (http://education.ti.com/educationportal/sites/US/nonProductSingle/about_press_release_news37.html) Archived (https://web.archive.org/web/20080627144010/http://education.ti.com/educationportal/sites/US/nonProductSingle/about_press_release_news37.html) 2008-06-27 at the Wayback Machine. Texas Instruments press release, 15 August 2002.
26. Electronic Calculator Invented 40 Years Ago (http://www.npr.org/templates/story/story.php?storyId=14845433) Archived (https://web.archive.org/web/20081205151504/http://www.npr.org/templates/story/story.php?storyId=14845433) 2008-12-05 at the Wayback Machine. All Things Considered, NPR, 30 September 2007. Audio interview with one of the inventors.

27. "50 Jahre Taschenrechner - Die Erfindung, die niemand haben wollte" (http://www.faz.net/aktuell/wirtschaft/wirtschaftswissen/50-jahre-taschenrechner-die-erfindung-die-niemand-haben-wollte-14944569.html) [50th anniversary of calculators - the invention not wanted by anyone]. *Wirtschaft* (in German). Frankfurter Allgemeine Zeitung (FAZ). 2017-03-27. Archived (https://web.archive.org/web/20170329202602/http://www.faz.net/aktuell/wirtschaft/wirtschaftswissen/50-jahre-taschenrechner-die-erfindung-die-niemand-haben-wollte-14944569.html) from the original on 2017-03-29. Retrieved 2017-03-30.
28. "The first calculators - How they got into your pocket" (https://www.dropbox.com/s/bwwc9q3y090o2r8/How_the_Computer_Got_Into_Your_Pocket.pdf) (PDF). *American Heritage of Invention & Technology*. **15** (4). 2000. Retrieved 2017-03-30.
29. Reid, T. R. (July 1982). "The Texas Edison". *Texas Monthly*.
30. "The First Handheld Digital Calculator Celebrates 50 Years" (http://electronicdesign.com/analog/first-handheld-digital-calculator-celebrates-50-years-part-1). Archived (https://web.archive.org/web/20170413153616/http://electronicdesign.com/analog/first-handheld-digital-calculator-celebrates-50-years-part-1) from the original on 2017-04-13.
31. "Single Chip Calculator Hits the Finish Line", *Electronics*, February 1, 1971, p19
32. "Microprocessor History" (https://web.archive.org/web/20110720142104/http://www.spingal.plus.com/micro/). Spingal.plus.com. Archived from the original (http://www.spingal.plus.com/micro) on 2011-07-20. Retrieved 2011-07-19.
33. "The one-chip calculator is here, and it's only the beginning", Electronic Design, February 18, 1971, p34.
34. "epocalc - Calculators" (http://www.epocalc.net/pages/calc_premieres). Archived (https://web.archive.org/web/20161028020141/http://www.epocalc.net/pages/calc_premieres) from the original on 28 October 2016. Retrieved 30 December 2016.
35. "U Bujama je izrađen prvi europski džepni kalkulator. Te 1971. koštao je koliko i fićo" (http://www.jutarnji.hr/40--rodendan-digitrona--u-bujama-je-izraden-prvi-europski-dzepni-kalkulator--te-1971-kostao-je-koliko-i-fico/954368/). Archived (https://web.archive.org/web/20160304003213/http://www.jutarnji.hr/40--rodendan-digitrona--u-bujama-je-izraden-prvi-europski-dzepni-kalkulator--te-1971-kostao-je-koliko-i-fico/954368/) from the original on 4 March 2016. Retrieved 30 December 2016.
36. Reversing Sinclair's amazing 1974 calculator hack – half the ROM of the HP-35 (http://righto.com/sinclair) Ken Shirriff, 2013. See in particular the section "Limited performance and accuracy". For more coverage of Shirriff's results, see Sharwood, Simon (September 2, 2013), "Google chap reverse engineers Sinclair Scientific Calculator" (https://www.theregister.co.uk/2013/09/02/google_chap_reverse_engineers_sinclair_scientific_calculator/), *The Register*, archived (https://web.archive.org/web/20170823073444/https://www.theregister.co.uk/2013/09/02/google_chap_reverse_engineers_sinclair_scientific_calculator/) from the original on August 23, 2017
37. "The Loan Arranger II" (http://mathcs.albion.edu/~mbollman/CI/loanarranger2.htm). Mathcs.albion.edu. Archived (https://web.archive.org/web/20110719134735/http://mathcs.albion.edu/~mbollman/CI/loanarranger2.htm) from the original on 2011-07-19. Retrieved 2011-07-19.
38. "Construction Master" (http://mathcs.albion.edu/~mbollman/CI/CM.htm). Mathcs.albion.edu. Archived (https://web.archive.org/web/20110719135006/http://mathcs.albion.edu/~mbollman/CI/CM.htm) from the original on 2011-07-19. Retrieved 2011-07-19.
39. http://electronika-5.ru/calc/doc/B3-21_pas.rar
40. Mark Bollman. "Mark->'s Calculator Collection" (http://mathcs.albion.edu/~mbollman/Calculators.html). Mathcs.albion.edu. Archived (https://web.archive.org/web/20110719135244/http://mathcs.albion.edu/~mbollman/Calculators.html) from the original on 2011-07-19. Retrieved 2011-07-19.
41. Thomas J. Bing, Edward F. Redish (2007-12-07). "Symbolic Manipulators Affect Mathematical Mindsets" (https://web.archive.org/web/20160414233812/http://arxiv.org/abs/0712.1187). Archived from the original (https://arxiv.org/abs/0712.1187) on 2016-04-14.
42. "Calculator Use in Elementary Grades" (http://www.nctm.org/Standards-and-Positions/Position-Statements/Calculator-Use-in-Elementary-Grades/). *NCTM*. Archived (https://web.archive.org/web/20150905072126/http://www.nctm.org/Standards-and-Positions/Position-Statements/Calculator-Use-in-Elementary-Grades/) from the original on 5 September 2015. Retrieved 3 August 2015.

43. Vasagar, Jeevan; Shepherd, Jessica (December 1, 2011). "Subtracting calculators adds to children's maths abilities, says minister" (https://www.theguardian.com/education/2011/dec/01/subtracting-calculators-adds-children-maths). *The Guardian*. London. Archived (https://web.archive.org/web/20160309100226/http://www.theguardian.com/education/2011/dec/01/subtracting-calculators-adds-children-maths) from the original on March 9, 2016. Retrieved December 7, 2011. "The use of calculators will be looked at as part of a national curriculum review, after the schools minister, Nick Gibb, expressed concern that children's mental and written arithmetic was suffering because of reliance on the devices. Gibb said: "Children can become too dependent on calculators if they use them at too young an age. They shouldn't be reaching for a gadget every time they need to do a simple sum. [...]""

References

- Hamrick, Kathy B. (October 1996). "The History of the Hand-Held Electronic Calculator". *The American Mathematical Monthly*. The American Mathematical Monthly, Vol. 103, No. 8. **103** (8): 633–639. doi:10.2307/2974875. JSTOR 2974875.
- Marguin, Jean (1994). *Histoire des instruments et machines à calculer, trois siècles de mécanique pensante 1642–1942* (in French). Hermann. ISBN 978-2-7056-6166-3.
- Williams, Michael R. (1997). *History of Computing Technology*. Los Alamitos, California: IEEE Computer Society. ISBN 0-8186-7739-2.
- Ifrah, Georges (2001). *The Universal History of Computing*. John Wiley & Sons, Inc. ISBN 0-471-39671-0.
- Prof. S. Chapman (October 31, 1942). "Blaise Pascal (1623–1662) Tercentenary of the calculating machine". *Nature*. London. **150**: 508–509. doi:10.1038/150508a0.

Further reading

- U.S. Patent 2,668,661 – *Complex computer* – G. R. Stibitz, Bell Laboratories, 1954 (filed 1941, refiled 1944), electromechanical (relay) device that could calculate complex numbers, record, and print results.
- U.S. Patent 3,819,921 – *Miniature electronic calculator* – J. S. Kilby, Texas Instruments, 1974 (originally filed 1967), handheld (3 pounds (1.4 kg)) battery operated electronic device with thermal printer
  - The Japanese Patent Office granted a patent in June 1978 to Texas Instruments (TI) based on US patent 3819921, notwithstanding objections from 12 Japanese calculator manufacturers. This gave TI the right to claim royalties retroactively to the original publication of the Japanese patent application in August 1974. A TI spokesman said that it would actively seek what was due, either in cash or technology cross-licensing agreements. 19 other countries, including the United Kingdom, had already granted a similar patent to Texas Instruments. – *New Scientist*, 17 August 1978 p455, and *Practical Electronics* (British publication), October 1978 p1094.
- U.S. Patent 4,001,566 – *Floating Point Calculator With RAM Shift Register* – 1977 (originally filed GB March 1971, US July 1971), very early single chip calculator claim.
- U.S. Patent 5,623,433 – *Extended Numerical Keyboard with Structured Data-Entry Capability* – J. H. Redin, 1997 (originally filed 1996), Usage of Verbal Numerals as a way to enter a number.
- European Patent Office Database – Many patents about mechanical calculators are in classifications G06C15/04, G06C15/06, G06G3/02, G06G3/04
- ^ *Collectors Guide to Pocket Calculators* by Guy Ball and Bruce Flamm, 1997, ISBN 1-888840-14-5 – includes an extensive history of early pocket calculators and highlights over 1,500 different models from the early 1970s. Book still in print.

External links

- On TI's US Patent No. 3819921 – at TI website
- 30th Anniversary of the Calculator – From Sharp's web presentation of its history; including a picture of the CS-10A desktop calculator
- "Things that Count: the rise and fall of calculators"
- The Old Calculator Web Museum – Documents the technology of desktop calculators, mainly early electronics
- History of Mechanical Calculators
- Vintage Calculators Web Museum – Shows the development from mechanical calculators to pocket electronic calculators
- The Museum of HP calculators (slide rules/mech. section)
- Microprocessor and single chip calculator history; foundations in Glenrothes, Scotland

- HP-35 – A thorough analysis of the HP-35 firmware including the Cordic algorithms and the bugs in the early ROM
- Bell Punch Company and the development of the Anita calculator – The story of the first electronic desktop calculator
- Epocalc computers & calculators manufacturers database – List of calculator manufacturers
- Dentaku-Museum (in Japanese) - Shows mainly Japanese calculators but also others.

WIKIPEDIA

Digital clock

A **digital clock** is a type of clock that displays the time digitally (i.e. in numerals or other symbols), as opposed to an analog clock, where the time is indicated by the positions of rotating hands.

Basic digital alarm clock without a radio. The mark in the top-left of the display indicates that the time is 4:00pm, not 4:00am.

Digital clocks are often associated with electronic drives, but the "digital" description refers only to the display, not to the drive mechanism. (Both analog and digital clocks can be driven either mechanically or electronically, but "clockwork" mechanisms with digital displays are rare.) The biggest digital clock is the *Lichtzelt Pegel* ("Light Time Level") on the television tower Rheinturm Düsseldorf, Germany.

A 1969 radio alarm clock (Sony Digimatic 8FC-59W) with an early mechanical-digital display

Contents

History

The first digital pocket watch was the invention of Austrian engineer Josef Pallweber who created his "jump-hour" mechanism in 1883. Instead of a conventional dial, the jump-hour featured two windows in an enamel dial, through which the hours and minutes ar visible on rotating discs. The second hand remained conventional. By 1885 Pallweber mechanism was already on the market in pocket watches by Cortébert and IWC; arguably contributing to the subsequent rise and commercial success of IWC. The principles of Pallweber jump-hour movement had appeared in wristwatches by the 1920s (Cortébert) and are still used today (Chronoswiss Digiteur). While the original inventor didn't have a watch brand at the time, his name has since been resurrected by a newly established watch manufacturer.[1]

Plato clocks used a similar idea but a different layout. These spring-wound pieces consisted of a glass cylinder with a column inside, affixed to which were small digital cards with numbers printed on them, which flipped as time passed. The Plato clocks were introduced at the St. Louis World Fair in 1904, produced by Ansonia Clock Company. Eugene Fitch of New York patented the clock design in 1903.[2] 13 years earlier Josef Pallweber had patented the same invention using digital cards (different from his 1885 patent using moving disks) in Germany (DRP No. 54093).[3] The German factory Aktiengesellschaft für Uhrenfabrikation Lenzkirch made such digital clocks in 1893 and 1894.[4]

The earliest patent for a digital alarm clock was registered by D.E Protzmann and others on October 23, 1956, in the United States. Protzmann and his associates also patented another digital clock in 1970, which was said to use a minimal amount of moving parts. Two side-plates held digital numerals between them, while an electric motor and cam gear outside controlled movement.[2]

In 1970, the first digital wristwatch with an LED display was mass-produced. Called the Pulsar, and produced by the Hamilton Watch Company, this watch was hinted at two years prior when the same company created a prototype digital watch for Kubrick's *2001: A Space Odyssey*.[5] Throughout the 1970s, despite the initial hefty cost of digital watches, the popularity of said devices steadily rose.

Over the years, many different types of digital alarm clocks have been developed.

In Soviet Russia, the 7-segment digital clocks were known as Elektronika 7.

Construction

Digital clocks typically use the 50 or 60 hertz oscillation of AC power or a 32,768 hertz crystal oscillator as in a quartz clock to keep time. Most digital clocks display the hour of the day in 24-hour format; in the United States and a few other countries, a more commonly used hour sequence option is 12-hour format (with some indication of AM or PM). Some timepieces, such as many digital watches, can be switched between 12-hour and 24-hour modes. Emulations of analog-style faces often use an LCD screen, and these are also sometimes described as "digital".

Displays

A digital clock's display changing numbers

To represent the time, most digital clocks use a seven-segment LED, VFD, or LCD for each of four digits. They generally also include other elements to indicate whether the time is AM or PM, whether or not an alarm is set, and so on.

Setting

If people find difficulty in setting the time in some designs of digital clocks in electronic devices where the clock is not a critical function, they may not be set at all, displaying the default after powered on, 00:00 or 12:00.[6][7]

Digital clocks that run on mains electricity and have no battery must be reset every time the power has an accident or if they are moved. Even if power is cut off for a second, most clocks will still have to be reset. This is a particular problem with alarm clocks that have no "battery" backup, because even a very brief power outage during the night usually results in the clock failing to trigger the alarm in the morning.

To reduce the problem, many devices designed to operate on household electricity incorporate a battery backup to maintain the time during power outages and during times of disconnection from the power supply. More recently, some devices incorporate a method for automatically setting the time, such as using a broadcast radio time signal from an atomic clock, getting the time from an existing satellite television or computer connection, or by being set at the factory and then maintaining the time from then on with a quartz movement powered by an internal rechargeable battery. Commercial digital clocks are typically more reliable than consumer clocks. Multi-decade backup batteries can be used to maintain time during power loss.

An LCD battery-operated clock without alarm

A premium digital clock radio with digital tuning

A basic digital clock radio with analog tuning

Uses

A digital clock built into an oven

Because digital clocks can be very small and inexpensive devices that enhance the popularity of product designs, they are often incorporated into all kinds of devices such as cars, radios, televisions, microwave ovens, standard ovens, computers and cell phones. Sometimes their usefulness is disputed: a common complaint is that when time has to be set to Daylight Saving Time, many household clocks have to be readjusted. The incorporation of automatic synchronization by a radio time signal is reducing this problem (see Radio clock).

A digital light clock that can determine room temperature

References

1. "Home page" (http://www.josefpallweber.com/). *JosefPallweber.com*. Archived (https://web.archive.org/web/20151001065436/http://www.josefpallweber.com/) from the original on 2015-10-01 Retrieved 2015-11-07.

2. Churm, Thomas M. (November 5, 2013). "A Short History of Digital Clocks and Watches" (http://blog.onlineclock.net/history-of-digital-clocks-watches/). *Alarm Clock Blog*. Archived (https://web.archive.org/web/20160301032625/http://blog.onlineclock.net/history-of-digital-clocks-watches/) from the original on March 1, 2016. Retrieved 2016-02-28.
3. (in German) Imperial Patent Office (October 27, 1890). "Patent No. 54093" (https://depatisnet.dpma.de/DepatisNet/depatisnet?window=1&space=menu&content=treffer&action=pdf&docid=DE000000054093A) (PDF). *German Patent and Trademark Office*. Retrieved 2015-11-07.
4. "Is digital more precise?" (http://www.deutsches-uhrenmuseum.de/en/museum/items-of-the-month/item-of-the-month-april-2015.html). *The German Clock Museum*. April 2015. Archived (https://web.archive.org/web/20150923213945/http://www.deutsches-uhrenmuseum.de/en/museum/items-of-the-month/item-of-the-month-april-2015.html) from the original on 2015-09-23. Retrieved 2015-11-07.
5. "The History of the Digital Watch" (http://h2g2.com/edited_entry/A1006534). *h2g2*. April 30, 2003. Archived (https://web.archive.org/web/20151106061115/http://h2g2.com/edited_entry/A1006534) from the original on November 6, 2015. Retrieved 2015-11-07.
6. "Radio Controlled LED Alarm Clock Instruction Manual — SM2442" (http://www.zeonltd.co.uk/instructions/Gifts%20and%20Gadgets/Science%20Museum/SM2442%20-%20R.C%20LED%20Alarm%20Clock.pdf) (DOC). Zeon Ltd. Archived (https://web.archive.org/web/20160303231702/http://www.zeonltd.co.uk/instructions/Gifts%20and%20Gadgets/Science%20Museum/SM2442%20-%20R.C%20LED%20Alarm%20Clock.pdf) (PDF) from the original on 2016-03-03. Retrieved 2015-11-07.
7. "Stopped Clock" (http://tvtropes.org/pmwiki/pmwiki.php/Main/StoppedClock). *TV Tropes*. Archived (https://web.archive.org/web/20151105101518/http://tvtropes.org/pmwiki/pmwiki.php/Main/StoppedClock) from the original on 2015-11-05. Retrieved 2015-11-07.

External links

- How Digital Clocks Work
- History of the Digital Watch
- Museum of Vintage Rare Digital LCD Wrist Watches

Retrieved from "https://en.wikipedia.org/w/index.php?title=Digital_clock&oldid=822252331"

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Digital Computers

A Digital computer can be considered as a digital system that performs various computational tasks.

The first electronic digital computer was developed in the late 1940s and was used primarily for numerical computations.

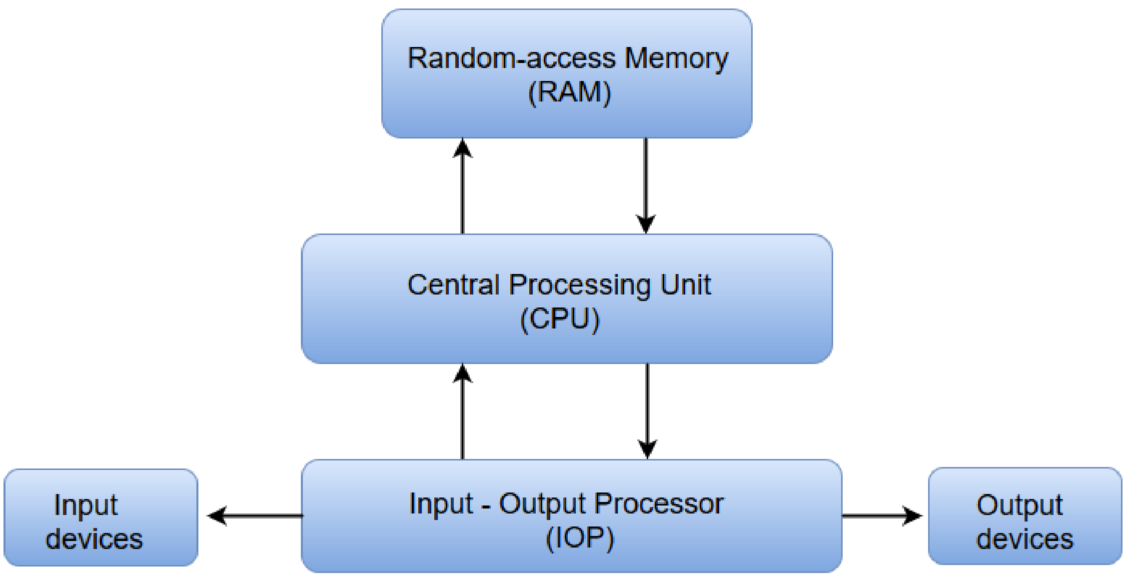
By convention, the digital computers use the binary number system, which has two digits: 0 and 1. A binary digit is called a bit.

A computer system is subdivided into two functional entities: Hardware and Software.

The hardware consists of all the electronic components and electromechanical devices that comprise the physical entity of the device.

The software of the computer consists of the instructions and data that the computer manipulates to perform various data-processing tasks.

Block diagram of a digital computer:



- The Central Processing Unit (CPU) contains an arithmetic and logic unit for manipulating data, a number of registers for storing data, and a control circuit for fetching and executing instructions.

- The memory unit of a digital computer contains storage for instructions and data.

- The Random Access Memory (RAM) for real-time processing of the data.

- The Input-Output devices for generating inputs from the user and displaying the final results to the user.
- The Input-Output devices connected to the computer include the keyboard, mouse, terminals, magnetic disk drives, and other communication devices.

Page 1

Introduction

It's no secret that more and more the internet is becoming an integral part of our everyday lives. But if you are new to the online experience, it may be a bit overwhelming. You may be wondering, **"What exactly is the internet, and how does it work?"**

In this lesson, we will give a **brief overview** of the internet, and we will talk about some fundamental concepts such as **networks**, **servers**, and **clients**.

Page 2

The Internet Today

In the early days, most people just used the internet to search for information. Today's internet is a constantly evolving tool, that not only contains an amazing variety of information, but also provides **new ways of accessing, interacting and connecting with people and content**. As a result, new terms are constantly appearing as new technologies are introduced.

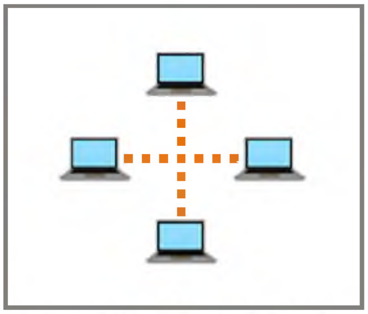
Click the buttons in the interactive below to learn about **a few common terms** that you might encounter online.

What is the Internet?

The internet is the largest **computer network** in the world, connecting millions of computers. A **network** is a group of two or more computer systems linked together.

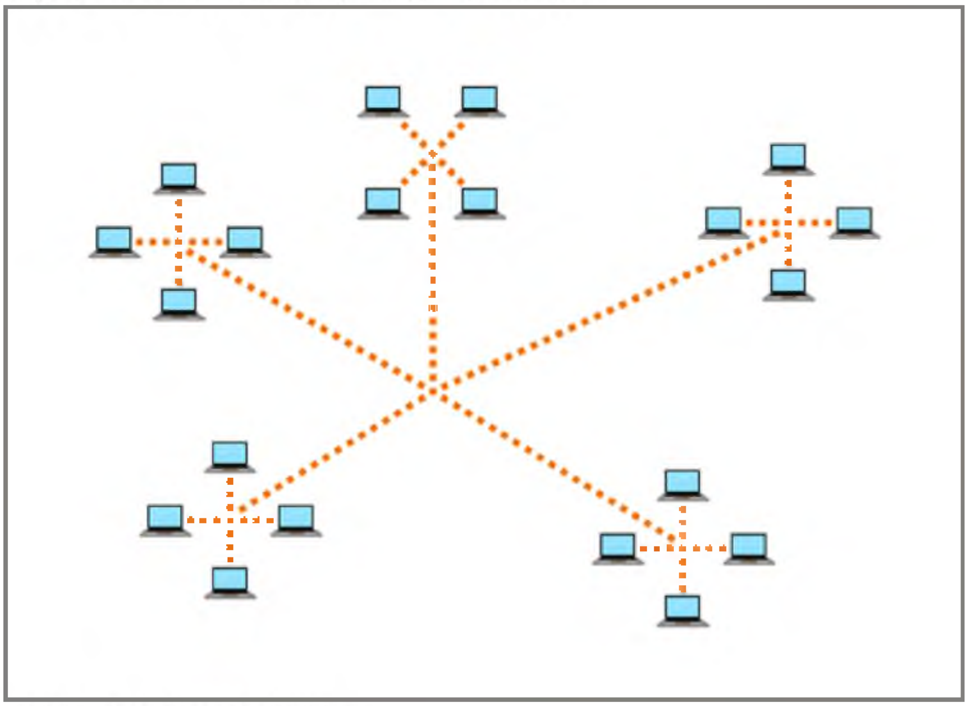
There are two main types of computer networks:

- **Local Area Network (LAN)**: A LAN is two or more connected computers sharing certain resources in a relatively small geographic location, often in the same building. Examples include home networks and office networks.



A Local Area Network (LAN)

- **Wide Area Network (WAN)**: A WAN typically consists of two or more LANs. The computers are farther apart and are linked by telephone lines, dedicated telephone lines, or radio waves. The **internet** is the largest Wide Area Network (WAN) in existence.



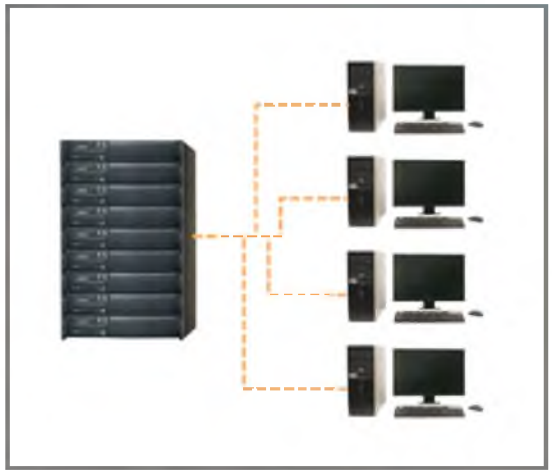
A Wide Area Network (WAN)

Servers and Clients

You may have heard someone say something like "The server is down" or "We're having problems with the e-mail server." A **server** is a computer that "serves" many different computers in a network by **running specialized software** and **storing information**. For example, web pages are stored on servers.

When you access a web page, your computer is acting as a **client**. A client runs familiar software such as **web browsers** or **email software**, and it communicates with the server to get the information it requires.

In order for your browser to display a web page, it **requests** the data from the server where the page is stored. The server processes the request, then sends the data to your browser, where it is displayed.



A server with multiple clients

In **peer-to-peer** (P2P) networks, each computer acts as **both a server and a client**. Examples of P2P software include Skype and BitTorrent.

The World Wide Web (WWW)

When most people think of the internet, the first thing they think about is the **World Wide Web**. Nowadays, the terms "internet" and "World Wide Web" are often used interchangeably—but they're actually not the same thing.

- The **internet** is the **physical network** of computers all over the world.
- The **World Wide Web** is a **virtual network** of **web sites** connected by **hyperlinks** (or **"links"**). Web sites are stored on **servers** on the internet, so the World Wide Web is a part of the internet.

HTML

The backbone of the World Wide Web is made of **HTML files**, which are specially-formatted documents that can contain links, as well as images and other media. All **web browsers** can read HTML files. In addition to HTML, it's also very common for websites to use technologies like **CSS (Cascading Style Sheets)** and **JavaScript** to do more advanced things.

HTML code

URL

To get to a web page, you can type the **URL (Uniform Resource Locator)** in a browser. The URL, also known as the **web address**, tells the browser exactly where to find the page. However, most of the time, people get to a web page by following a **link** from a different page or by searching for the page with a **search engine**.

An example of a URL

The World Wide Web was created in 1989 by **Tim Berners-Lee**, a software engineer. Before then, computers could communicate over the internet, but there were no web pages.

Did you know?

- The foundation of the internet began in 1969, when the US Department of Defense created **ARPAnet**, a project to allow military personnel to communicate with each other in an emergency.
- By 2012, the number of internet users worldwide reached **2.4 billion**—about one third of the world's population.
- To store all of the information on the internet, you would need over **1 billion DVDs** or **200 million Blu-ray discs**.

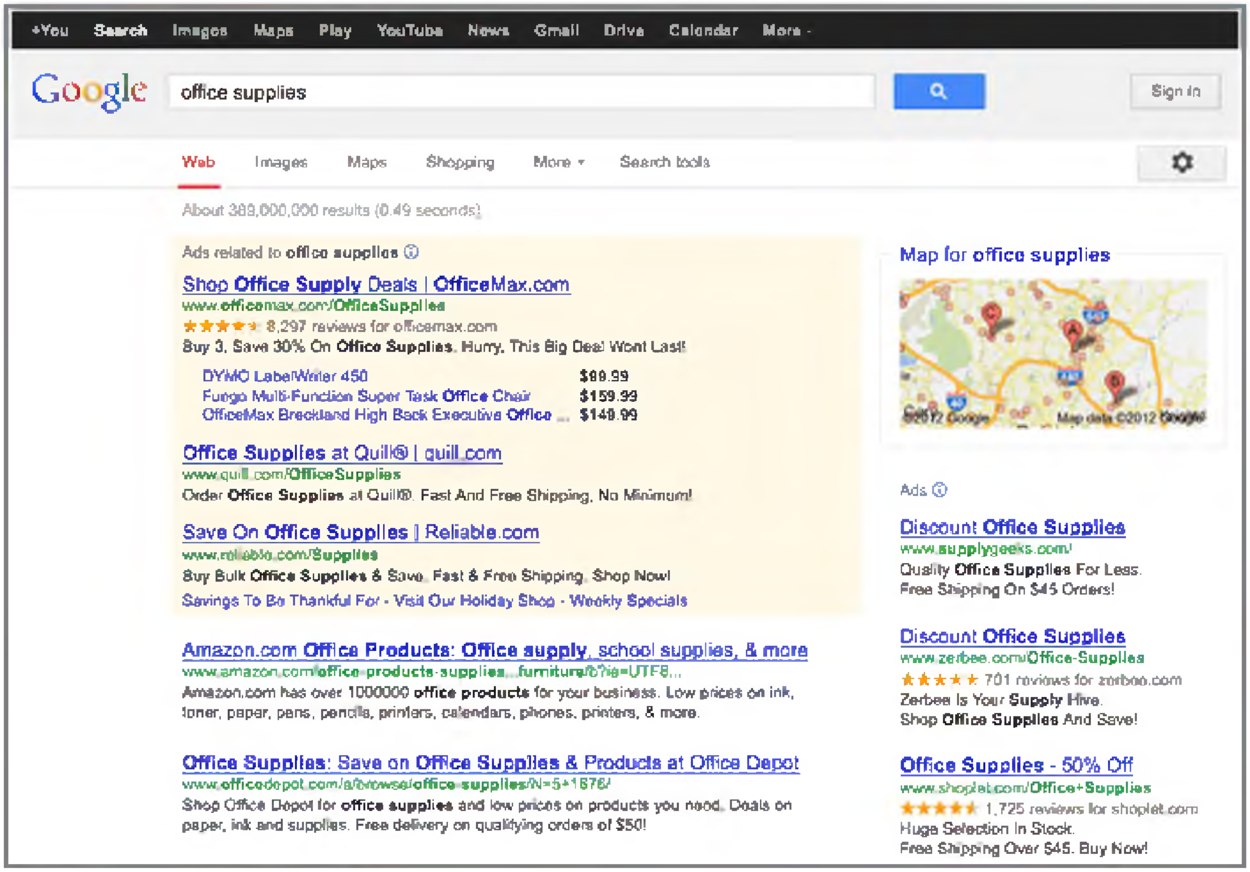
Introduction

As the internet has grown, it has developed into a multifaceted tool with a vast range of uses. It's now easy to **keep in touch with friends**, publish your own **articles**, or even watch your favorite **TV shows** using the internet.

In this lesson, we'll talk about some of the ways the Internet is used today, including **blogs**, **social networking**, **instant messaging**, **VoIP**, and **media.**

Finding Information Online

The most common way to find information online is with a **search engine**. All you have to do is type in a few words, and the search engine will give you a list of results that you can click on. There are many different search engines that you can use, but **Google** is the most popular one.



Using Google to search the web

Intelligent Personal Assistants

If you're using a mobile device, there are some situations where it's not convenient to type a search into a search engine. Instead, you can simply **talk** to your device's **intelligent personal assistant**. One example is **Siri**, which comes pre-installed on the **iPhone 4S** and the **iPhone 5**.

Asking Siri a question

With Siri, you can ask a question like **"What's the weather today?"** or **"Are there any Thai restaurants nearby?"** Siri will then try to give you an answer. You can also use Siri to do other things on your device such as setting up reminders. For example, you could say, **"Remind me to go to the dentist on Thursday."**

For more information, you can go to Apple's Learn more about Siri page.

Using the Internet to Communicate

The internet isn't just about finding information. It's also about connecting with friends, family, and people you've never met before. Today, there are many different ways to communicate online, including **social networking**, **chat**, **VoIP**, and **blogging**.

Social Networking

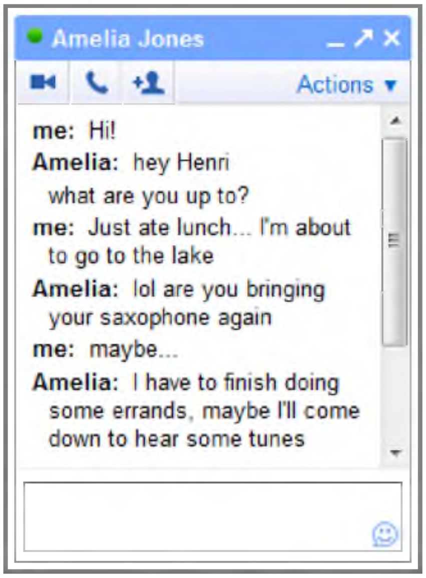
Social networking has become one of the main ways people keep in touch. Below are a few of the most popular social networking sites:

- **Facebook** is used by about **one billion people**. If you have family or friends that live far away, you can use Facebook to keep up with their lives. You can also share things you've found online that interest you.
- **Twitter** lets you share brief messages (or **"tweets"**) with the entire world, or with just your circle of friends. By following people with similar interests, you can discover new things that you wouldn't have found otherwise.
- **LinkedIn** is a site that you can use for **business networking**. It allows you to connect with other people in your field and find out about new job opportunities.

A Facebook News Feed

Chat and Instant Messaging

Chat and **instant messaging** programs allow you to have conversations with your friends or just write them a quick note. Two examples are **Yahoo! Messenger** and **Microsoft Messenger**. Some sites, such as **Gmail** and **Facebook**, allow you to chat within your browser.



A conversation using Gmail's built-in chat

VoIP

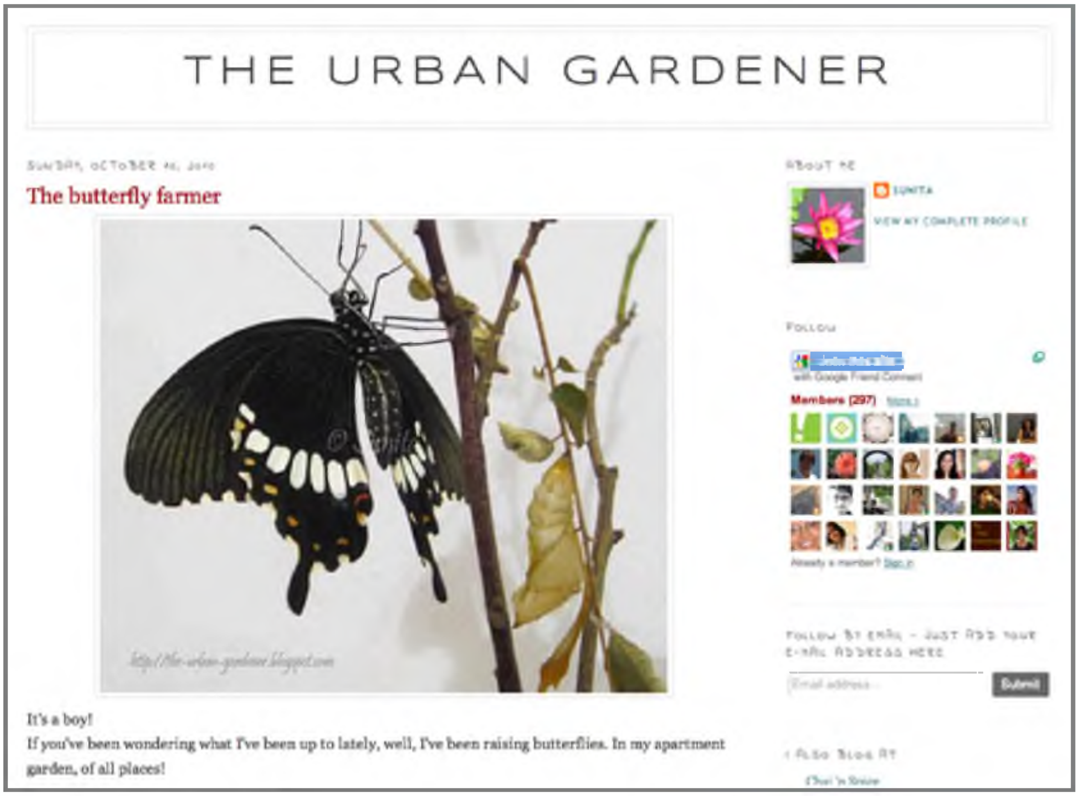
VoIP (Voice over Internet Protocol), allows you to have **telephone service** through your internet connection. Some services also let you do **video conferencing**, such as **Skype** and **Facebook Video Calling**. Many of these services are free or very inexpensive, and some people use them as a replacement for a landline, or just to save minutes on their mobile phones.

Using a video conferencing program

Blogs

Today, the average user has the ability to shape the web by **adding** to it. If you have knowledge or interests that you're passionate about, you can **create your own blog** and share your thoughts with the world.

There are many sites like blogger.com and wordpress.com that let you create a blog for free. You don't need any web design experience—most of the technical stuff has already been created for you, and you can choose a pre-designed template that has the look and feel that you want.

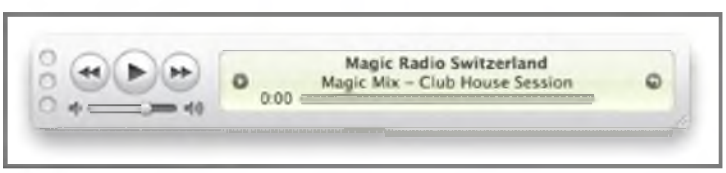


An example of a blog

To learn more about communicating online, check out our Beyond Email tutorial.

Media on the Internet

TV, **radio**, and the **internet** used to be completely separate things, but that's no longer true with today's technology. You can now watch TV shows on your computer, and you can connect to the internet on many TVs and DVD/Blu-ray players. In addition, you can listen to online radio from all over the world, thus granting you greater access to a more diverse range of media.



iTunes radio

Streaming Media

TV and radio on the internet are examples of **streaming media**, which means the media **downloads while it's**

playing so you don't have to wait for it to download first.

Not all media is streaming. If you've ever bought music on the iTunes store, you probably had to wait for it to download before you could listen to it.

Media Players and Embedded Media

Media is often **embedded** in a web page, which means that it plays within the web browser. Other times, you'll use a separate program called a **media player** to play it. Examples include **Windows Media Player** and **iTunes**. An **iPod** contains built-in media player software that can play various types of files.

Windows Media Player

Online Media on Your TV

You can now access online TV shows, movies, and music on your TV. Many newer TVs are able to connect to an existing internet connection. If yours doesn't have this feature built-in, you can buy a separate **digital media receiver**, which is a small device that connects to your TV. Apple TV and Roku are two examples of digital media receivers. Many game consoles, such as the Xbox 360 and PlayStation 3, can also be used to access online content.

Browsing movies with Apple TV

Using the Internet in the Future

The internet is **always changing**, and the ways in which we access it will also continue to change. Current trends will become more common and integrated into our everyday lives. In addition, we'll see many technologies and devices in the future that will allow us to use the internet in **new** and **exciting** ways.

Introduction

So you're interested in getting an internet connection in your home, or maybe you'd just like to upgrade to a faster service. There are a lot of factors to consider, such as **how much speed** you need and **where you live**.

In this lesson, we'll talk about **bandwidth**, different types of **internet service**, **wireless internet (Wi-Fi)**, **home networking**, and **mobile phone internet access**.

How Do I Connect to the Internet?

Once you've set up your computer, you'll probably want to get **internet access** so that you can send and receive email, browse the web, watch movies, and more. Before you can access the internet, there are three things that you need: **internet service**, a **modem**, and a **web browser**.

Watch the video to learn about connecting to the internet.

Watch the video (3:38). Need help?

Choosing an Internet Service

Which Service is Best for Me?

It all depends on **where you live** and **how much speed** you need. **Internet Service Providers** usually offer different levels of speed based on your needs. If you're mainly using the internet for **e-mail** and **social networking**, a slower connection might be all you need, but if you want to download a lot of **music** or watch **streaming movies**, you'll want a faster connection. You'll need to do some research to find out what the options are in your area.

Types of Internet Service

Review the following interactive to see a few of the more well-known types of internet service.

Choosing an Internet Service Provider

Once you have decided which **type of internet access** you are interested in, you can determine which **ISPs** are available in your area that offer the type of internet access you want. Then, you will need to purchase internet service from one of the available ISPs. Talk to friends, family members, and neighbors to see what ISP they use. Below are some things to consider as you research ISPs:

- Speed
- Price
- Ease of Installation
- Service Record
- Technical Support
- Contract Terms

Although **dial-up** has traditionally been the **cheapest** option, many ISPs have raised dial-up prices to be the **same as broadband**. This is intended to encourage people to switch over to broadband. Generally, you should only use dial-up if it's the only option available.

Hardware Needed

Modem

A DSL modem

Once you have your computer, you really don't need much additional hardware to connect to the internet. The primary piece of hardware you need is a **modem**.

The type of internet access you choose will determine what type of modem you need. **Dial-up** access uses a **telephone modem, DSL** service uses a **DSL modem**, **cable** access uses a **cable modem**, and **satellite** service uses a **satellite adapter**. Your ISP may give you a modem (often for a fee) when you sign a contract with them, which helps to ensure that you have the **right kind** of modem. However, if you would prefer to shop for a **better** or **cheaper** modem, then you can choose to buy one separately.

Router

A **router** is a hardware device that allows you to connect **several computers** and **other devices** to a single internet connection, which is known as a **home network**. Many routers are **wireless**, allowing you to easily create a **wireless network**.

You **don't necessarily need to buy a router** to connect to the internet. It's possible to connect your computer directly to your modem using an Ethernet cable. Also, many modems now include a **built-in router**, so you have the option of creating a network without having to buy more hardware.

Most routers also act as a **hardware firewall**, which helps prevent people from gaining access to your computer through the internet.

A wireless router

Network Card

A network card

A **network card** is a piece of **hardware** that allows computers to communicate over a computer network. Most newer computers have a network card built into the motherboard, so it probably is not something you will need to purchase. The network card will either have an **Ethernet** port, a **wireless** connection, or **both**.

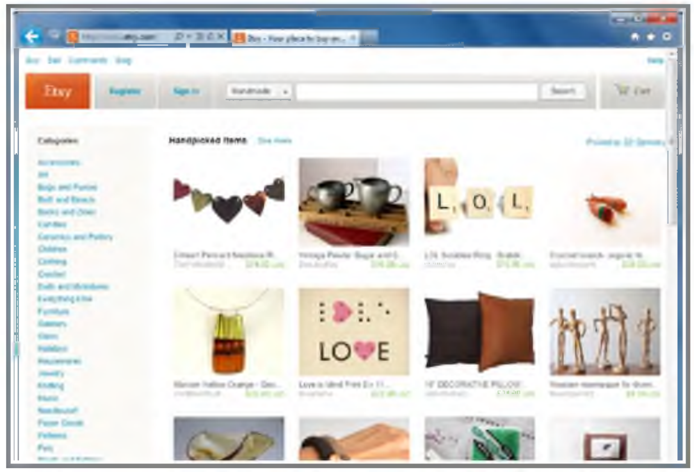
If you have a **laptop** with a wireless connection, you can access the internet at any place that offers a **Wi-Fi** connection. Many **restaurants**, **coffee shops**, **bookstores**, **hotels** and other businesses offer free Wi-Fi. In addition, many cities provide free Wi-Fi in public areas such as **parks** and **downtown areas**.

Web Browsers

A **web browser** is the tool that you use to access the **World Wide Web**. The browser's main job is to **display web pages**. It also lets you create **Bookmarks** (sometimes called **Favorites**) for sites you like, so that you can easily find them again later.

The **World Wide Web** is a **virtual network** of **web sites** connected by **hyperlinks** (or **"links"**). Web sites are stored on **servers** on the internet, so the World Wide Web is a part of the internet.

Your computer probably came with a browser **pre-installed**. **PCs** come with Internet Explorer, and **Macs** come with Safari. If you prefer to use a different browser, you can download Firefox, Google Chrome, or Opera. All of these browsers are **free**.



Internet Explorer

Setting Up Your Internet Connection

Once you have chosen an **ISP** and purchased the appropriate **modem**, you can use the instructions provided by your ISP (or included with the modem) to set up your internet connection. Depending on what type of service you have, your ISP may need to **send a technician to your house** in order to turn the connection on.

After you have everything set up, you can open your **web browser** and begin using the internet. If you have any problems with your internet connection, you can call your ISP's **tech support** number.

Opening Internet Explorer

Internet on Mobile Devices

With tablet computers and mobile phones, it's possible to have full internet access, allowing you to **check your e-mail** and **browse the Web** away from home. To do this, you'll need a **data plan**, which adds an additional monthly fee to your mobile phone bill. Data plans are also available for **laptops** and **e-readers** such as the Kindle.

Using mobile internet

Just like regular cell phone service, it's important to choose a provider that has **good coverage in your area**. You may want to ask your friends, family, or coworkers which provider they use.

With some devices, such as the iPad, you can choose not to buy a data plan, and you'll still be able to access the internet whenever you are connected to a **Wi-Fi** network. If you set up a **home wireless network**, your device can automatically connect to it whenever you're at home. Also, many restaurants, libraries, and downtown areas offer free Wi-Fi.

Mobile data plans are often referred to as **3G**, which means it's the **third generation** of wireless standards. Many companies now provide **4G (fourth generation)** data services, which allow you to have **broadband** speeds on your mobile device.

Home Networking

If you have multiple computers at home and want to use all of them to access the internet, you'll probably want to create a **home network**. In a home network, all of your devices connect to your **router**, which is connected to the **modem**. That means everyone in your family can use the internet **at the same time**, and you don't have to purchase a separate internet service for each computer.

How is a Home Network Used?

Using multiple computers on a home network

Each computer on a network doesn't just connect to the internet - it also connects to the **other computers and devices** on the network. That means you can easily **share files** with other computers. Some programs even let you **stream music and movies** from one computer to another. One example of this is the **Home Sharing** feature in **iTunes**. These types of features are easy to set up, but it's up to you whether you want to use them.

Home networks aren't just for families! Even if you live alone, you may have multiple devices that can connect to a network. Many **phones**, **printers**, **mp3 players**, **video game consoles**, and **Digital Video Recorders (DVRs)** are equipped with wireless cards and often require very little setup to connect them to your home network.

Wireless Security

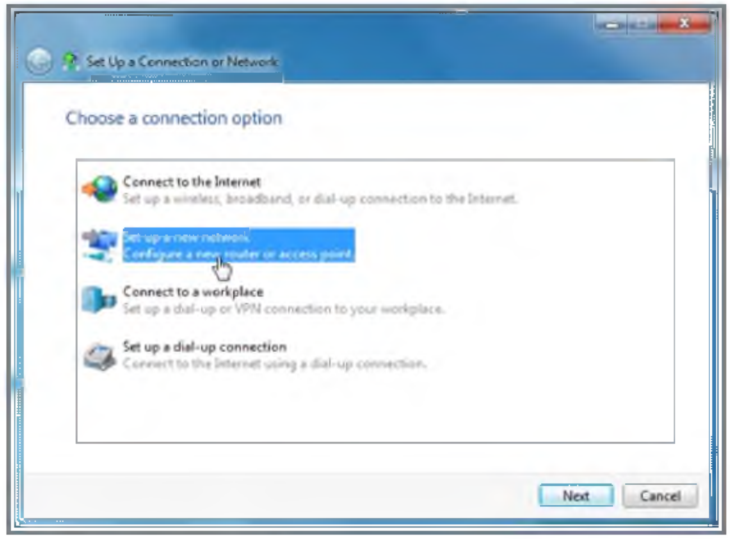
A home network can be **wired** (using Ethernet cables) or **wireless** (using Wi-Fi). It may also be a **mixture** of the two, with some devices connecting with Ethernet and others connecting wirelessly. Wireless is generally more convenient; however, you'll need to think about **wireless security**. Below are some important security terms that you'll need to know:

A router with Ethernet cables attached

- **SSID:** A **service set identifier**, commonly called the SSID, is the **name** of a wireless network. You should change the default SSID to something unique that you'll remember. You may not want to use your actual name, but you can use a hobby or other interest (for example, **rockclimbing1**).
- **Encryption password:** An encryption password is a **series of characters** that is used to control access to the network. For even greater security, some people use a **passphrase**, which is longer (and therefore more secure) than a password. You should choose a password or passphrase that's easy for you to remember, but hard for other people to guess.
- **Encryption:** Encryption prevents unauthorized people from reading the data that is transmitted over your wireless network. The data is **coded** into an unreadable form, and it can only be **decoded** by a computer that has the correct **password** (or passphrase). The most common types of encryption for wireless networks are **WPA (Wi-Fi Protected Access)** and **WPA2**.

Although it's possible to create a wireless network that doesn't have a password, it is **very risky**. You should always create a password or passphrase to protect it from unauthorized access.

Before you set up your home network, you'll need to have a **working internet connection**. The exact process of creating a network will vary depending on what type of computer you have, as well as what type of internet service you have. You should use the instructions provided by your **ISP** (or the ones included with your **router**) when setting up your network. The following steps will give you an idea of what to expect:



Setting up a network

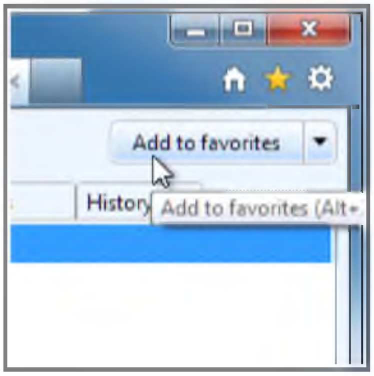
1. If you have a separate **router**, connect it to the **modem**, and make sure it has power through the power adapter. If you have a combined router/modem, you won't have to do this.
2. Connect all non-wireless devices to your router using **Ethernet** cables. You may also need to connect your **computer** to the router until setup is complete, even if your computer has a wireless card.
3. From your computer, you will need to create the **SSID** and **password** (or passphrase) for your router. You now have a **wireless network** that you can begin connecting wireless devices to.
4. On each **wireless device**, you will need to go to your network settings and select the name (SSID) of the network that you just created. You will then be prompted to type in your password.

At this point, your home network setup is complete. If your network isn't working, the instructions from your **ISP** should include some troubleshooting tips. You can also call your ISP's **tech support** number if you're still having trouble.

To learn how to safely use a wireless network, check out Wireless and Mobile Device Safety in our Internet Safety tutorial.

Page 1

Introduction



A **web browser** is the tool that you use to access the **World Wide Web**. In order to get the most out of the Web, it's important to understand the various features of a browser.

In this lesson, we'll talk about **navigating** the Web with a browser, **downloading** files, **bookmarking** your favorite web sites, **tabbed browsing**, **plug-ins** and more.

Page 2

Browser Basics

To get the most out of your web browser, there are some basic **concepts** that you need to be familiar with, including navigation, downloading, bookmarking, tabbed browsing, and plug-ins.

Watch the video to learn some of the basics of using a browser.

Watch the video (2:20). [Need help?]

Common Web Browsers

Today, **Chrome** and **Internet Explorer** are the most popular web browsers. Other browsers include **Firefox**, **Safari**, and **Opera**. Each one has its own look and feel, but they have the same goal: to display web pages correctly. For most web pages, any well-known browser will work.

Chrome

Internet Explorer

Firefox

Like most modern programs, browsers use a **Graphical User Interface (GUI)**, which means you can navigate by pointing and clicking with a mouse instead of just typing. Some devices such as mobile phones use different types of GUIs, such as **touchscreens**. However, many of the principles remain the same.

Point-and-click interface

Touchscreen interface

For tips that are more specific to your browser, you can check out our tutorials on Internet Explorer 8 and Chrome.

Page 3

Navigating to a Web Site

To get the most out of your web browser, there are some basic **concepts** that you need to be familiar with.

Watch the video to learn some of the basics of using a browser.

Watch the video (2:20). Need help?

Address Bar

Browsers have an **address bar** that shows the web address (also called a URL) of the page you are on. To go to a different page, you can type an address in the address bar and then press **Enter** (or **Return**).

The address bar

Links

Most of the time, you will get to a different page by clicking on a **link**. A link can be **text** or an **image**, and it's usually formatted to stand out so you know to click on it. Many text links are **blue**, and they may also be **underlined**.

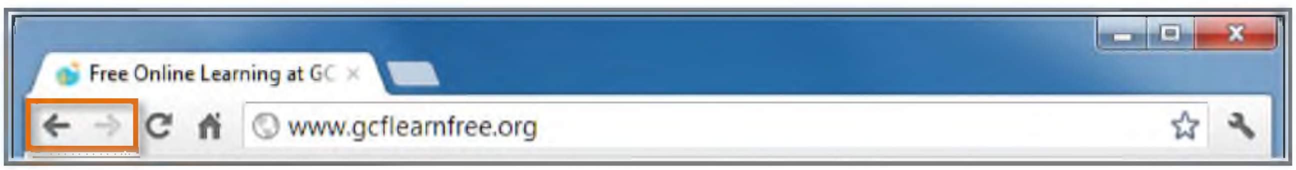
For example, this is a link. It will open a web page in a new window, and you can close it to come back to this page.

A link may lead to another web page, or it could lead to a document, video, or any other type of file. If you're not sure if something's a link, hover the mouse over it. **The pointer should change to a hand symbol**.

Hovering over a link

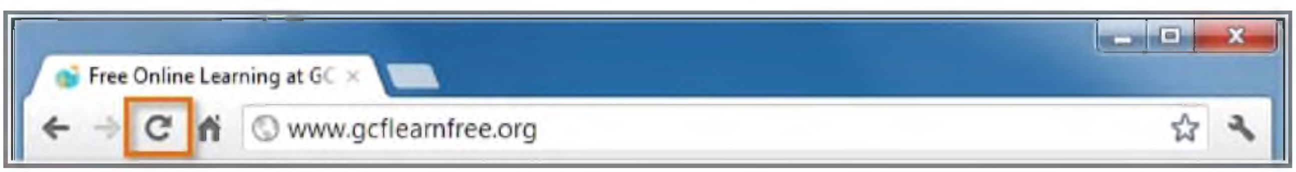
Navigation Buttons

Sometimes, after you click on a link, you might want to go back to the previous page. You can do this using your browser's **Back** button. Once you've pressed the Back button, you can press the **Forward** button to follow the link again.



The Back and Forward buttons

When you use the **Back** and **Forward** buttons, your browser may use its **web cache** to display the page. The web cache stores recently-viewed web pages so that they don't need to be downloaded again. That's usually good because it speeds up your web browsing, but sometimes you want to see the most up-to-date information on the page. You can use the **Refresh** button (sometimes called **Reload**) to tell the browser to load the page again.

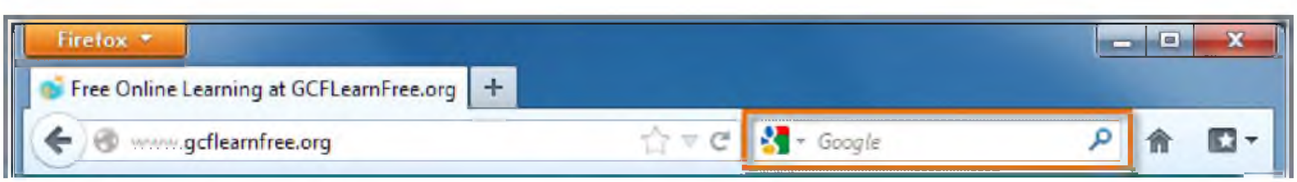


The Refresh button

There are some instances where you don't want to use the navigation buttons. For example, in some online stores, you shouldn't refresh the page after purchasing an item, as it could cause you to purchase the item twice.

Search Bar

Some browsers have a built-in **search bar** for performing web searches. However, many browsers have combined the address bar and the search bar into a single bar where you can type web addresses or search terms. We'll talk more about web searches in the next lesson.



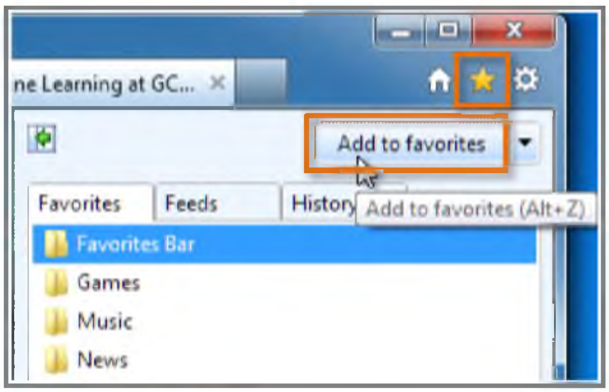
The Search Bar in Firefox

Some websites may track your activities online, usually for marketing purposes. It's also possible to encounter **malicious sites** that could harm your computer. For more tips, check out Staying Safe While Browsing in our Internet Safety tutorial.

Adding Bookmarks

If you've found a page you'd like to go back to later, you can add it to your **bookmarks** (sometimes called **favorites**). Bookmarks make it easier to find a page later on. Instead of having to remember the exact **web address**, you can just **scroll through your bookmarks** until you see the name of the page.

- In Internet Explorer 9, you can add a bookmark by clicking the **star icon** and then selecting **Add to Favorites**. Other browsers are similar, but they may use different wording.



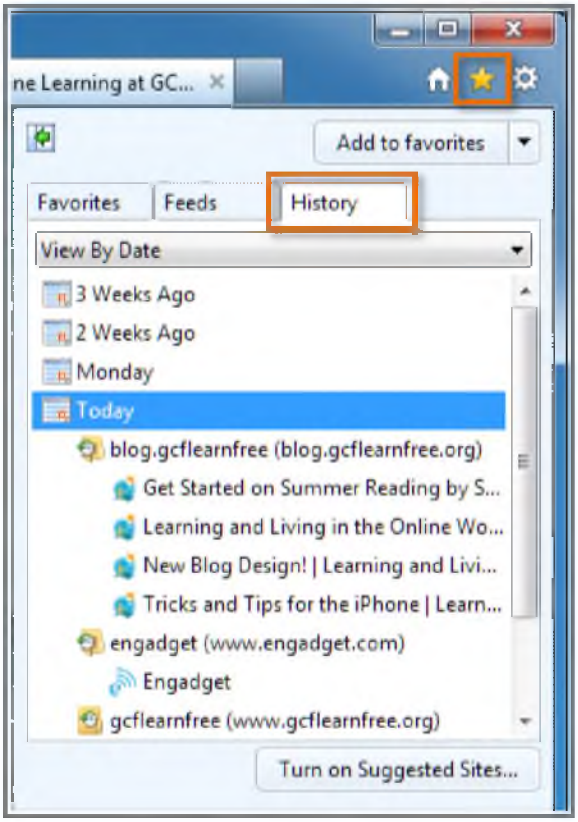
Adding a bookmark

Browsing History

Suppose you visited a page a few days ago but forgot to bookmark it. You can find the page again by using your **history**, which is a list of web sites you've visited. Usually, pages will stay in the history for a certain number of days. To maintain privacy, you can **delete your history** at any time.

Viewing Your History

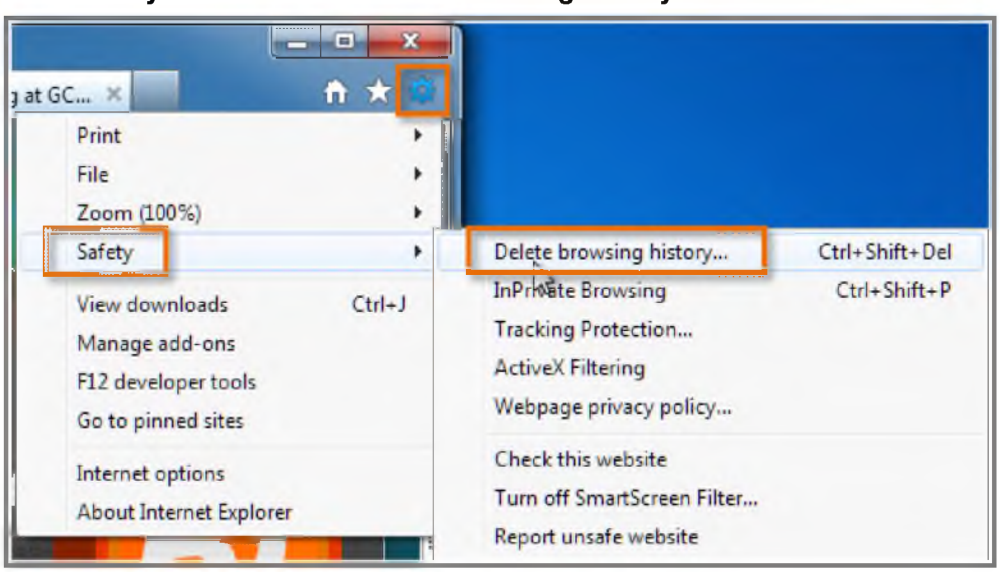
- To view your history in Internet Explorer 9, click the **star icon** and then select the **history** tab.



Browsing history

Deleting Your History

1. In Internet Explorer 9, click the **gear icon** to open the **Tools** menu.
2. Click **Safety** and then select **Delete browsing history...**.



Deleting browsing history

If you're using a browser other than Internet Explorer, the process of viewing and deleting history will be a little bit different.

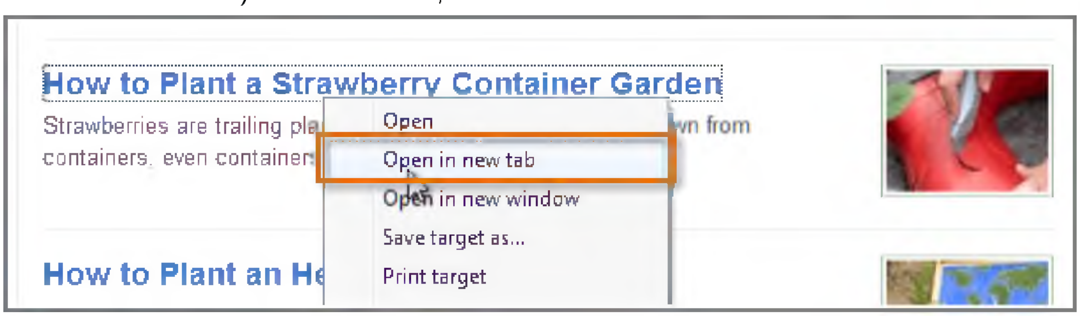
Tabbed Browsing

Many browsers allow you to open a link in a new **tab**. This allows you to keep the current page open instead of going directly to the new page. For example, if you're reading an article that has a link in it, you can **open the link in a new tab** so that you can finish reading the article. Then, you can go to the **new tab** to view the link.

A browser window with three open tabs

Tabs are designed to make browsing **more convenient**. You can open as many links as you want, and they'll stay in the **same browser window** instead of cluttering up your screen with multiple windows.

- To open a link in a new tab, **right-click** the link and click **Open in new tab** (the wording may vary from browser to browser). To close a tab, click the "X" on the tab.



Opening a link in a new tab

Downloading Files

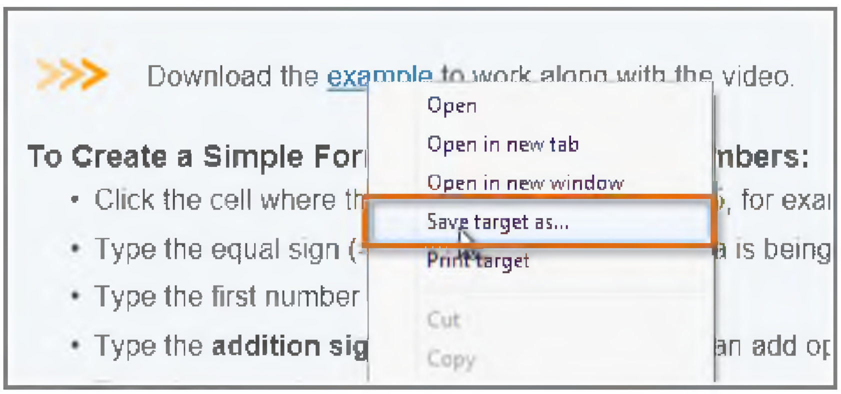
Your browser can display many different types of documents, media, and other files. But there are times when you'll want to access a file **outside your browser**. **Downloading** enables you to do this by putting the file **on your computer** so that you can access it.

For example, suppose you needed to complete and print a form that you found online. You could download it to your desktop, then open it with the appropriate program (such as **Microsoft Word**) to edit it.

How to Download a File

If you click on a **link** to a file, it may download automatically, but sometimes it just **opens within your browser** instead of downloading. To prevent it from opening in the browser, you can **right-click** the link and select **Save Target As...** (different browsers may use slightly different wording). You'll be able to choose the folder where the file is saved.

Since the process of downloading a file **varies** from site to site, it may require some trial and error.

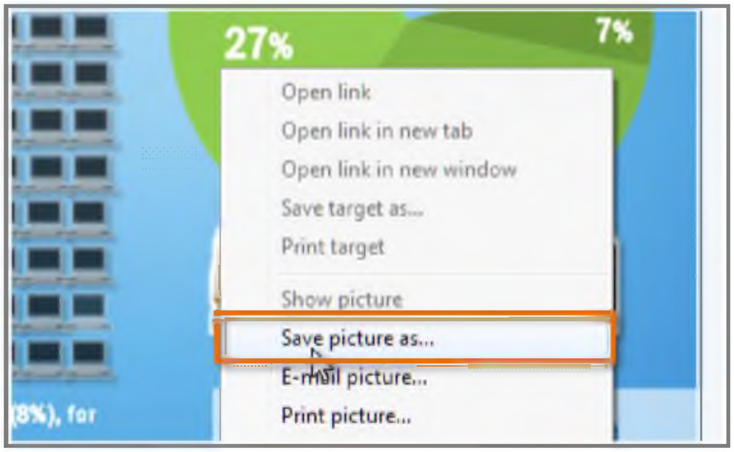


Downloading a file

For various reasons, many sites **do not allow** you to download content. For example, YouTube does not offer a way to download its videos.

Saving Images

Sometimes you might want to save an image to your computer. To do this, right-click the image and select **Save Picture As...**.



Saving a picture

Some sites do not allow images to be saved to your computer.

Plug-ins

Plug-ins are programs that are installed in your browser that enable it to play various types of media, such as video. Examples of plug-ins include **Quicktime Player** and **Flash Player**. If you don't have the correct plug-in, the site will usually provide a link to download the plug-in.

Once you have the necessary plug-ins, you'll be able to enjoy **streaming video** from sites such as Hulu, and play **games** on sites such as Newgrounds.

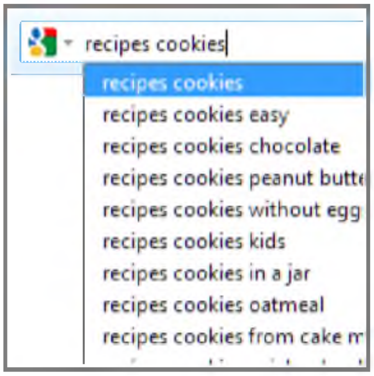
Playing a Flash game in a browser

Your browser may have come with some plug-ins **already installed**.

Internet 101
Search Engines and Strategies

Page 1

Introduction



With **billions** of web pages on the World Wide Web, how can you find exactly what you're looking for? By using a **search engine**.

Search engines are specialized web sites that help you find what you're looking for on the Web. All you have to do is **type in one or more keywords**, and the search engine will look for **matching web sites** from all over the Web.

In this lesson, you'll learn the basics of using a **search engine**, as well as some techniques you can use to get better **search results**.

Page 2

Performing a Search

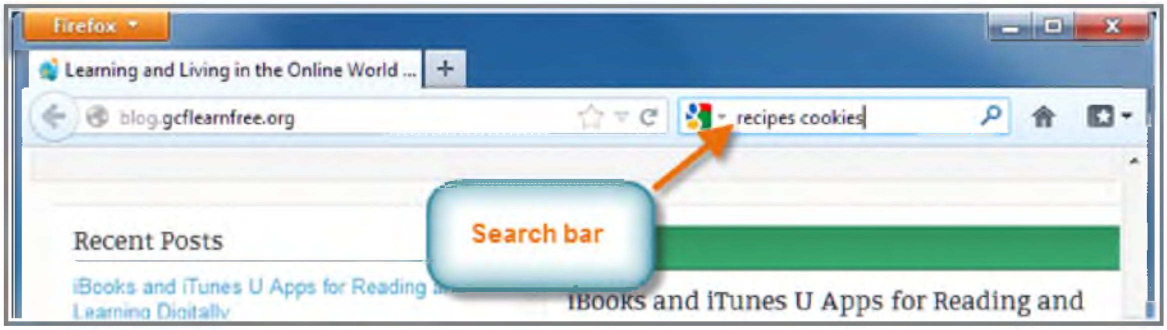
There are numerous search engines out there, but the most popular ones are Google, Yahoo, and Bing. Each one has its **own unique features**, but the process of doing a search is very similar on each.

Check out the video to learn how to do an effective search using Google.

Watch the video (3:36). Need help?

Using the Search Bar

Many browsers have a built-in **search bar**, located to the right of the address bar. To do a search, just type what you're looking for (known as the **search terms**) in the search bar, and then press **Enter**. Your browser will then take you to the search engine's web site to show you the **search results**, which is a list of all of the web sites that contain your search terms.



Firefox's built-in search bar

Many browsers allow you to **add to or change the search engines** used by the search bar.

Assessing the Search Results

After you do a search, **glance over the first page** of search results. Did it return what you are looking for, or is it just a lot of unnecessary "junk"?

If your search results don't seem very good, you may need to try different search terms. Remember, the search engine **can't read your mind**; it just looks for matching words. For example, if you just search for the word **polish**, the search engine doesn't know whether you're looking for **shoe polish** or a history of the **Polish language**!

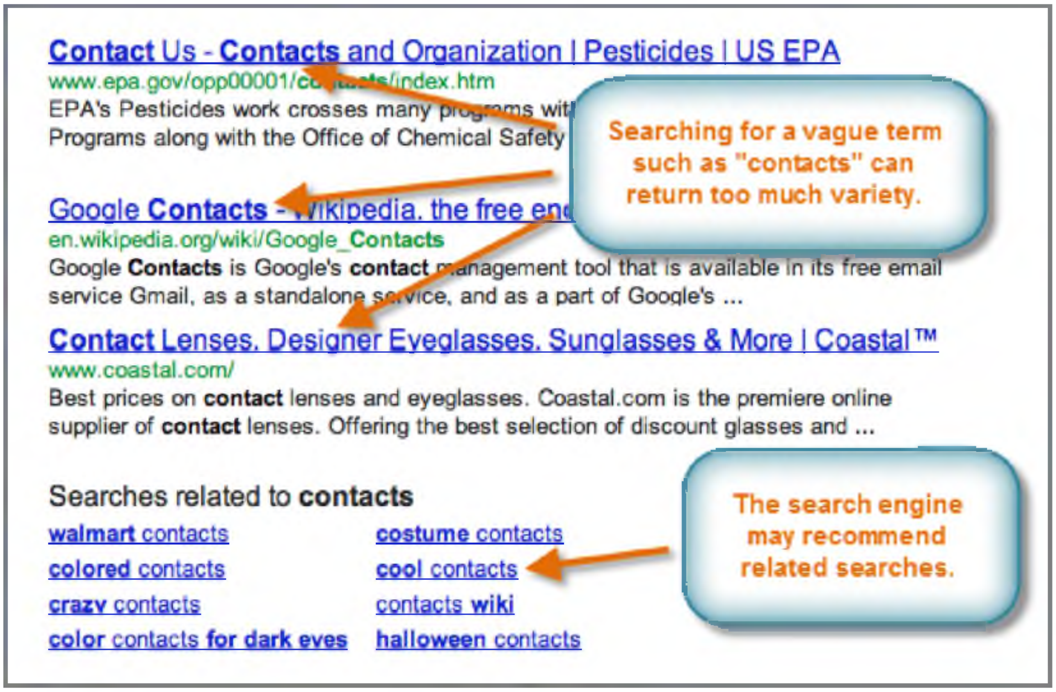
You could improve your search results by searching for **shoe polish**. However, that still may return a wide variety of web sites, such as:

- **Stores** that sell shoe polish
- Guides on **how to polish shoes**
- The **history** of shoe polish
- And probably **much more**

To get the best results, ask yourself: What **exactly** am I looking for? **Specific terms** usually return better results.

Related Searches

A search engine will often recommend **related searches** that may be more **specific** than the search terms you used. Related searches are usually listed at the bottom of the page. **Bing** also lists them to the left of the search results.

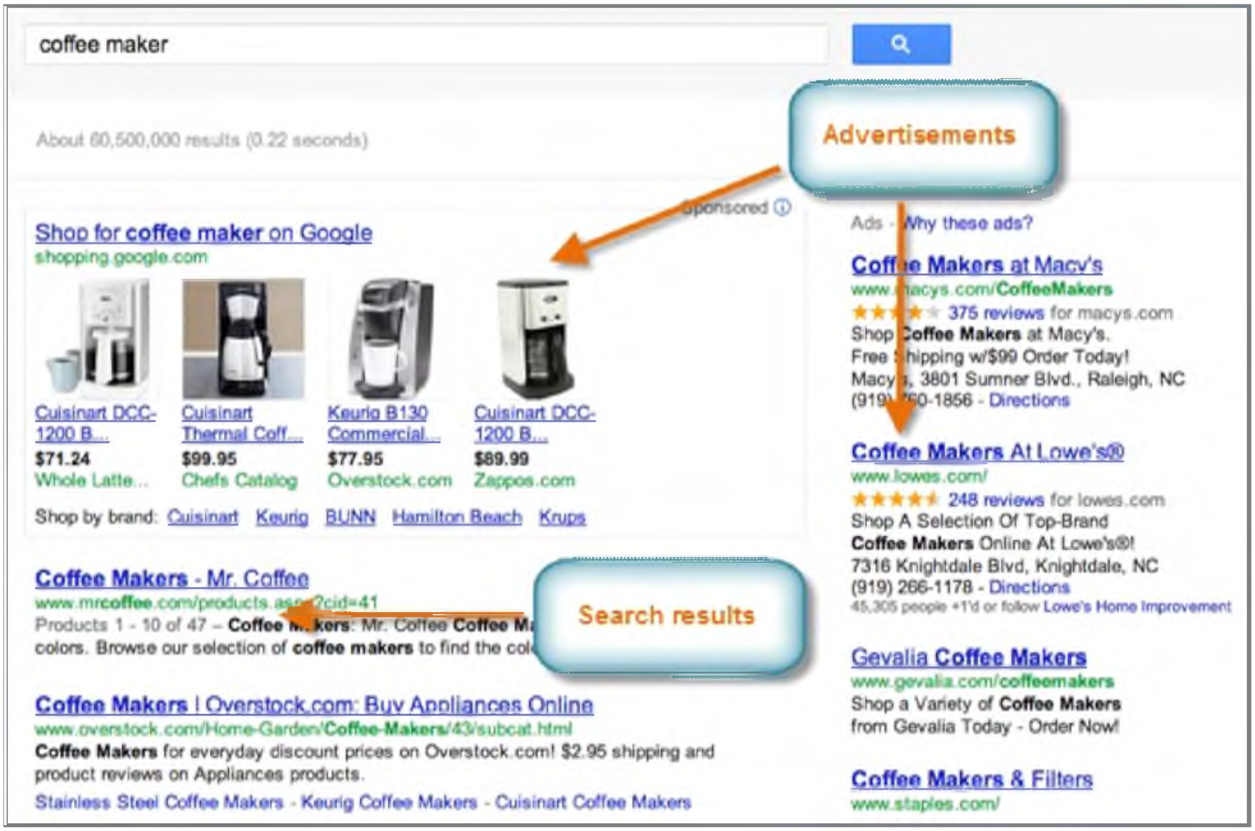


Using related searches to narrow down a search

Advertisements

Search engines may include **advertisements** along with the search results. These ads are picked by the search engine based on your search terms, and they look a lot like the actual search results. While they may be useful in some cases, it's usually more effective to focus on the "regular" search results.

Google puts its ads at the top and to the right of the search results.

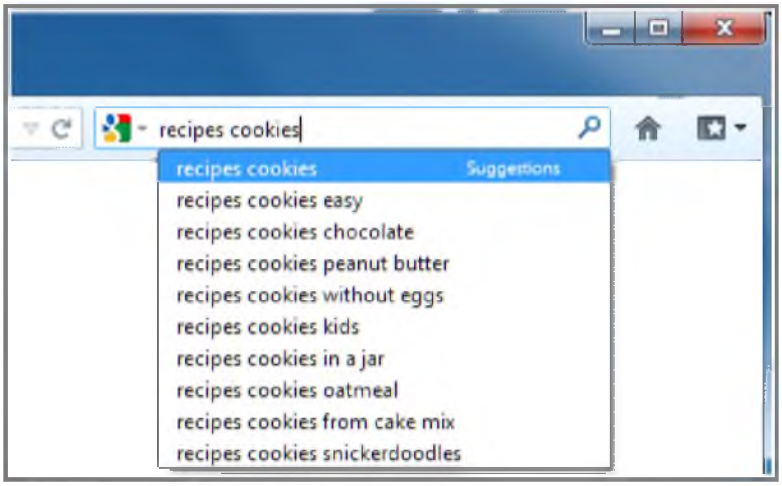


Ads and search results

Improving Your Searches

As you gain experience with search engines, you'll be able to do better and better searches, which means it will become quicker and easier to find what you are looking for. Here are a few tips for improving your searches:

- **Take suggestions**. As you're typing your search terms, the search engine will **try to guess** what you're searching for, and it will show a list of **search suggestions** (which are similar to **related searches**, except they happen while you're typing). These can give you **ideas for search terms** that you may not have thought of.



Search suggestions

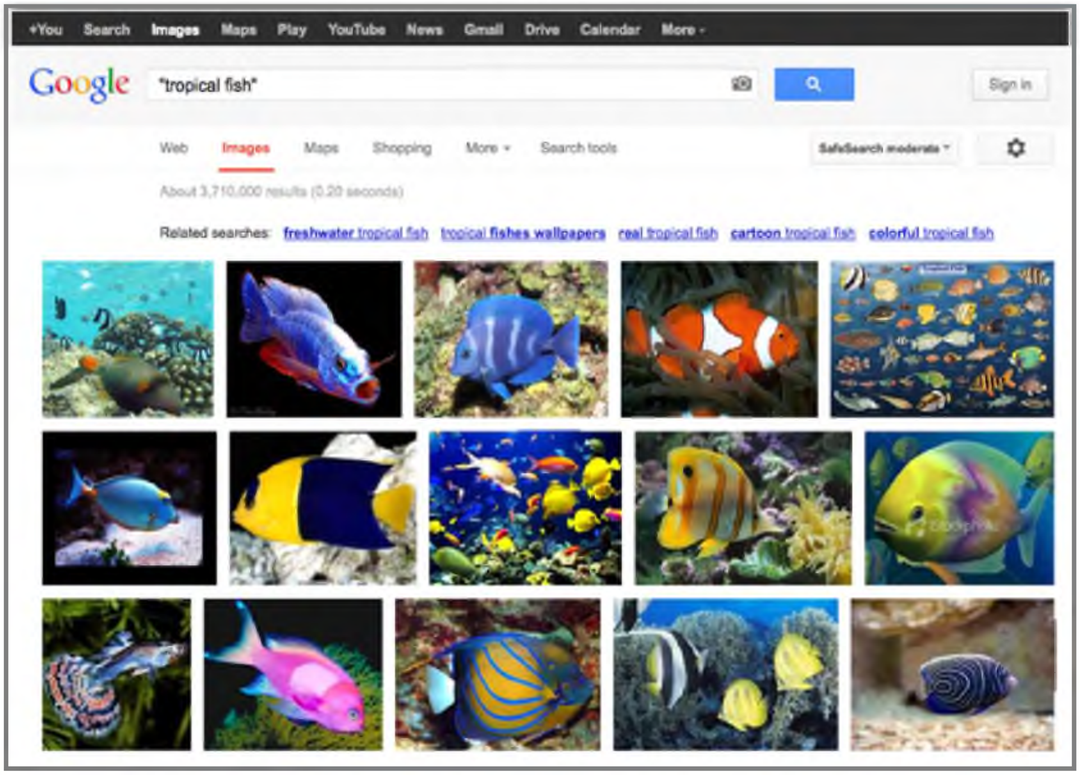
- **Search phrases**. Put quotes around a phrase so each word in the phrase isn't searched for separately. For example, if you put quotes around **"sugar cookies"**, the search engine searches for that entire phrase in a web page. However, if you simply type **sugar cookies**, the search engine searches for each of the words individually, and it will find recipes for other types of cookies that have sugar in the ingredients.
- **Exclude words**. Use a hyphen (-) at the beginning of a word to **exclude** search results containing it. For example, **macaroni -cheese**. Note that there is a space before the hyphen, but not after it. In many search engines the word NOT (in all caps) is used, as in **macaroni NOT cheese**.
- **Use OR**. You can use OR (all caps) to include either of two search words. For example, **soup recipe tofu OR fish** should return recipes for soup that contain tofu or fish (or both). You could also search for **soup recipe tofu OR fish OR chicken OR beef**.
- **Get Help**. Go to your search engine's **Help page** for more tips.

For more search tips, check out our Search Better tutorial.

Specialized Searches

Are you looking for **news articles**, **images**, **videos**, or **online stores**? You can use a **specialized search** to search for a specific type of content. For example, if you do an **image search**, the search will find and display images for you, instead of finding links to pages that may or may not have relevant images.

Generally, a search engine will include **links** at the top of the page to go to the specialized searches.



Searching for images

Page 1

Introduction

Do you ever feel like the only person who doesn't use email? You don't have to feel left out. More than ever, email is easy to understand and use.

In this lesson, you will learn **what email is**, how it compares to **traditional mail**, and **how email addresses are written**. We'll also discuss various **types of email providers** and the **features and tools** they include with an email account.

Page 2

Getting to Know Email

You may know that **email** (electronic mail) is a way to **send and receive messages** across the internet, but do you know how individual emails are sent or what they cost or how email compares to traditional "snail" mail? To get a better idea of what email is all about, review the infographic below and consider how you might benefit from its use.

UNDERSTANDING EMAIL

What is Email?

Email is a way to send and receive digital messages and content over the internet.

Snail Mail vs. Email

Address	Michelle Garcia 202 Cedar Lane Raleigh, NC 27601	mgarcia212@yahoo.com
Delivery	• Your envelop or package is delivered by a mail carrier • Received in a home mail box or post office box	• Your digital message is delivered electronically across the internet through various servers • Received online in the Inbox of your email service provider (Gmail, Yahoo, Hotmail, etc.)
Time	• Average of 2 days for letters • Average of 3-10 days for packages	Instantly or within a few minutes if servers are busy
Contents	May include packets with documents or packages with larger items	May include attachments for digital documents, files, images, video and more
Costs	The price of stamps or	Free with internet connection

shipping for larger items

Email Advantages

Productivity Tools

Email is usually packaged with a calendar, address book, instant messaging and more for convenience and productivity.

Access to Web Services

If you want to sign up for accounts like Facebook, or order products from services like Amazon, you will need an email address, so you can be safely identified and contacted.

Easy Mail Management

Email service providers have tools that allow you to file, label, prioritize, find, group, and filter your emails for easy management. You can even easily control spam, or junk email.

Communicate with Multiple People

You can send an email to multiple people at once allowing you the option of having a conversation with several people or sending out a message to a hundred.

Private

You email is delivered to your own personal and private account with a password required for accessing and viewing emails.

Access Anywhere at Anytime

You don't have to be at home to get your email. You can access it from any computer or mobile device that gets an internet connection.

Understanding Email Addresses

To receive emails, you will need an **email account** and an **email address**. Also, if you want to send emails to other people, you will need to obtain their email addresses. It's important to learn how to write email addresses correctly, because if you do not enter them exactly right, your emails will not be delivered or they might be delivered to the wrong person.

Email addresses are always written in a standard format that includes a **username**, the **@** (at) symbol and the **email provider's domain**. The **username** is the name you choose to identify yourself and the **email provider** is the website that hosts your email account.

Review the graphic for examples of how email addresses are written.

Sample Email Addresses

About Email Providers

In the past, people usually received an email account from the same companies that provided their internet access. For example, if AOL provided your internet connection, you'd have an AOL email address. While this is still true for some people, today it's increasingly common to use a **free web-based email service**, also known as **webmail**. Anyone can use these services, no matter who provides their internet access.

Webmail Providers

Today, the top three webmail providers are **Yahoo!**, Microsoft's **Hotmail**, and Google's **Gmail**. These providers are popular because they allow you to access your email account from anywhere with an internet connection. You can also access webmail on your **mobile devices**.

Visit the links below to compare the features of the three top webmail providers:

- Yahoo Features
- Hotmail Features
- Gmail Features

Top Webmail Providers

Other Email Providers

Many people also have an email address **hosted by their company, school, or organization**. These email addresses are usually for professional purposes. For example, the people who work for this website have email addresses that end with **@gcflearnfree.org**. If you are a part of an organization that hosts your email, they'll show you how to access it.

Many hosted web domains end with a suffix other than **.com**. Depending on the organization, your provider's domain might end with a suffix like **.gov** (for government websites), **.edu** (for schools), **.mil** (for military) or **.org** (for non-profit organizations).

information Management Software

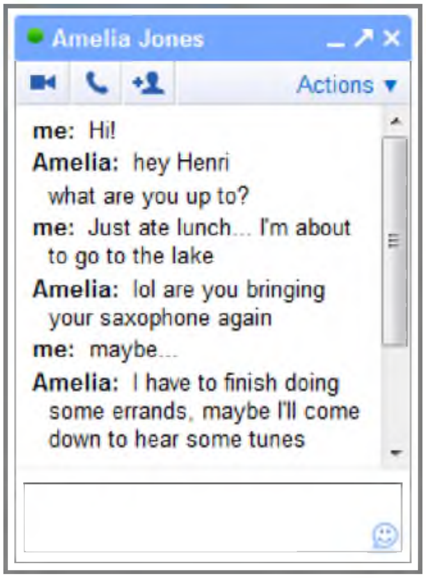
Many companies and organizations use an information management application, like **Microsoft Outlook**, for communicating and managing their email. This software can be used with any email provider, but is most commonly used by organizations that host their own email.

Visit our Outlook 2010 tutorial to learn more about using this application.

Email Productivity Features

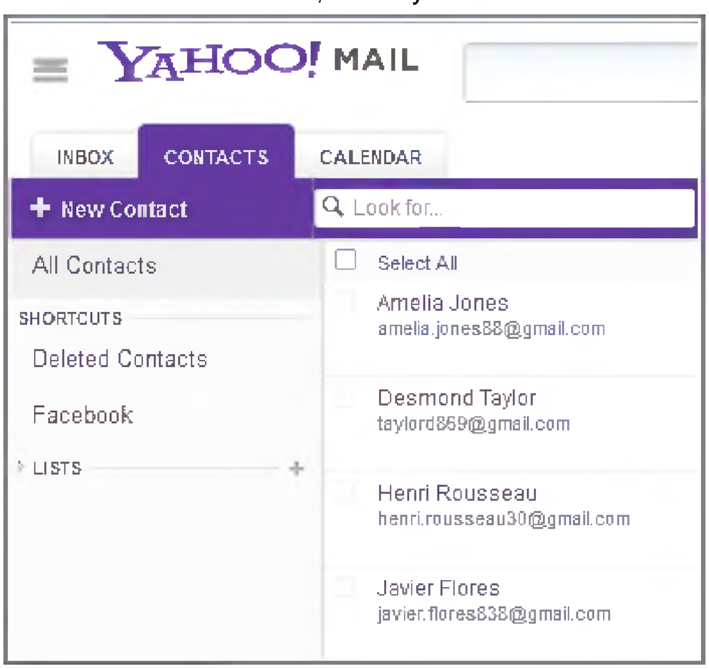
In addition to email access, webmail providers also offer **various tools and features**. These features are part of a **productivity suite**—a set of applications that help you work, communicate, and stay organized. The tools offered will vary by provider, but all major webmail services offer the following features:

- **Instant messaging**, or **chat**, which lets you have **text-based conversations** with other users. Check out our Beyond Email lesson to learn more about the basics of instant messaging.



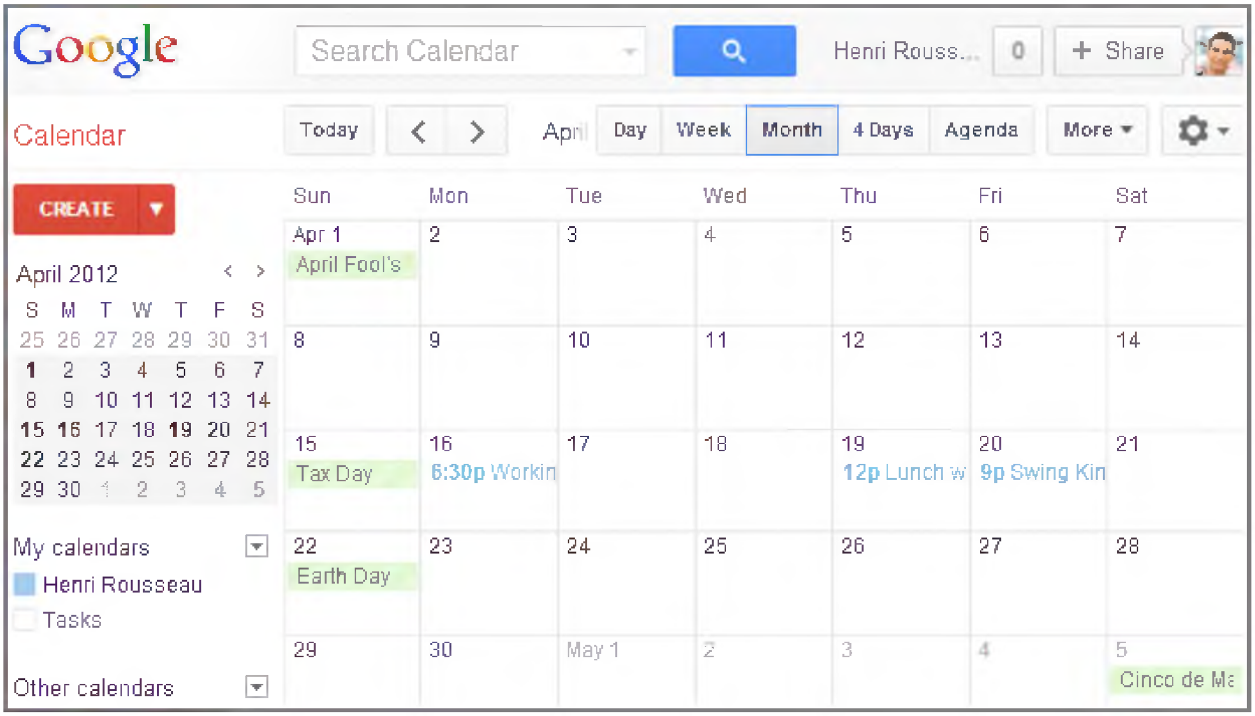
Gmail's instant messaging client

- An **online address book**, where you can store **contact information** for the people you contact frequently.



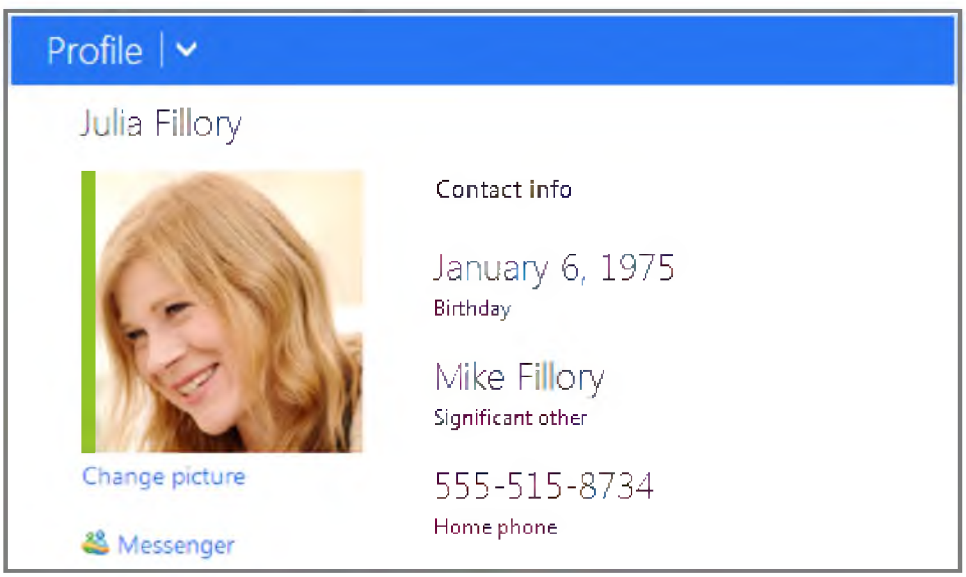
Yahoo! Contacts

- An **online calendar** to help **organize your schedule** and **share that schedule** with others.



Google Calendar

- A **public profile** that contains your name and basic contact information.



A Microsoft (Hotmail) profile

In addition, each provider offers some unique features. For instance, when you sign up for Gmail, you get access to a full range of Google services, including **Google Drive**, **Google Docs**, and more. Hotmail, on the other hand, offers connectivity with **SkyDrive** and **Microsoft Office Web Apps.** You can visit our tutorials on Google Drive and Docs and SkyDrive to learn more.

Getting Started With Email

You should now have a good understanding of what email is all about. Over the next few lessons, we will continue to cover essential **email basics**, **etiquette** and **safety tips**.

Try this!

When you're ready, you can try one or both of the following:

Get Your Own Email Account:

If you want to sign up for your **own email account**, we suggest choosing from one of the three major webmail providers.

Follow the links below to sign up for an email account:

- Yahoo! Mail: Click **Create New Account**
- Hotmail: Click **Sign Up Now**.
- Gmail: Click **Create an account**. You can visit our lesson on Signing Up for a Gmail Account for help.

Learn How to Use an Email Program:

Keep in mind that **Email 101** will not show you how to use a specific email account. For that, you will need to visit our Gmail topic. It's a useful course for learning the basics, even if you ultimately end up choosing an email provider other than Gmail, such as Yahoo! or Hotmail. There, you will learn how to:

- Sign up for an email account
- Navigate and get to know the email interface
- Compose, manage, and respond to email
- Set up email on a mobile device

Beyond Email: More Ways to Talk Online

Once you've completed the lessons in this topic, you may wish to explore other popular ways of communicating and sharing online. Check out our Beyond Email topic to learn more about **online chat**, **text messaging**, **video chat**, **social networking** and more.

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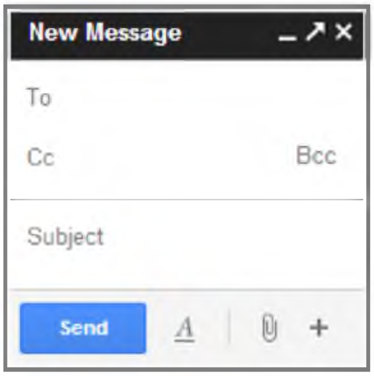
Page 1

Introduction



No matter what email service you choose, you'll need to learn how to interact with an **email interface**, including the **inbox**, the **Message pane** and the **Compose pane**. Depending on the email provider, the interface may look and feel different, but they all function in essentially the same way.

In this lesson, we'll talk about using an **email interface** to send and receive messages. We'll also discuss various **terms**, **actions** and **features** that are commonly used when working with email.

Page 2

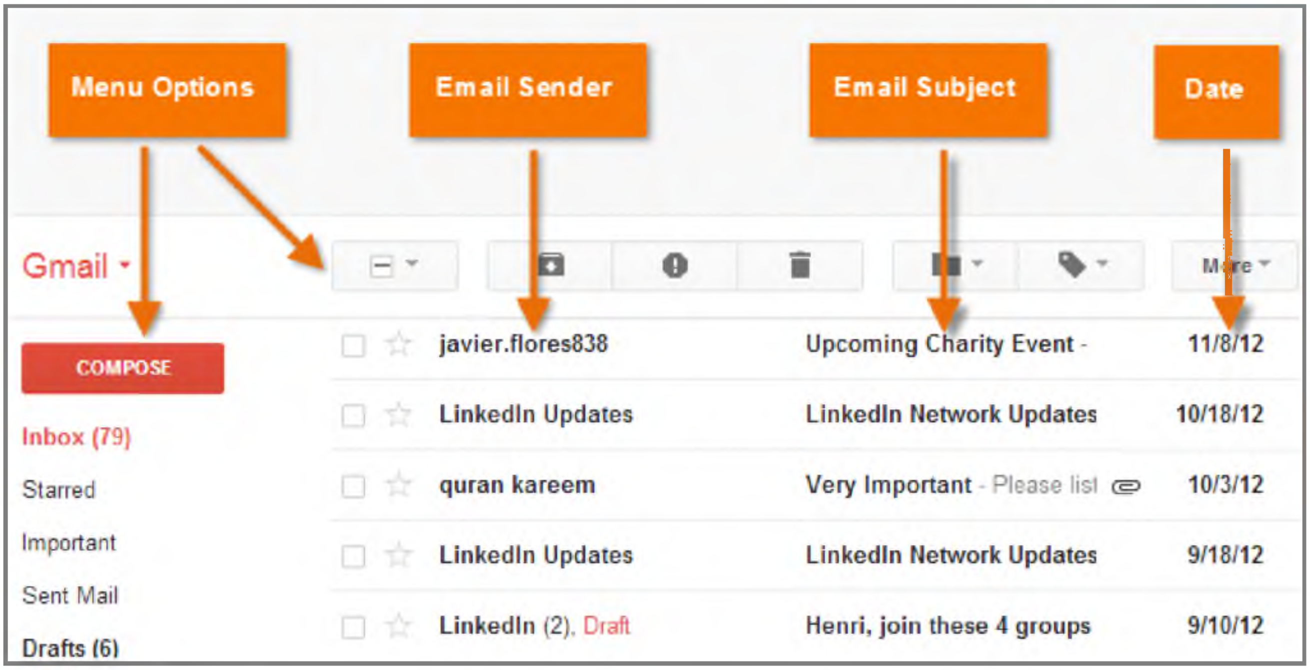
Understanding the Email Interface

Below are some examples of different **email interfaces** from the top webmail providers: **Gmail**, **Yahoo!** and **Hotmail**. Review the images below to become familiar with various email interfaces.

Keep in mind that these examples will only provide a general overview. You can visit our Gmail topic to learn how to use an email application in detail.

Inbox

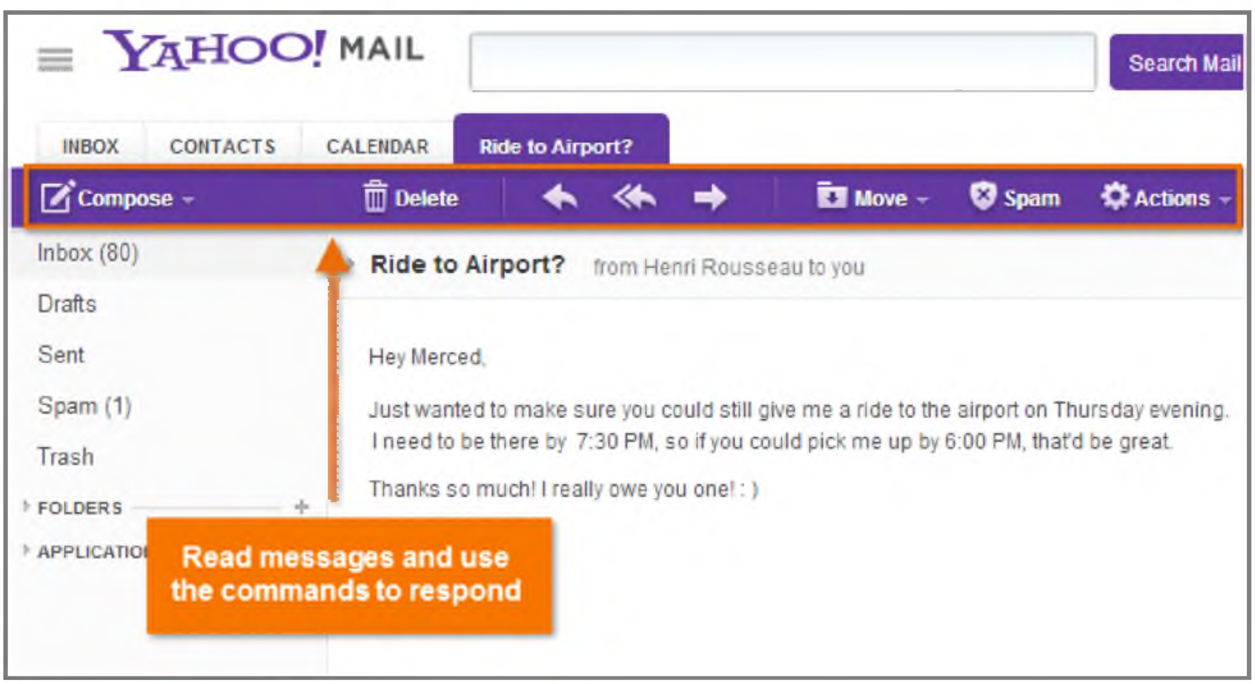
The **inbox** is where you'll view and manage **emails** you receive. Emails are listed with the name of the **sender**, the **subject** of the message and the **date received**.



Gmail inbox

Message Pane

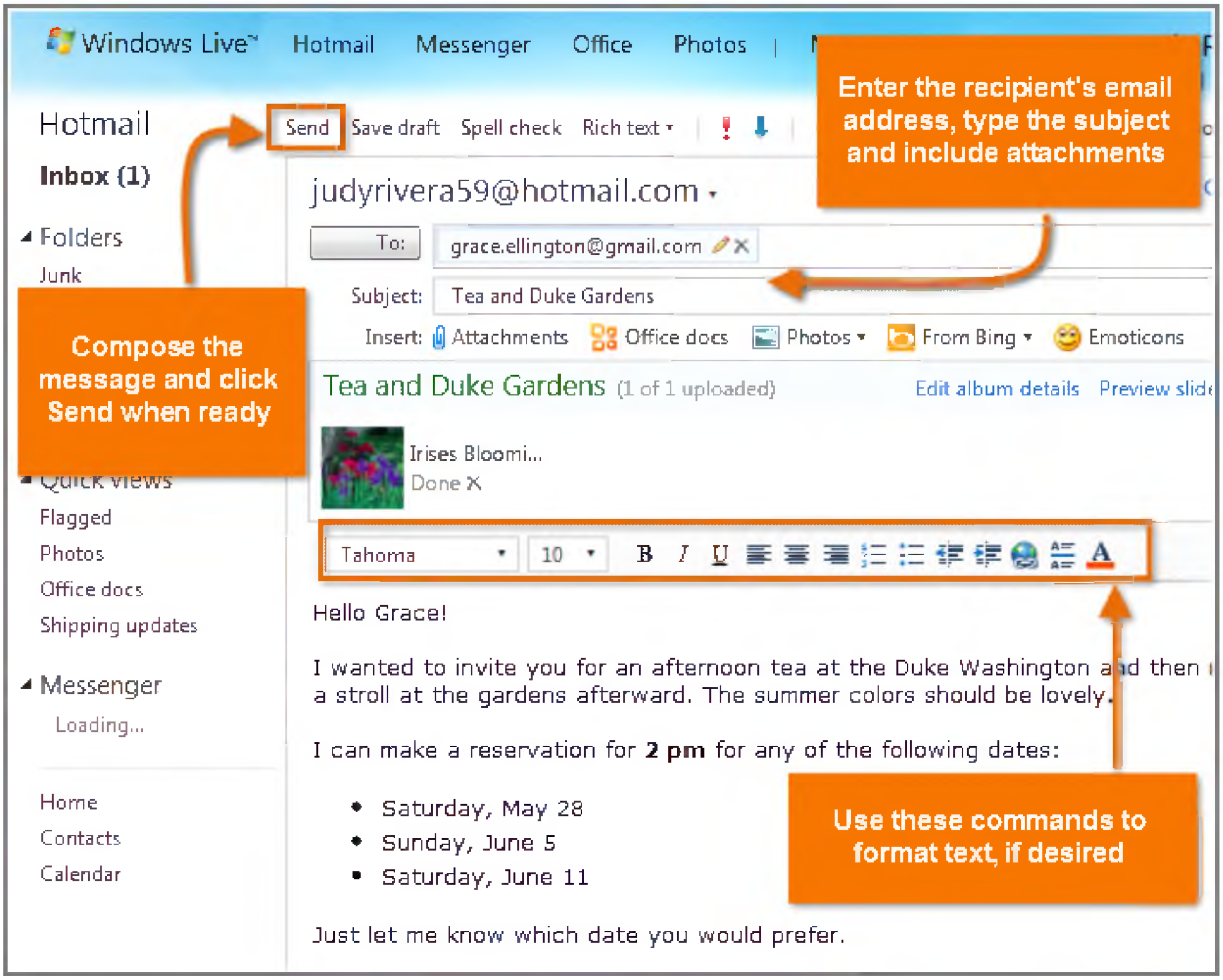
When you select an email in the inbox, it will open in the **Message pane**. From here, you can **read the message** and choose **how to respond** with a variety of commands.



Yahoo! Message pane

Compose Pane

You can click the **Compose** or **New button** from your inbox to open the **Compose pane** to create your own email message. From here, you'll need to enter the **recipient's email address** and a **subject**. You'll also have the option to upload files (photos, documents, etc.) as **attachments** and **add formatting** to the message.



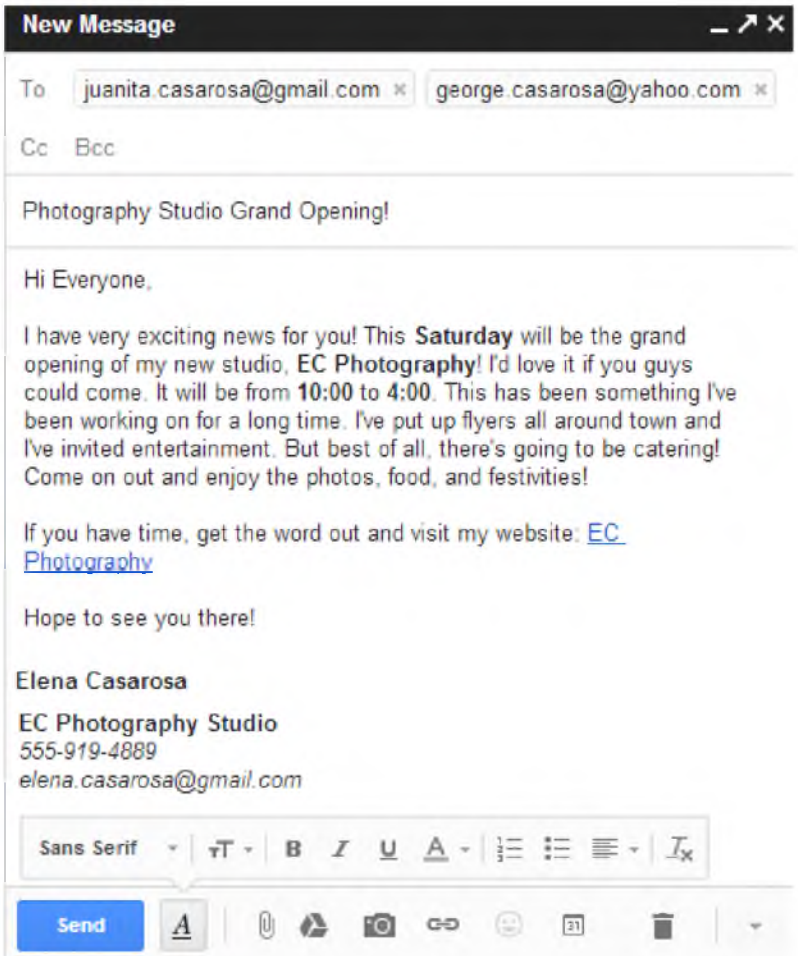
Hotmail Compose pane

A Compose pane will also appear when you select **Reply** or **Forward**. The text from the original message will be copied into the Compose pane.

Common Email Terms and Actions

All email applications use certain **terms** and commands that you will need to understand before using email. Click the buttons in the interactives below to learn more about basic email terms and commands.

The examples below use **Gmail's Compose pane** and **Message pane** to introduce basic email terms, but these will still be applicable for Yahoo! or Hotmail.



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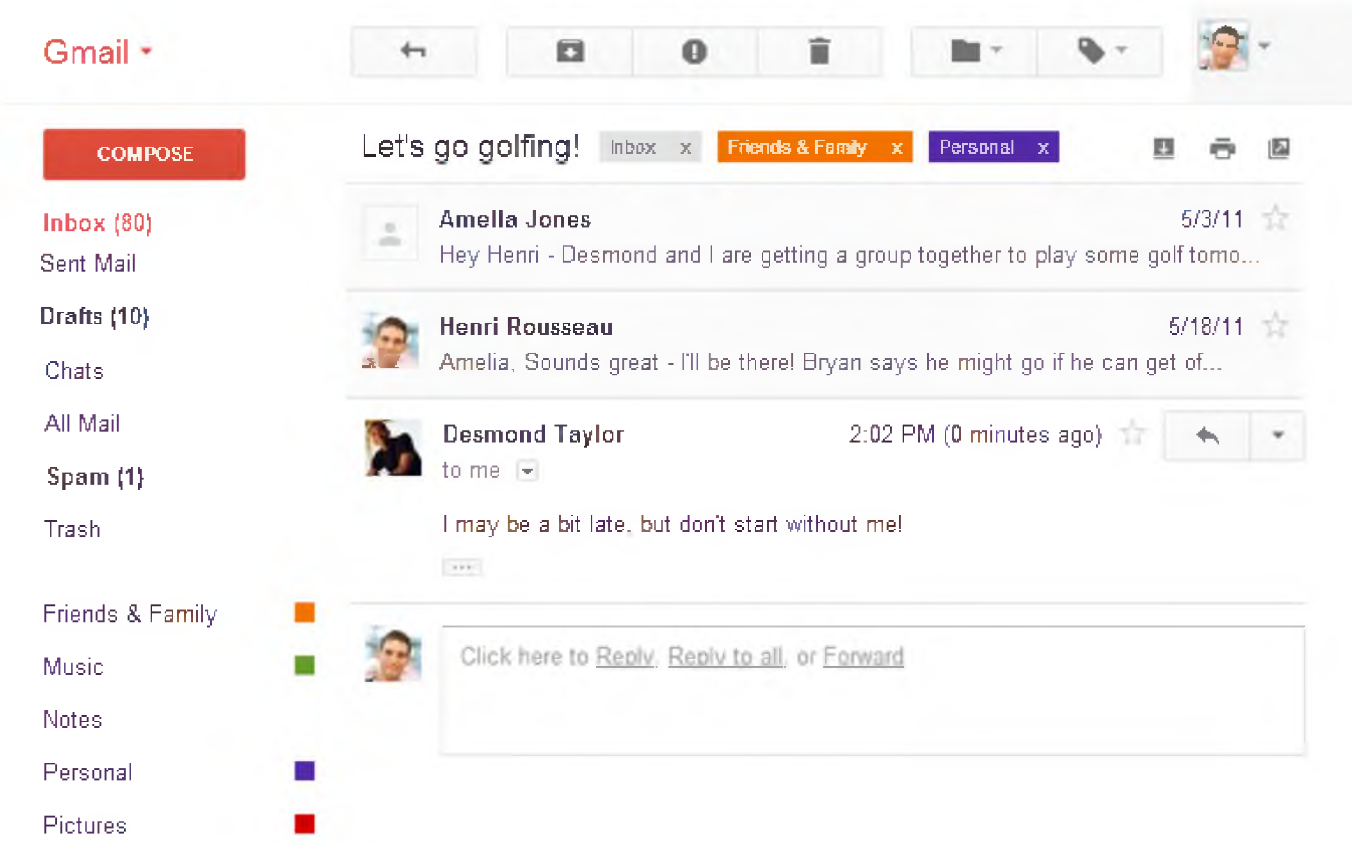

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CONTEMPORARY APPROACH TO ENHANCED ROAD TRANSPORT SYSTEM IN NIGERIA THROUGH THE APPLICATION OF IT-BASED (ONLINE) BUS TICKETING AND PAYMENT SYSTEM

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G. N. Okeudo[2]
E. C. Amadi[3]

ABSTRACT

The world is trending towards IT based technologies and Nigeria as a country is not left behind. The nature of transport needs makes it a key player in any viable economy. Owing to the possibilities that IT offers and the need for improved services (ticketing and otherwise) in the transport sector it is proper to look at what exists currently in the country and what steps could be taken based on current findings. This study looks at the existing ticketing systems, makes comparison with contemporary approaches to ticketing, draws information from other materials, journals, investigations and makes recommendations based on the findings. It further suggest a theoretical model for the Nigerian road transport system.

Key Words: Contemporary approach, road transport system, IT-based bus ticketing and payment system

INTRODUCTION

Contemporary approach involves using the state-of-the art means of transportation to overcome those inherent problems of the ancient road transport system. This modern means of transportation incorporates Internet facilities to provide access to the users at the remote areas. Transportation could simply be defined as the movement of people and goods from one location to another. Throughout history, the economic wealth and military power of people or nation have been closely tied to efficient methods of transportation. Transportation provides access to natural resources and promotes trade, allowing a nation to accumulate wealth and power. Transportation system and the routes they use have greatly influenced both how and where people live. Reliable transportation allows a population to expand throughout a country's territory and to live comfortably in remote areas far from factories and farms.

Transportation is vital to a nation's economy so reducing the cost of transporting natural resources to production sites and moving finished goods to the market is one of the key factors in economic competition. Transportation is usually classified by the medium in which the movement occurs,

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such as land, air, water or pipeline. Within each of the three media, many different methods are used to move people and goods from place to place. Pipelines are used mainly for transportation of liquids or gases over long distances.

BACKGROUND OF THE STUDY

Sustenance in a highly competitive transport industry harbors on patronage. This patronage is dependent upon the type and quality of service offered to her customer; the watchwords are diversity and quality, both of which are interrelated and interdependent on each other. The question is how can an organization achieve this?

Diverse emphasizes on the ability of the organization to offer various services to the customer while the quality relates to the efficiency and effectiveness of these services. This need is even enunciated in a transport company (ABC Transport) quarterly publication of August 2004 where the Assistant Manager of Cargo Operations wrote "…these steps; managing the spirit of innovation, performance and consolidation are necessary now that the competitors have taken advantage and dangerous positions, even ready to take advantage of our facilities and convert them to sustainable opportunities." With the advent of the Internet in Nigeria, there's being much major advancements in our Information Technology. Among the socio-economic effects, the Internet has spurred some forms for business transactions and exchange coined as Electronic Commerce. Though a recent development has already being internet banking system which many banks have initiated to enhance the service offered to their customers and also a medium of attracting new ones. So transport sector as an organization could integrate this technology like the banking sector, its services would definitely reap the bountiful opportunities and unique features it offers.

Aims of the Research

The aims of this system are:

- ✓ To provide a web-based buying bus ticket functions. Customer can buy bus ticket through the online system and no need to queue up to buy bus ticket in the counter.
- ✓ To provide anytime anyplace service for the customer. Customer can buy bus ticket 24 hours a day, 7 days a week over the Internet.
- ✓ To enable customer to check the availability of the bus ticket online. Customer can check the time departure and arrival for every bus through the system.
- ✓ To ease the bus ticket payment by online. Customer has to pay for the bus ticket by Credit/Debit Card.
- ✓ To minimize the number of staff.

Boundaries of the Research

IT-based bus ticketing and payment system is an easy-to-use self-service system which enables the customer buy bus ticket online and pays for the bus ticket through Credit/Debit Card. The application is deployed in one of the Nigerian most popular transport company called ABC Transport Company (Your transport to service). The company uses the software to reserve seats for customers from far and near to the company and captures customer information. It will equally be used to schedule time for bus departure from its origin and arrival to its destination. It also allows customer to pay and print receipt online.

Why This Research Is Very Important?

This study would spur up a greater desire for an improvement in business strategies and services rendered in a bid to further enhance the organizations' performance. It is important to customers because they can check availability of the bus tickets, and pay for the bus ticket online. E-ticket is different from the traditional paper ticket because e-ticket is safer, faster, reliable and maybe cheaper. The profit of any transportation company that uses this system will be increased because the online system will attract more customers and no need to hire many staffs at the counter to sell bus ticket because ticket can be sold efficiently online.

It should also assist the branch manager in calculating their daily collections and generating reports. In the long-term operation, the financial turnout from the sales of tickets is expected to increase as passengers' satisfaction is almost guaranteed with the availability of accurate information, shorter queues and better services.

REVIEW OF RELATED WORK

Introduction

The internet has become an integral part of a modern society helping revolutionize how businesses are conducted and our personal lives as well in addition to creating more jobs and transfer of technology by teaching new skills. This chapter defines facts and finding on Online Automated reservation system for transportation.

IT-based (Online) bus ticketing and payment system

IT-based bus ticketing and payment system is synonymous to an online reservation system or computer reservations system (CRS) or central reservation system, Wikipedia, 2011. IT-based bus ticketing and payment system is a computerized system used to store and retrieve information and conduct transactions related to bus travel. This idea of IT-based bus ticketing and payment system was originally designed and operated by airlines operators before its use was later extended to road transport travel agencies. Major CRS operations that book and sell tickets for multiple airlines are known as global distribution systems (GDS). Airlines have divested most of their direct holdings to dedicated GDS companies, who make their systems accessible to consumers through Internet gateways. Modern GDSs typically allow users to book hotel rooms and rent cars as well as airline tickets. They also provide access to railway reservations in some markets although these are not always integrated with the main system.

Based on Pedone (2001), widespread use of Internet has led to the emergence of a variety of electronic services, e-services. Electronic ticket, or e-ticket, is an example of such a class of e-services. E-tickets give evidence to their holders to have permission to enter a place of entertainment, use a means of transportation, or have access to some Internet services. Users can get the e-tickets by purchasing them from a web server, or simply receiving from a vendor, or from another user who previously acquired them**.** E-tickets can be stored in desktop computers or personal digital assistants for future use.

Advantages of IT-based bus ticketing and payment system

Quicker as the individual does not need to contact the airline, the bus company, and the hotel all separately

- Convenient as it can be done by anyone and anywhere with an internet connection
- Customers can compare bus, flight, hotel, and rental car rates
- Saves the time and trouble to find a suitable travel agent
- Cheaper fares/flying rates as some websites give lower rates for certain packages. Cheaper rates are also used to attract potential customers.

Road Transportation in Nigeria

Road transport (British English) or road transportation (American English) is transport on roads of passengers or goods. A hybrid of road transport and ship transport is the historic horse-drawn boat. The first methods of road transport were horses, oxen or even humans carrying goods over dirt tracks that often followed game trails. Transportation is a requirement for every nation, regardless of its industrial capacity, population size, or technological development. Moving goods and people from one place to another is critical to maintain strong economic and political ties between regions in the same state. How that movement takes place can be unique to location and technological development, but the requirement remains. Transportation derives demand from the things that it moves—it is only a valid economic force if there are valuable things to transport. The 'products' moved through a transportation network could be grain silage, electronics, or business executives. The cost of moving things from one place to another, whether it is measured in currency, fuel, or animals, typically remains stable over time, meaning that the relative cost of transporting a product decreases as the value of the product being transported increases. This phenomenon becomes important when examining nations with weak economies. If the relative value of the goods transported is low, the cost overhead for transportation is high. The reason for the relatively high cost of transport—and the low value of the products moved—is partially self-fulfilling. Because there are few valuable products to transport, there will be no transportation infrastructure to transport them. Because there is no way to transport valuable products reliably and cheaply to places where they might be marketed, there is no incentive to produce valuable products. If there is a correlation between transport systems and economic strength, part of the reason for modern Nigeria's economic weakness is its lack of strong transportation architecture. The current state of Nigerian transportation is a product of fifty years of colonial rule and mismanagement and another forty of relative neglect under self-rule. Civilian governments were often under-funded and their priorities were on maintaining regional divisions instead of maintaining transportation networks. This policy may have been self-fulfilling; by reinforcing regional divisions the appeal of inter-region transport infrastructure was further reduced. While some of the handfuls of military governments were interested in developing better transportation systems, they were often long term pipe dream-like solutions that would be solved with the future's money. This is evident in the practice of “National Development Plans” that don't come to fruition (Falola, Toyin and S.A. Olarenwaju, 1989). In addition, there is an ever-increasing amount of stress on Nigerian transport systems as the demand for transport services rises.

Finally, the Nigerian transport systems designed under colonial rule and maintained under civilian rule were poorly designed and are unable to scale up to meet greater demand, a design flaw which causes traffic congestion on roads, overstressed railways, faltering airfields, and mass-transport blind spots. This paper covers the origins of modern Nigerian transportation problems, covering the pre-colonial, colonial, and post-colonial developments and problems in Nigerian transportation technology and systems. Pre-colonial transportation and trade systems were limited to porter age over land by animals and humans, as well as on small boats over the many waterways through southern and central Nigeria. Nigerian states had extensive trade routes within their own territory, but also included moving goods across the desert to trade with North Africa and later to the coast to trade with Europeans. In this period, goods included gold, salt, slaves, groundnuts, and palm oil.

Roads were maintained by local leaders using hired labor, or conscripted locals on the basis of age. The king of the state of Wawa insisted on maintaining his roads even in the middle of the rainy season when roads often turned to muck. He believed that poorly maintained roads were a sign of 'a careless, slothful, cowardly governor' and that roads 'of convenient width, smooth, and free from grasses,' were a sign of a populous and prosperous society (Falola, Toyin and S.A. Olanrewaju, 1989). However, these tracks were often winding and elliptical; they were described by one European visitor as, “infinitely devious, turning aside here to dodge a thorn branch grown across the track, here to avoid a pool of the last season's rain” (Falola, Toyin and S.A. olarenwaju, 1989). These footpaths were highly subject to weather, many paths would turn into swamps during the rainy season and bridges would wash away. European travelers remarked that on some paths during the rainy season, “scarcely a day passed without our having several times to wade through water or soft mud nearly up to our waists, the result being that our feet were scarcely ever dry.”(Falola, Toyin and S.A. Olanrewaju, 1989).

The primary vehicles of trade in pre-colonial Nigeria were pack animals and human porters. Favored pack animals in Nigeria were the camel and the donkey, each for different tasks and for different reasons. The camel was ideally built for crossing the Sahara Desert into North Africa; it could travel for weeks without water and a week without food and it could carry five times the load of a donkey and ten times as much as a person. The camel was the basis for a robust and ancient trans-Saharan trade network dealing in gold, slaves, horses, and weapons. It became known as the *marktoub el Sahara,* or 'ship of the desert.' Donkeys, and to a lesser extent oxen, were used throughout Nigeria as pack animals. The donkey was especially popular because it was cheap, low-maintenance, could carry a significant weight, and could cover about 32 kilometers in a day.

Transport over water was done with a canoe made out of a dugout tree trunk, reeds, or pieces of wood sewn and sealed together. Larger boats were generally out of the question before river dredging by Europeans, they were simply too shallow to support deep-draft ships. In rainy season they could be as deep 11 feet, but only a foot and a half deep two months later in the dry season. However, despite the restrictions on the size of boats usable on Nigerian waterways, enough commerce passed along the rivers for it to be profitable to be a pirate.

The British claimed Nigeria in the late 19th century, and the pattern of British infrastructure development clearly revealed their intentions. The British immediately sought out to build a transportation network that would make ruling over the area as well as resource extraction easier. Road construction, and later railroad construction became primary goals of the colonial government. The unification of the Protectorate of Sokoto and the southern regions into one political entity in 1912 intensified these goals. A vast majority of the roads and railroads in Nigeria lead south-north, from the coast to the inland and back again. East west transportation routes weren't necessary because the flow of goods—such as ground nuts, cocoa, and cotton—was from the inland to the coast where it could be shipped to Britain for processing. The designers of the British road networks attempted to use existing footpaths to connect cities in Nigeria, but found that the nature of these footpaths made them difficult, if not impossible, to expand into wide roads suitable for automobiles. These new roads were still subject to the damaging effects of their rainy season, though, so they were often damaged destroyed every season when the rains came. Frustrated by repeatedly rebuilding bridges, some local governments stopped importing wood, steel, or concrete and used entirely local material to produce cheap, expendable bridges, instead.

Nigerians took advantage of the introduction of automobiles by developing taxi and goods transportation services. Nigerian methods of transportation were often more efficient than their British counterparts. They were more flexible, made use of more appropriate technology, and could charge lower rates. A British transport company called Weakes Transport announced that it was offering scheduled services in 1923. Because of the inflexibility of scheduled routes, weak Transport vehicles often ended up carrying less than full loads at higher prices than their indigenous counterparts. Nigerians tended to favor American vehicles for transportation during the colonial period. They were cheaper than British vehicles, costing about half as much as the equivalentBritish imported machine. They were also common and easily-serviced because of a plethora of spare parts, while British vehicles had lacking after-market support in colonial Nigeria.
American cars, especially the Ford, were also very light and had pneumatic tires, which allowed it to travel over roads that wouldn't be suitable for the heavier British vehicles. A colonial administrator in Lagos commented that, “there are nearly 2,000 miles of road over which motor cars can travel. But only 180 miles are metaled to take heavy motor cars” (Drummond-Thompson and Phillip, 1990). He went on to comment that the American Ford completely outstrips the English equivalent in versatility.

The drivers of Nigerian Lorries would wait to fill his vehicle before leaving for a destination. In this way they could outmaneuver their British competition. Below is the account of a traveler of his experiences with Nigerian drivers, written in 1950. He describes the poor condition of the road, and the Nigerian skill in avoiding its pitfalls, as well as the jury-rigged nature of the vehicles that travel Nigerian roads.

Historical Background of Abc Transport

Associated Bus Company Limited, operators of ABC transport commenced operations in road transportation on the 13th of February, 1993 as an off-shoot of rapid ventures with a view of running a modern road transportation system in Nigeria. ABC transport operates luxury bus services according to accepted international standards of road transportation. Its services are specially designed for distinguishing travellers who would otherwise use air service.

The operations of the company with the country is carried out with modern terminals, comfortable passengers lounge in various cities like Lagos, Aba, Owerri, Port-Harcourt, Abuja, Enugu, Onitsha, Umuahia etc. ABC buses are dubbed with the company's trademark the REINDEER. The choice of the REINDEER as the company's symbol was made after a careful study of the peculiarities of the animal which is strong, fast and move in herds. For the company's remarkable achievement in transportation, ABC transport was in 1996/2000 adjudged the best transporters in Nigeria by the chartered institute of transport in Nigeria and has since then consistently won the national bus operator of the year award along with other accolades by renowned bodies.

Services

- **Parcel/cargo:** After being licensed, this service offers non-traveling passengers an avenue to transporting mails, documents, parcels and goods to consign who pick them up at the terminals. Unaccompanied goods (way bills) are carefully tagged and delivered safely to the terminal, where the consignee comes to collect them with proper identification; this is not a door-to-door service. For hauling bulky goods' ABC transport also offer cargo delivery services with heavy duty trucks. The company effectively carries out haulage activities nationwide.
- **Transport Services:** Recently, the company increased its reach out with the expansion of facilities, terminals and the acquisition of state of the art buses like the sleeper. The company covers its routes daily in normal batches. ABC transport covers here zones – east, west and north with concentration on the east-west routes.

  Also, ABC has recently being involved in transportation between Nigeria and some close by West African countries like Ghana and others.

Classes of Bus Transport Service

ABC transport for operates two classes of services:

- **Business class:** A non-air conditioned but comfortable luxurious bus service at an affordable price with lunch packs.
- **Executive class:** This class of service is for passengers who want to travel in comfort. The price is a also affordable but slightly higher than that of the business class. It offers a non stop air conditioned service.

Operational Standards

Standards are policies or protocols which a company adhere to in all its official dealings. In ABC there are quite a number of them.

- **Safety:** Drivers do not move more than 90kkm/hr. must move in herds (if necessary) and stop in between terminals to rest the engine and for passengers to rest their legs. ABC has a road safety department which ensures compliance.
- **Receipt:** All payments must be accompanied with a receipt.
- **Ticketing:** Tickets for trips must be obtained from the terminals and cannot be transferred. Sales of tickets are on a first come, first serve basis.
- **Tagging:** All cargos/loads accompanied or not must be tagged for identification purposes and clearance.

- **Cancellation:** A ticket cancellation made before the departure of the bus attracts 15% of the cost, after departure attracts 50% of the cost of the ticket. Tickets are valid for 90 days after issuance.
- **Reservation:** Reservations can be made in advance of three days provided it is accompanied with full payments. Passengers must try and confirm their reservation before departure time.
- **Exceptional cases:** Children below 12 years will be given rebate of 50% and must be accompanied. An adult passenger is entitled to two kids only.
- **Frequent Traveler Program:** Passengers who make up to eleven trips within a year are entitled to 50% discount on their twelfth trip. Such passengers will be awarded diamond card, which entitles them to privileges as provided by the company. Four times winner of the diamond cards consecutively within an operational year or four years will graduate into gold class with benefits as provided by the company.

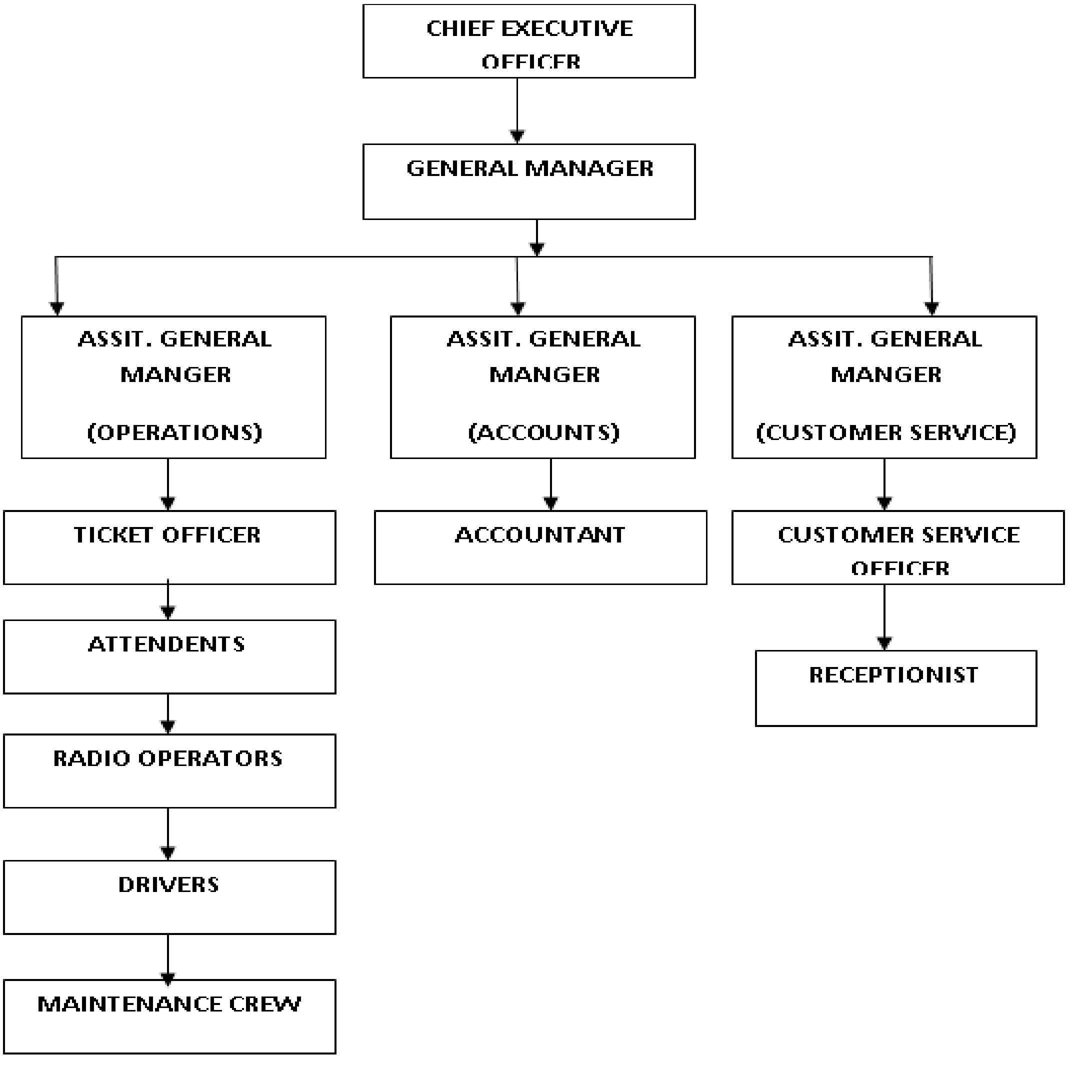


Fig-1. Organizational Structure

METHODOLOGY AND SYSTEM ANALYSIS ADOPTED

A research methodology defines what the activity of research is, how to proceed, how to measure progress and what constitutes success. Methodology is generally a guideline for solving a problem with specific components such as phases, tasks, methods, techniques and tools. It can be defined as the analysis of the principles of methods, rules and postulates employed by a discipline. It could also be seen as a documented process for the management of projects that contains procedures, definitions and explanations of techniques used to collect, store, analyze and present information as part of a research process in a given discipline.
The study adopts SSADM (Structural system Analysis and Design Methods) for development which follows definite steps to achieve a given task.

SYSTEM INVESTIGATION AND ANALYSIS

System study aims at establishing requests for the system to be acquired, development and installed. It involves studying and analyzing the ways in which the transport organizations currently process the data to produce information. Analyzing the problem thoroughly forms the vital part of the system study. In system analysis, prevailing situation of problem is carefully examined by breaking them into sub-problems. Problematic areas are identified and information is collected. Data gathering is essential to any analysis of requests. It is necessary that this analysis familiarizes the designer with objectives, activities and the function of the organization in which the system is to be implemented.

METHOD OF DATA COLLECTION

This involves gathering facts about the existing system. The purpose of this analysis is to identify the inefficiencies associated with the existing system and the requirement analysis for the proposed system, Online Bus Ticket Reservation System. There are many fact-gathering techniques that can use in gathering the information such as interview, observation, questionnaires and other method.

- ✓ **Observation method:** This method is a technique used to obtain an overall virtual impact of a system environment. This takes into the study of details relating to customers and the traditional reservation system, the speed of operations, number of staff, bottlenecks and delays. Etc. The researcher took time to examine the way factors that are detrimental to customer satisfaction. This method helped the researcher to know the problem encountered by the traditional system that will be eliminated by the computerized system.
- ✓ **Questionnaire method:** This method was used to obtain information from external party about the system. Concise and unambiguous questions made up the questionnaire.
- ✓ **Interviews:** This method was engaged so as to get detailed understanding of the system and clearer insight to the system and policies were also gathered. Summarily, this method gave up some integral dynamics and uses of the system.

Analysis phase is the step that is concern with first studying the existing system, then using the information gathered to define the requirements for a new system. Analysis follows the problem recognition and feasibility phases and must be completed before the design phase can begin.

ANALYSIS OF EXISTING SYSTEM

Here the researcher made a fact finding and was able to identify procedures and operations mapped out for the existing system.

To avoid queues and hassles associated with last minute immediate travel bookings at terminals, some passengers look forward to make reservations before the actual date of travel. There are two methods involved; Direct and Call-in reservation. With both reservation methods, the customer must first confirm the financial implications, if there are available seats; the passenger must now

choose a seat. All of this requires the staff manually opening and checking documents and books each time to get the required indication while the customer and the other possibly in a queue exercise the virtue of patience same applies to those calling the terminus. Finally the passengers' data is required in order to issue the ticket and prepare manifest.
Basic data contained in the ticket are: Name, Address Seat number, Cost of fare and Next of kin phone number A ticketing officer handling more than one route repeats this process for every route and passenger. Routinely each day's operation starts with the ticketing officer drawing circles with numbers and crossing those seat numbers that have been reserved.

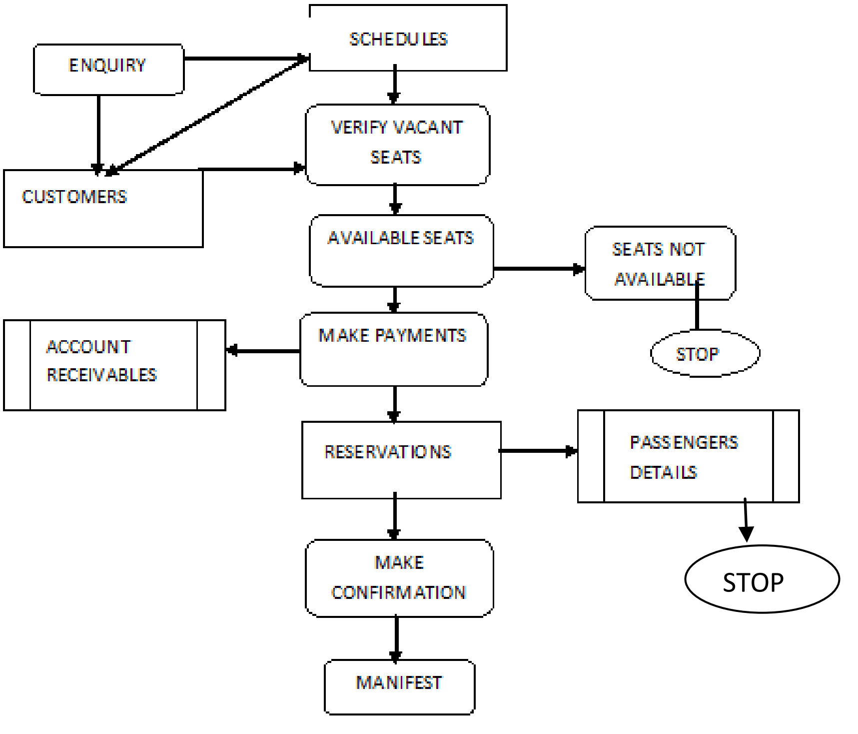


FIG.2 - PROCESS MODEL

Weakness of the Existing System

Due to the fact that most reservation systems are human-driven, it gives room for the following identified weakness:

- Existing system is totally on book and thus a great amount of manual work has to be done. The amount of manual work increases exponentially with increase in bus services.
- Needs a lot of working staff and extra attention on all the records.
- There are various problems like keeping records of items, seats available, prices of per/seat and fixing bill generation on each bill.
- Finding out details regarding any information is very difficult, as the user has to go through all the books manually.
- Major problem is the lack of security.

OVERVIEW AND EXPECTATIONS FROM THE MODEL OF THE PROPOSED SYSTEM

After carrying out the analysis on the present system and thus highlighting its shortcomings, the researcher considered the option of introducing an innovative, efficient and effective system to implement the advance booking and reservation policy. The system is very simple in design and to implement. The system requires very low system resources and the system will work in almost all configurations. It has got following features

- Ensure data accuracy.
- Records are efficiently maintained by DBMS.
- DBMS also provides security for the information.
- Any person across the world, having internet can access this service.
- Seat numbers are auto generated
- Reservations can be cancelled.
- Minimum time needed for the various processing.
- Better Service.
- Minimum time required.
- This would help the corporation prepare and organize its schedules more efficiently on the basis of traffic demand.
- Personalized services.
- Optimization of manpower available.

3.3.4 Data Flow Diagram

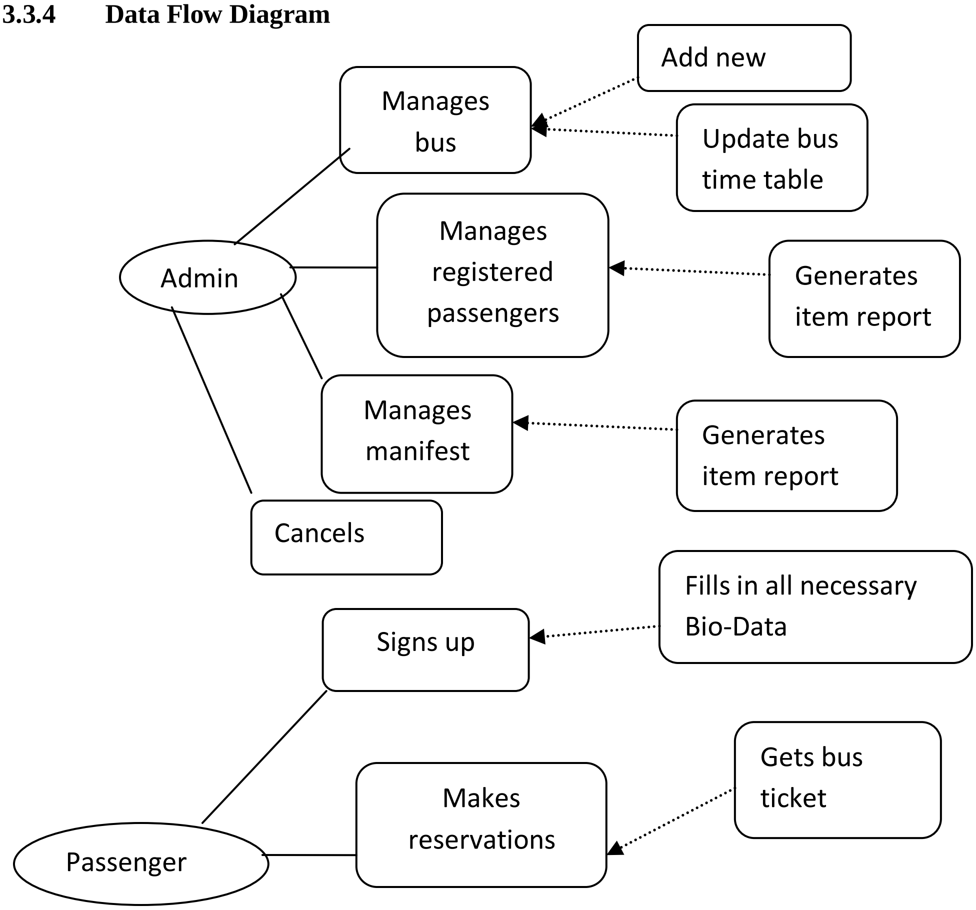


Fig.3 – Data Flow Diagram

System Design and Implementation

This chapter deals with the technical details of modeling the system, designing its inputs and outputs, the application architecture and producing specifications which will enable the application work.

Objective of the Proposed System

Amongst the objective of the system design is the implementation of a system that integrates the function of the existing system yet modifying and proffering innovation methods superior to the previous system.

Being a little specific, the new system is expected to be;

- Timely and reliable
- Scalable – The new system should be able to be moved into a larger and more demanding environment with ease.
- Security enabled – This is vital in the design and expectation of any system. It should contain mechanism to protect the integrity and avoid changes or access by unauthorized users.

- Flexible – As a result of the huge resources expected to be invested into the system, the system is expected to be extensible to accommodate changes in infrastructure, business policies of the Transport Company in the future.
- Easily maintainable, easy to upgrade and make adjustments to.

HIGH LEVEL MODEL OF THE PROPOSED SYSTEM

(ONLINE BUS TICKET RESERVATION SYSTEM (OBTRS))

The proposed system will be divided into four subsystems as shown below;

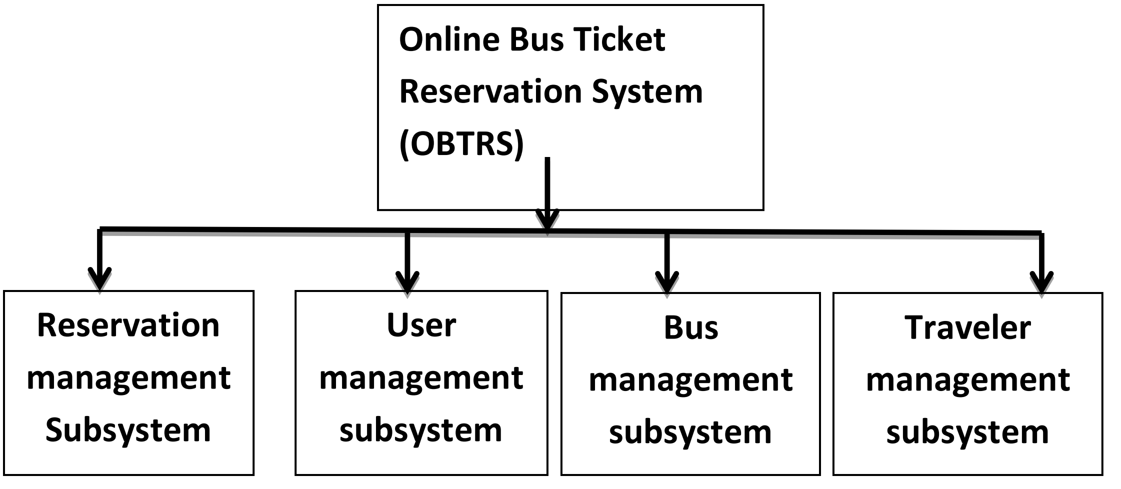


Fig-4.HIGH LEVEL MODEL OF THE PROPOSED SYSTEM

Reservation Management System

The automated system allows the traveler to use the OATRS to make reservations and enquiries. It performs the following functions;

- Receives processes and stores requested user enquiries or reservation request.
- Changes passengers' reservations request and updates account.
- Generates online seat availability report.

This subsystem virtually takes the manual reservation operation and enquiry processing of the existing system.

User Management Subsystem

The user here is a staff of the transport Company that would be allowed to use the system whose authorization properties would determine his/her type of access. This subsystem will allow for;

- Addition of new users
- Removal of users
- Changing users passwords

Bus Management Subsystem

This manages the bus schedule and fare details for each service. This subsystem allows for the following;

- Modification of bus fare
- Schedule and number of buses assigned to a route.

Traveler Management Subsystem

This subsystem provides the following functions;

- Registration of new travelers
- Travelers account transactions and auditing functions.

Database Design

The data in the database must be logically organized to store data and relevant information.
For this project, MYSQL database management system was decided to be used for the database development. After making a selection for the relational database to be used and also receiving requirement Information on the data to be managed in the project, a design showing the Entity Relationship Diagram for the database as drafted below.

Conceptual Design

Requirement Analysis: This concept deals with what data is needed.
List of Entities and their associated attributes:

- Bus-(*Bus id, Bus name, Executive type, Business type, Maximum seats, Route, Departure time, Price, status etc.*)
- Passenger- (*Passenger id, First-Name ,Middle-Name, Last-Name Mobile number, E-mail, Address, Username, Password, Registration date etc.*)
- Admin – (*Admin ID, Username, password etc*)
- Reservation- (*Bus reserved ID, Full name, Phone number, Route, Bus number, Bus name, Category, Username, Price, Date/time, MasterCard type, MasterCard pin, MasterCard expiry date*)etc.
- *Payment(payment_id,name,*
- *States(state_id, name etc.)*
- *Staff(staff_id, First name, middle_name, etc.)*
- *Trip(trip_id,total_amount,created date, schedule_idect.)*
- *Driver(Driver_id , First name, middle_name, etc.)*
- *Terminal(terminal_id, official phone,address, city, state_idetc)*
- *Schedule(schedule_id,from_terminal_id,to_terminal_id.amount etc.)*
- *Bus type(id,name,capacity etc.)*

Logical Design

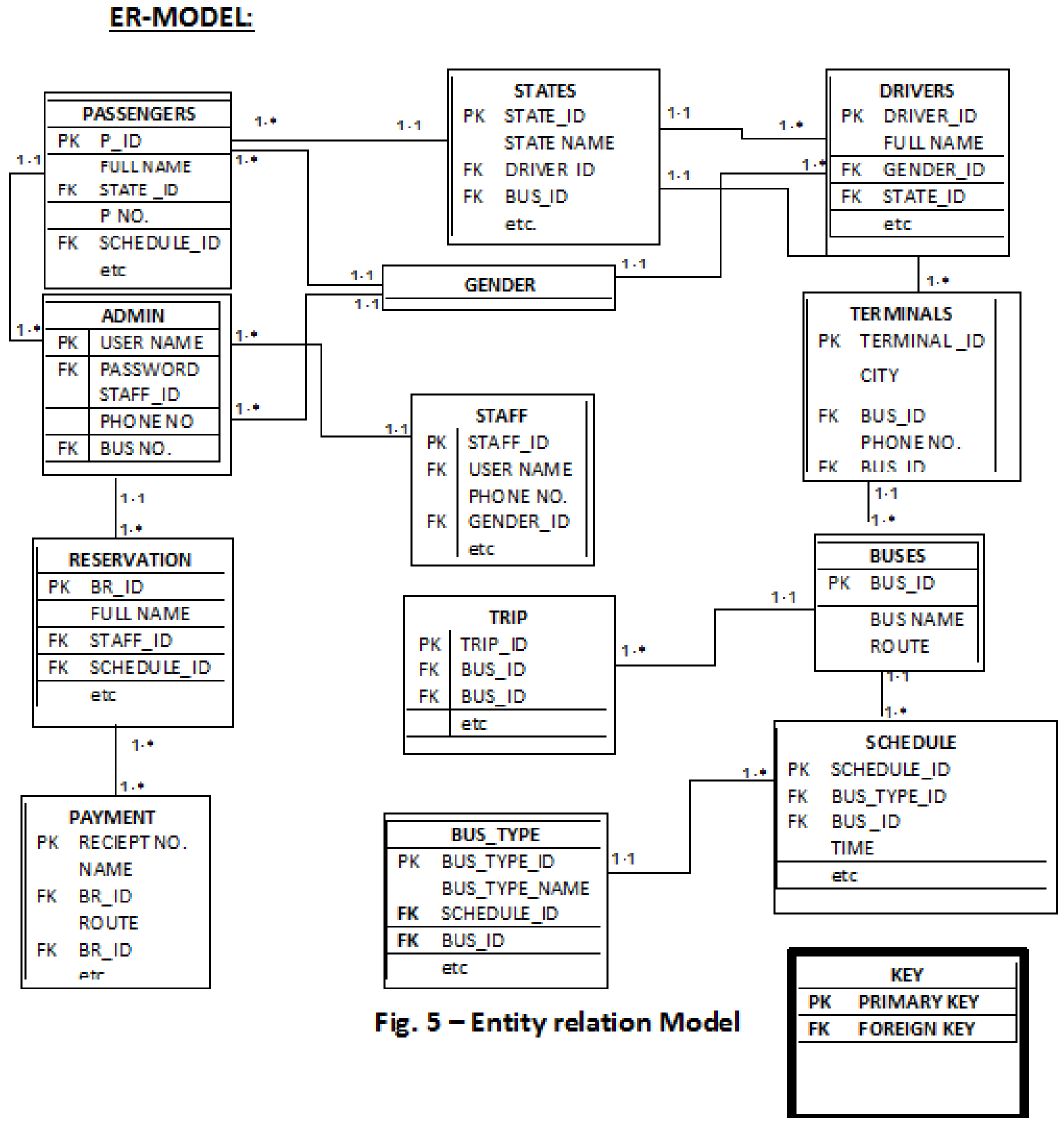


Fig. 5 – Entity relation Model

Table 1: ADMIN TABLE

FIELD NAME	TYPE	SIZE	DESCRIPTION	NULL	DEFAULT
ADMIN_ID	TINYINT	3	ADMIN ID	NOT NULL	YYY
USERNAME	VARCHAR	15	ADMIN USERNAME	NOT NULL	
PASSWORD	VARCHAR	10	ADMIN PASSWORD	NOT NULL	
STAFF_ID	TINYINT	3	STAFF IDENTIFICATION NUMBER	NOT NULL	YYY

Table-3.*Reservation Table*

FIELD NAME	***TYPE***	***SIZE***	***DESCRIPTION***	***NULL***	***DEFAULT***
BR_ID	*TINYINT*	*3*	*BUS RESERVED ID*	*NOT NULL*	
FIRST NAME	*VARCHAR*	*10*	*PASSENGER FIRST NAME*	*NOT NULL*	
MIDDLE NAME	*VARCHAR*	*10*	*PASSENGER MIDDLE NAME*	*NULL*	*NULL*
LAST NAME	*VARCHAR*	*10*	*PASSENGER LA ST NAME*	*NOT NULL*	
PHONE	*VARCHAR*	*13*	*PASSENGER PHONE NO*	*NOT NULL*	
ROUTES	*VARCHAR*	*10*	*BUS ROUTE*	*NOT NULL*	
BUS _NO	*VARCHAR*	*10*	*BUS NUMBER*	*NOT NULL*	
BUS_NAME	*VARCHAR*	*10*	*BUS NAME*	*NOT NULL*	
CATEGORY	*VARCHAR*	*10*	*BUS CATEGORY*	*NOT NULL*	
USERNAME	*VARCHAR*	*10*	*PASSENGER USERNAME*	*NOT NULL*	
PRICE	*DECIMAL*	*10*	*TRANSPORT FARE*	*NOT NULL*	*0.00*
DATE TIME	*VARCHAR*	*8*	*DATE AND TIME OF DEPARTURE*	*NOT NULL*	
CCTYPE	*VARCHAR*	*10*	*MASTERCARD TYPE*	*NOT NULL*	
CCPIN	*VARCHAR*	*10*	*MASTERCARD PIN*	*NOT NULL*	*0*
CCEXPIRY	*VARCHAR*	*10*	*MASTERCARD EXPIRY DATE*	*NOT NULL*	

Table -4. *Staff Table*

FIELD NAME	TYPE	SIZE	DESCRIPTION	NULL	DEFAULT
STAFF_ID	TINYINT	3	STAFF IDENTITY	NOT NULL	YYY
FIRST_NAME	VARCHAR	10	STAFF FIRST NAME	NOT NULL	
MIDDLE_NAME	VARCHAR	10	STAFF MIDDLE NAME	NULL	NULL
LAST_NAME	VARCHAR	10	STAFF LAST NAME	NOT NULL	
GENDER_ID	TINYINT	3	STAFF GENDER IDENTITY	NOT NULL	YYY
PHONE	VARCHAR	13	STAFF PHONE NUMBER	NOT NULL	
REG_DATE	DATETIME	8	REGISTRATION DATE	NOT NULL	
ADDRES	VARCHAR	30	STAFF ADDRESS	NOT NULL	
STATE_ID	TINYINT	3	STAFF STATE IDENTITY	NOT NULL	YYY
USERNAME	VARCHAR	10	STAFF USER NAME	NOT NULL	
USERPASSWORD	VARCHAR	10	STAFF PASSWORD	NOT NULL	

Table-5. *Trip Table*

FIELD NAME	TYPE	SIZE	DESCRIPTION	NULL	DEFAULT
TRIP_ID	DECIMAL	3	TRIP IDENTITY	NOT NULL	YYY
TOTAL_AMOUNT	DATETIME	10,2	TRIP TOTAL AMOUNT	NOT NULL	0.00
CREATED DATE		8	TRIP DATE	NOT NULL	
SCHEDULE _ID	TINYINT	3	SCHEDULE IDNTITY	NOT NULL	YYY
BUS_ID	TINYINT	3	BUS IDENTITY	NOT NULL	YYY

Table-6. *Drivers Table*

FIELD NAME	*TYPE*	*SIZE*	*DESCRIPTION*	*NULL*	*DEFAULT*
DRIVER_ID	*TINYINT*	*3*	*DRIVER IDENTITY NUMBER*	*NOT NULL*	*YYY*
FIRST NAME	*VARCHAR*	*10*	*DIRVER'S FIRST NAME*	*NOT NULL*	
MIDDLE NAME	*VARCHAR*	*10*	*DIRVER'S MIDDLE NAME*	*NULL*	*NULL*
LAST NAME	*VARCHAR*	*10*	*DIRVER'S LAST NAME*	*NOT NULL*	
GENDER_ID	*TINYINT*	*3*	*DRIVER'S GENDER IDENTITY*	*NOT NULL*	*YYY*
PHONE	*VARCHAR*	*13*	*DRIVER'S PHONE NUMBER*	*NOT NULL*	
STATE_ID	*TINYINT*	*3*	*STATE IDENTITY*	*NOT NULL*	*YYY*
ADDRESS	*VARCHAR*	*30*	*DRIVER'S ADDRESS*	*NOT NULL*	
STATUS	*VARCHAR*	*7*	*DRIVER'S STATUS*	*NOT NULL*	

Table 7: Bus Table

FIELD NAME	*TYPE*	*SIZE*	*DESCRIPTION*	*NULL*	*DEFAULT*
BUS_ID	*INT*	*11*	*BUS IDENTITY*	*NOT NULL*	*YYY*
BUSNAME	*VARCHAR*	*10*	*BUS NAME*	*NOT NULL*	
MAX SEATS	*CHAR*	*5*	*MAXIMUM SEAT*	*NOT NULL*	
EXECUTIVE	*CHAR*	*5*	*EXECUTIVE BUS TYPE*	*NOT NULL*	
BUSINESS	*CHAR*	*8*	*BUSINESS BUS TYPE*	*NOT NULL*	
ROUTES	*VARCHAR*	*10*	*DESTINATION ROUTE*	*NOT NULL*	
DEPARTURE TIME	*VARCHAR*	*10*	*DEPARTURE TIME*	*NOT NULL*	
PRICE	*DECIMAL*	*7*	*TRANSPORT FARE*	*NOT NULL*	*0.00*
STATUS	*VARCHAR*	*9*	*BOOKED OR PENDING BUSES*	*NOT NULL*	

Ttable-8. *BusType Table*

FIELD NAME	***TYPE***	***SIZE***	***DESCRIPTION***	***NULL***	***DEFAULT***
BUS_ID	*TINYINT*	*3*	*BUS ID*	*NOT NULL*	*YYY*
BUS_TYPE_NAME	*VARCHAR*	*10*	*BUS TYPE NAME*	*NOT NULL*	
CAPACITY	*TINYINT*	*4*	*MAXIMUM SEAT*	*NOT NULL*	*0*

Table-9. *Schedule Table*

FIELD NAME	*TYPE*	*SIZE*	*DESCRIPTION*	*NULL*	*DEFAULT*
SCHEDULE_ID	*SMALLINT*	*5*	*SCHEDULE_ID*	*NOT NULL*	*YYY*
FROM_TERMINAL_ID	*TINYINT*	*3*	*BUS DEPARTURE TERMINAL*	*NOT NULL*	*YYY*
TO_TERMINAL_ID	*TINYINT*	*3*	*BUS DESTINATION TERMINAL*	*NOT NULL*	*YYY*
AMOUNT	*DECIMAL*	*6*	*STIPULATED AMOUNT*	*NOT NULL*	*0.00*
BUS_TYPE_ID	*TINYINT*	*3*	*BUSINESS BUS TYPE*	*NOT NULL*	*YYY*
TIME	*TIMESTAMP*	*10*	*CURRENT DB TIME*	*NOT NULL*	

Table 10: Terminal Table

FIELD NAME	*TYPE*	*SIZE*	*DESCRIPTION*	*NULL*	*DEFAULT*
TERMINAL_ID	*TINYINT*	*3*	*TERMINAL ID*	*NOT NULL*	*YYY*
PHONE	*VARCHAR*	*13*	*TERMINAL OFFICIAL PHONE NO*	*NOT NULL*	
CITY	*VARCHAR*	*10*	*MAXIMUM SEAT*	*NOT NULL*	
STATE_ID	*TINYINT*	*3*	*EXECUTIVE BUS TYPE*	*NOT NULL*	*YYY*

SYSTEM DESIGN

System design is the design of various program modules, their characteristics and functions and how they will interact with each other. The system design will consist of designing the front-end that is the database where all the data will be stored and functions and subroutines that will link the front-end and the back-end and provide data manipulations.

The objectives of the new system will be used to develop some program modules to communicate; they will need a way to interact with each other.

The Admin user, apart from management of users, bus availability, prices, and route management can also generate reports of signed up users, reservation made and manifest. These developments were all generally achieved using the development tool Dreamweaver to code the layout in HTML and CSS, while the function that is performed by different users were generally achieved using PHP scripting language and JavaScript whenever it is necessary. Finally the session tracking of the system users' were also implemented to track users' accessibility and authorization to various functions for example a regular user can't perform the functions of the admin of the system.

Choice of Programming Language

In software engineering, a web based application-sometimes called a webapp and much less frequently a web application-is an application that is accessed with a web browser over a network such as the internet or intranet. Web applications are popular due to the ubiquity of the browser as a client, sometimes called a thin client. The ability to update and maintain web applications without distributing and installing software on potentially thousands of client computers is a key reason for their popularity. Web applications are used to implement web mail, online retail sales, online auctions, wikis, discussion boards, web logs, MMORPGs, video logging and perform many other functions.

Though many variations are possible, a web application is commonly structured as a three-tiered application. In its most common form, a web browser is the first tier, an engine using some dynamic web content technology (e.g. CGI, PHP, Java servlets or Active Server Pages) is the middle tier, and a database is the third tier. The web browser sends requests to the middle tier, which services them by making queries and updates against the database and generatinga user interface.

Therefore, the web based application is chosen in the development of this system.

Hypertext Pre-processor (PHP): is a general-purpose scripting language that is especially suited to server-sideweb development where PHP generally runs on a web server. Any PHP code in a requested file is executed by the PHP runtime, usually to create dynamic web page content. It can also be used for command-line scripting and client-sideGUI applications. PHP can be deployed on most web servers, many operating systems and platforms, and can be used with many relational database management systems (RDBMS). It is available free of charge, and the PHP Group provides the complete source code for users to build, customize and extend for their own use.

Advantages of PHP

- It's fast**:** This is because it is embedded in HTML code, the time to process and load a Web page is short.
- It's free: PHP is proof that free lunches do exist and that you can get more than you paid for.
- It's easy to use**:** The syntax is simple and easy to understand and use, even for non-programmers. PHP code is designed to be included easily in an HTML file.
- It's versatile**:** PHP runs on a wide variety of operating systems, like Windows, Linux, Mac OS, and most varieties of UNIX.
- It's secure: As long as your scripts are designed correctly, the user does not see the PHP code.
- It's customizable: The open source license allows programmers to modify the PHP software, adding or modifying features as needed to fit their own environments.

My SQL

MySQL is a popular choice of database for use in web applications, and is a central component of the widely-used LAMP web application software stack — LAMP is an acronym for "Linux, Apache, MySQL, and PHP". Its popularity is closely tied to the popularity of PHP. MySQL is used in some of the most frequently visited web sites on the Internet, including Flickr, Facebook, Wikipedia and Google— though not for searches.

Java Script Programming Language

JavaScript is a programming language that can be included on web pages to make them more interactive. You can use it to check or modify the contents of forms, change images, open new windows and write dynamic page content. You can even use it with CSS to make DHTML

(Dynamic HyperText Markup Language). This allows you to make parts of your web pages appear or disappear or move around on the page. JavaScripts only execute on the page(s) that are on your browser window at any set time. When the user stops viewing that page, any scripts that were running on it are immediately stopped. The only exception is a cookie, which can be used by many pages to pass information between them, even after the pages have been closed.

How the System Is Implemented

This has to do with the orderly schedule of events and list of materials necessary to put the new system into use. The system implementation process for the online bust ticket reservation system is necessary for the following reasons:

- To define the hardware and software requirement
- To provide methodology for testing
- To provide management with a test plan and to implement the new system.

Hardware and Software Requirements

This is the minimum requirement by a computer system to be able to run the program well.

System Test Run

This involves the various ways required to verify whether the system is workable. Different specifications were used in testing the program. The test data were analyzed and fed into the computer. During testing, bugs found were debugged and the system was subjected to further testing. The output of the test run is attached to Appendix One.

Hardware Requirements

- A hard disk minimum size of 60GB
- A minimum of 600 MHZ Pentium processor.
- The minimum RAM requirement is 1GB
- A web server with robust storage device

Software Requirements

This includes both system software and application software. For optimal performance the following software was used:

- Database Management System (MySQL)
- WAMP Server
- PHP and PHP editor (WAMP server and Macromedia Dreamweaver 8 handle this)
- Macromedia Dreamweaver 8

System Changeover

After the design of a new system, it is expedient to change to the new system. System changeover is simply the turning over from the manual system to the newly designed system. This changeover process can be achieved through parallel direct, Phase and Pilot changeover.

RECOMMENDATIONS

- Before the use of the new system, proper training and orientation should be given to both staff and management.
- Due to the time and cost constraints, especially the scope of the design was limited to the most basic capabilities.
- Numerous potentials of this system should not be neglected irrespective of its high overhead cost of implementation

- Management should endeavour to join the moving tend of IT sector to enjoy the competitive advantage provided by the IT
- Worker should be acquainted with contemporary IT awareness and literacy.

CONCLUSION

Transportation services have moved from the manual method to the one aided by new technology which gives comfort to travelers to make booking and reservations ahead of time rather than being in a queue waiting to get tickets.
The ancillary infrastructure such as better internet services and rising level of awareness among the transportation sector towards this technology will promote the development and growth of the transport sector in Nigeria. Therefore, this system designed for luxurious bus owners especially ABC transport to integrate the new system of automation to the manual method is regarded as a value-added service in increasing revenue acquisition.

FEW HTML PROGRAM SEGMENTS

Passenger Registration Code

```
<?phprequire_once('Connections/OBTRS.php'); ?>
<?php
functionGetSQLValueString($theValue, $theType, $theDefinedValue = "", $theNotDefinedValue
= "")
{
  $theValue = (!get_magic_quotes_gpc()) ? addslashes($theValue) : $theValue;

switch ($theType) {
case "text":
      $theValue = ($theValue != "") ? "'" . $theValue . "'" : "NULL";
break;
case "long":
case "int":
      $theValue = ($theValue != "") ? intval($theValue) : "NULL";
break;
case "double":
      $theValue = ($theValue != "") ? "'" . doubleval($theValue) . "'" : "NULL";
break;
case "date":
      $theValue = ($theValue != "") ? "'" . $theValue . "'" : "NULL";
break;
case "defined":
      $theValue = ($theValue != "") ? $theDefinedValue : $theNotDefinedValue;
break;
  }
return $theValue;
}

$editFormAction = $_SERVER['PHP_SELF'];
if (isset($_SERVER['QUERY_STRING'])) {
  $editFormAction .= "?" . htmlentities($_SERVER['QUERY_STRING']);
}

if ((isset($_POST["MM_insert"])) && ($_POST["MM_insert"] == "form1")) {
```

```
  $insertSQL = sprintf("INSERT INTO passenger (Fullname, PhoneNo, Email, Address, Username,
Pwd) VALUES (%s, %s, %s, %s, %s, %s)",
GetSQLValueString($_POST['Fullname'], "text"),
GetSQLValueString($_POST['MobileNo'], "text"),
GetSQLValueString($_POST['EmailId'], "text"),
GetSQLValueString($_POST['Address'], "text"),
GetSQLValueString($_POST['Username2'], "text"),
GetSQLValueString($_POST['Password2'], "text"));

mysql_select_db($database_OBTRS, $OBTRS);
  $Result1 = mysql_query($insertSQL, $OBTRS) or die(mysql_error()); etc.
```

Passenger Details Code

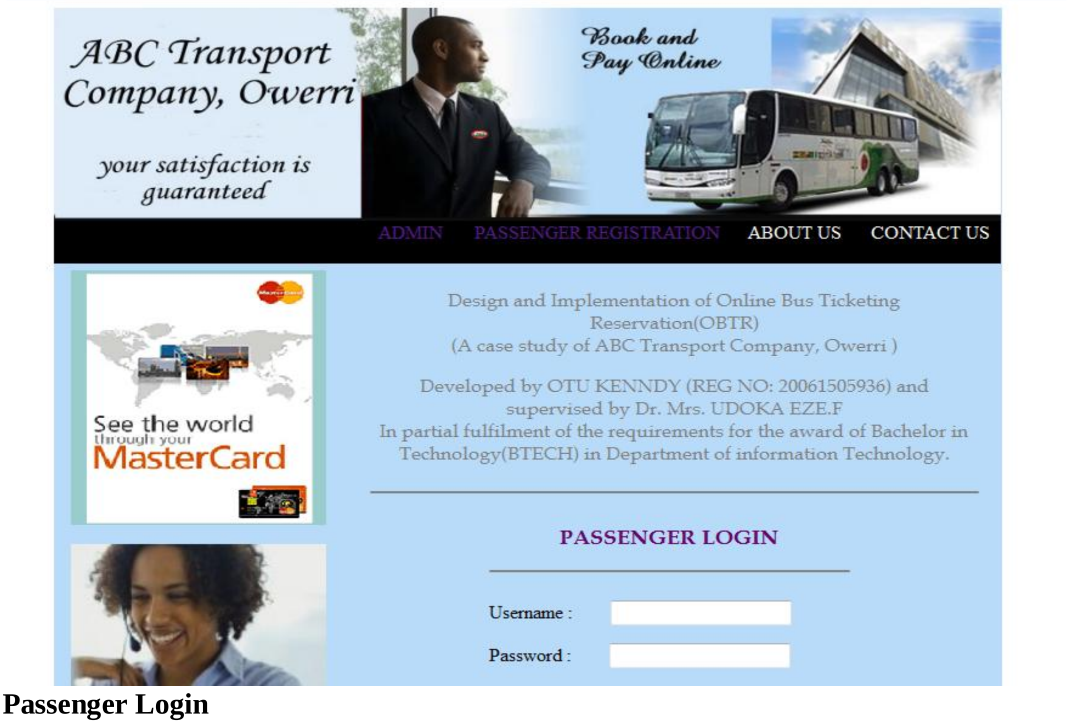
```
<?phprequire_once('Connections/OBTRS.php'); ?>
<?phprequire_once('Connections/OBTRS.php'); ?>
<?php
//initialize the session
if (!isset($_SESSION)) {
session_start();
}

// ** Logout the current user. **
$logoutAction = $_SERVER['PHP_SELF']."?doLogout=true";
if ((isset($_SERVER['QUERY_STRING'])) && ($_SERVER['QUERY_STRING'] != "")){
  $logoutAction .="&". htmlentities($_SERVER['QUERY_STRING']);
}

if ((isset($_GET['doLogout'])) &&($_GET['doLogout']=="true")){
  //to fully log out a visitor we need to clear the session varialbles
  $_SESSION['MM_Username'] = NULL;
  $_SESSION['MM_UserGroup'] = NULL;
  $_SESSION['PrevUrl'] = NULL;
unset($_SESSION['MM_Username']);
unset($_SESSION['MM_UserGroup']);
unset($_SESSION['PrevUrl']); etc
```

Bus Reservation Code

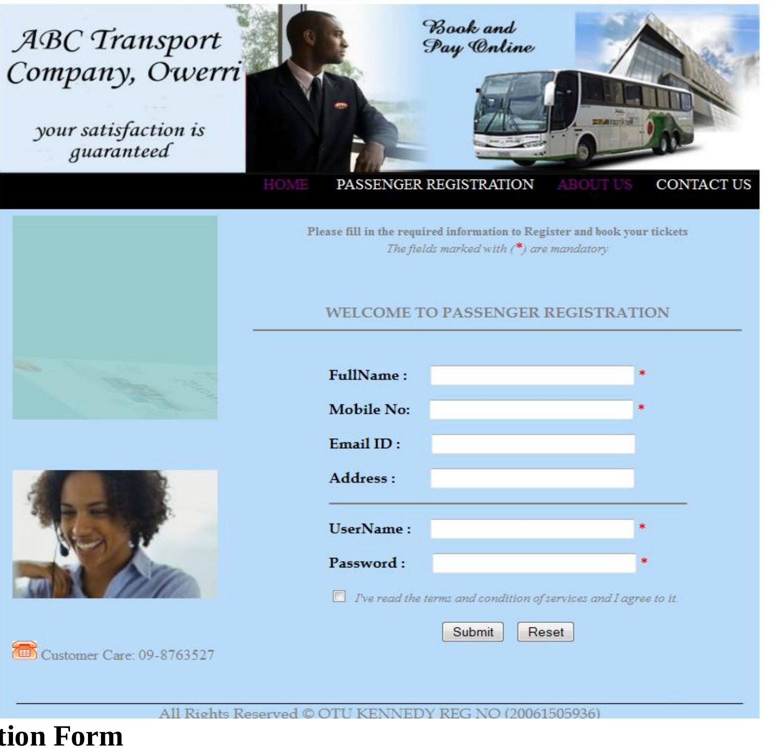
```
<?phprequire_once('Connections/OBTRS.php'); ?><?php
//initialize the session
if (!isset($_SESSION)) {
session_start();
}

// ** Logout the current user. **
$logoutAction = $_SERVER['PHP_SELF']."?doLogout=true";
if ((isset($_SERVER['QUERY_STRING'])) && ($_SERVER['QUERY_STRING'] != "")){
  $logoutAction .="&". htmlentities($_SERVER['QUERY_STRING']);
}

if ((isset($_GET['doLogout'])) &&($_GET['doLogout']=="true")){
  //to fully log out a visitor we need to clear the session varialbles
  $_SESSION['MM_Username'] = NULL;
  $_SESSION['MM_UserGroup'] = NULL;
```

```
  $_SESSION['PrevUrl'] = NULL;
unset($_SESSION['MM_Username']);
unset($_SESSION['MM_UserGroup']);
unset($_SESSION['PrevUrl']);

  $logoutGoTo = "index.php";
if ($logoutGoTo) {
header("Location: $logoutGoTo");
exit;
  }
}
?>
<?php
if (!isset($_SESSION)) {
session_start();
}
$MM_authorizedUsers = "";
$MM_donotCheckaccess = "true"; etc
```

GENERATED OUTPUTS



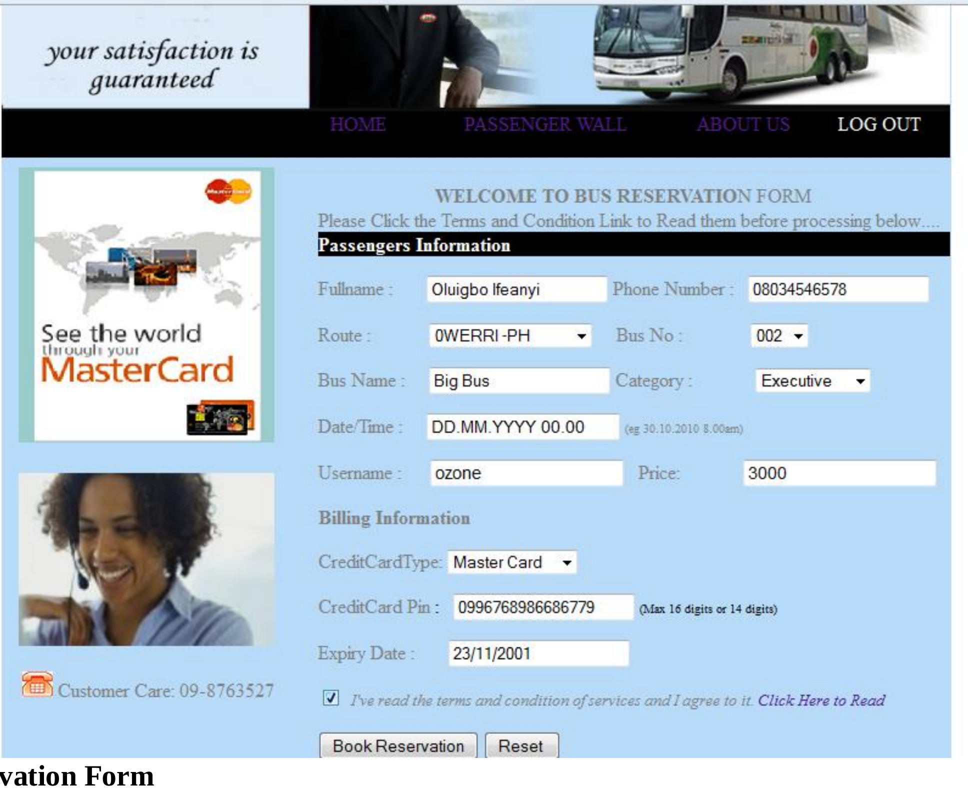
Passenger Login



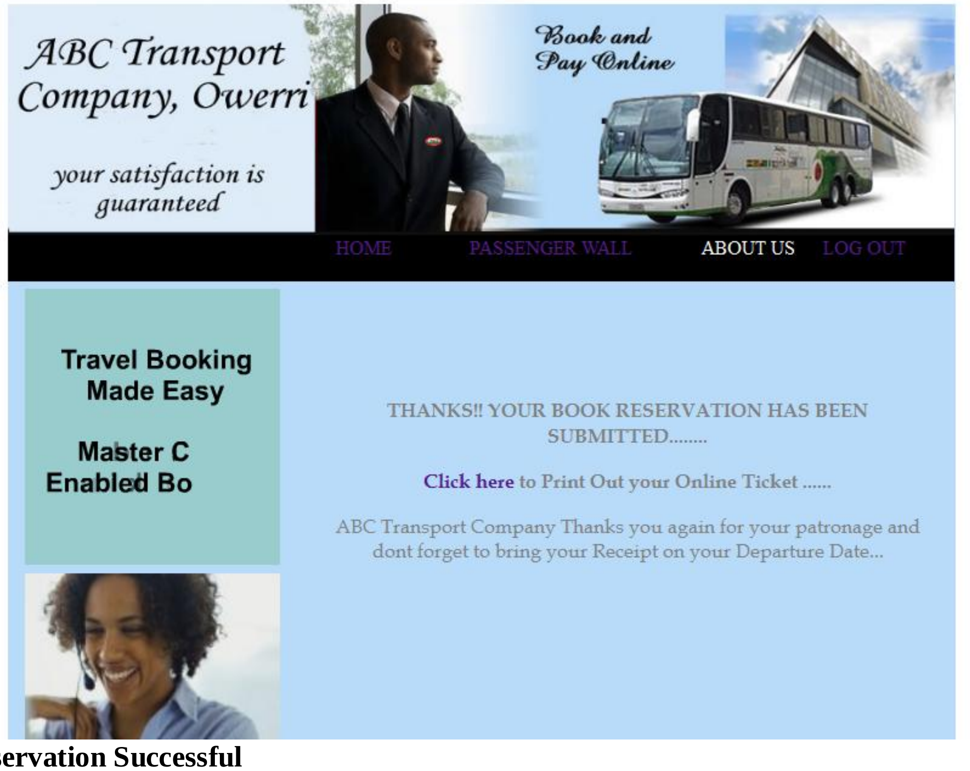
Passenger Registration Form

DAYS	ROUTES	BUS NAME	BUS NO	CATEGORY	PRICE	STATUS	TIM
7/11/2011	OWERRI-LAGOS	BIG BUS	002	BUSINESS	N3000	PENDING	8.00
	OWERRI-LAGOS	SHUTTLE	005	EXECUTVE	N5000	PENDING	10.00
8/11/2011	OWERRI-PH	SHUTTLE	006	EXECUTVE	N1000	BOOKED	8.00
	OWERRI-BENIN	SHUTTLE	010	BUSINESS	N2500	PENDING	8.00
9/11/2011	OWERRI-LAGOS	BIG BUS	007	EXECUTVE	N5000	BOOKED	10.00
	OWERRI-PH	SHUTTLE	008	BUSINESS	N1000	PENDING	10.00
10/11/2011	OWERRI-PH	SHUTTLE	009	EXECUTVE	N1000	BOOKED	8.00
	OWERRI-LAGOS	BIG BUS	011	BUSINESS	N3000	PENDING	10.00
11/11/2011	OWERRI-PH	SHUTTLE	006	EXECUTVE	N1000	BOOKED	8.00
	OWERRI-BENIN	SHUTTLE	010	BUSINESS	N2500	PENDING	8.00
12/11/2011	OWERRI-LAGOS	BIG BUS	002	EXECUTVE	N5000	PENDING	10.00

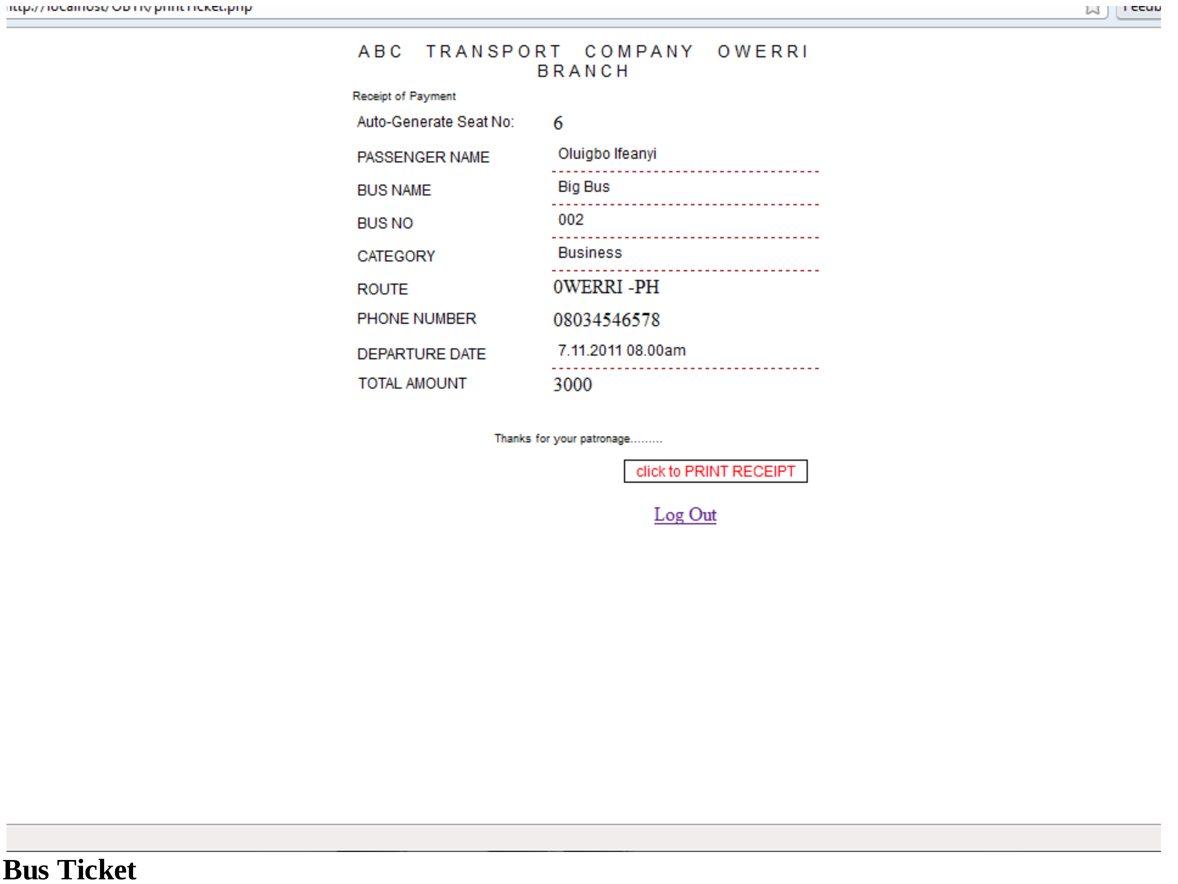
Passenger Wall



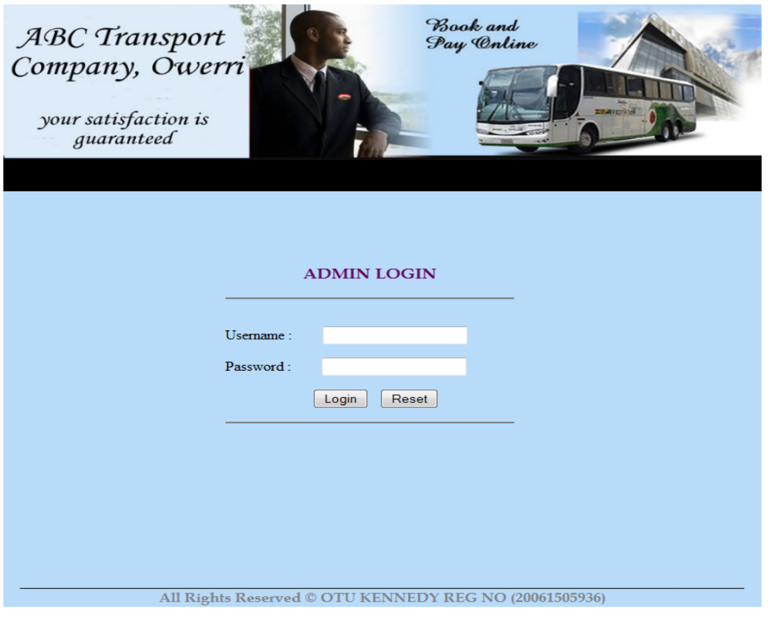
Reservation Form



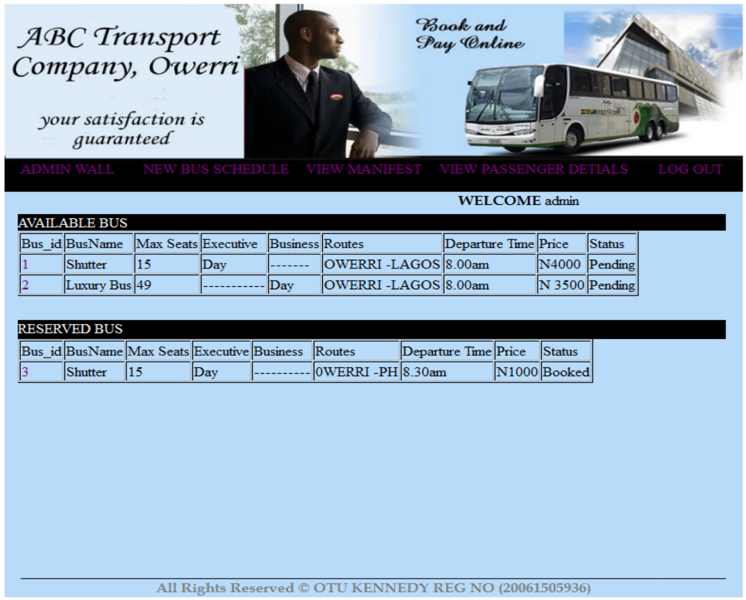
Reservation Successful



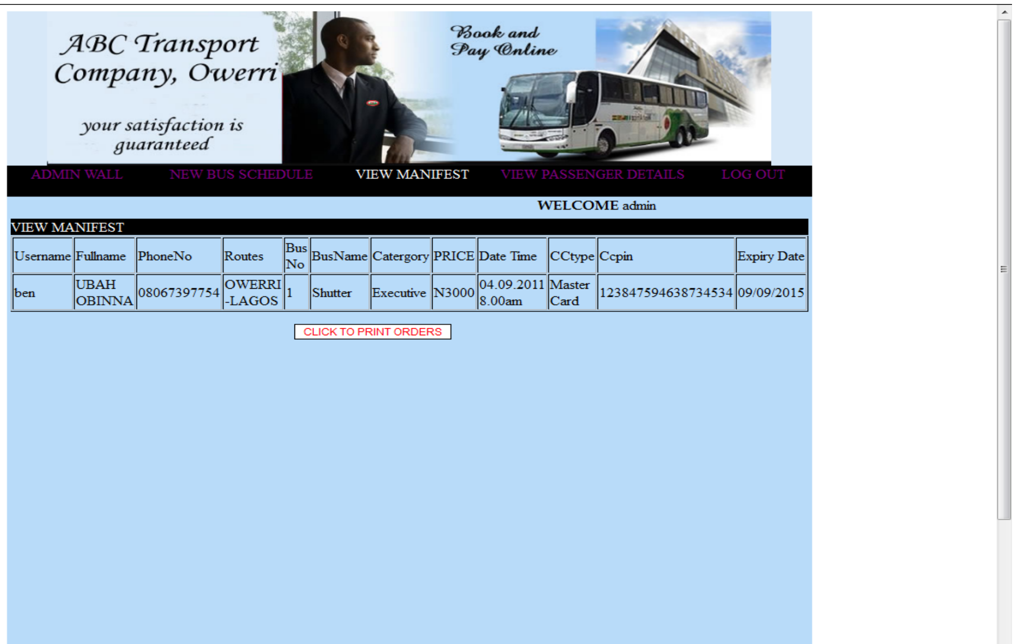
Bus Ticket



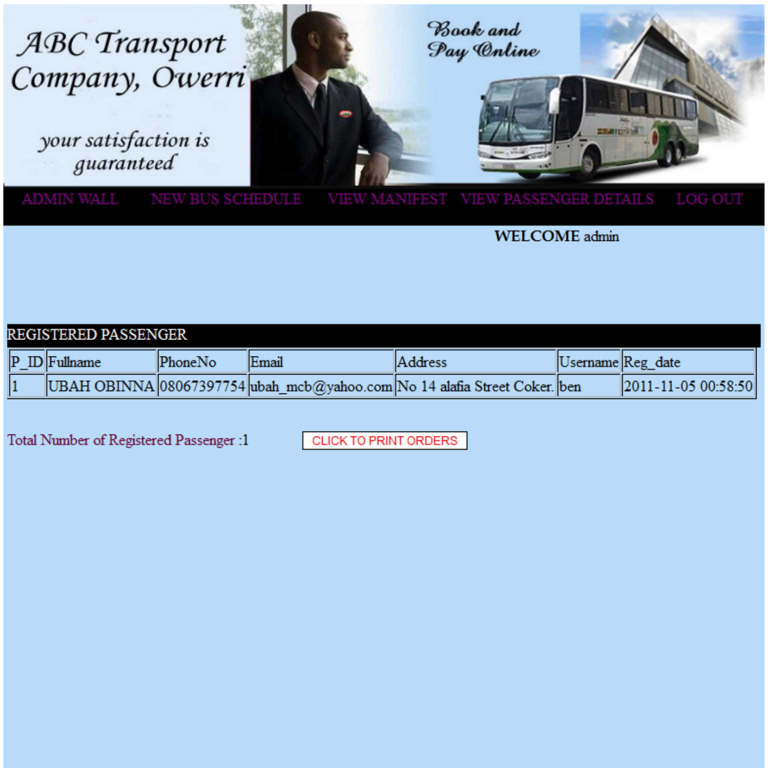
Admin Page



Admin Wall



Manifest



Registered Passenger

REFERENCES

"Computerized Reservation System".Retrieved on October, 2011 from http://en.wikipedia.org/wiki/Computer_reservations_system.htm.

Falola, Toyin and S.A. Olanreqaju, ed. *Transport Systems in Nigeria.* Maxwell School of Citizenship and Public Affairs, Syracuse University, Syracuse. 1986.

Drummond-Thompson, Phillip. "*The Rise of Entrepreneurs in Nigerian Motor Transport"* from the Journal of Transport History. 1990. pp. 46-63.

Pendone E. (2001). "*The History of Internet"* retrieved from history of internet.pdf

Asika N. (1993) R*esearch Methodology in the behavioral science"* Lagos: Longman Nigeria plc

French C.S (1997) "*Computer studies"* London:DP Publication Ltd, 5th Edition

Microsoft Encarta Premium 2009.

http://en.wikipedia.com

Barcode technology and its application in libraries and Information centers

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Mrs. Monika Sharma**

Abstract

The utility of barcoding for faster library transactions is time-tested, and more and more computerized libraries in our country are using this technology. The application of barcode technology in circulation system of a library and information technology is most successful due to its speed, accuracy and reliability. Barcoding though relatively an old technology, is one of the important steps in library automation and is still not widely used in libraries. This article covers various aspects of barcode technology and its application in libraries.

Keywords : Barcoding, Keyboard wedge, Barcode Printers, Security Check, Symbologies.

INTRODUCTION :

Nearly every type of industry is using barcode technology to replace keyboard data entry because bar coding is much faster and more accurate than keyboard data entry. A bar code is a piece of Automatic Identification Technology (Auto ID) that stores real time data. It is a series of vertical bars or a graphical bar pattern which can, (depending on the width and pattern) encode numbers and letters in a format which can easily be retrieved and interpreted by a bar code reader. The circulation work in an automated library involves keying in a large amount of data. Sometimes, the library staff at the counter has to retype the same information due to error in data entry. A bar code reader decodes a bar code by scanning a light source across the bar code and measuring the intensity of light reflected back by the white spaces. Nowadays bar-codes are cheap to print and the reading technologies are varied and reliable.

Barcoding is a computer aided process of generating codified information, which is subsequently printed on a predefined stationary, invariably on a self-adhesive label for several later applications. This technology plays a vital role in automating the functions of library, especially the circulation system.

WHAT IS BARCODE

Barcode are a pattern of bars and spaces of varying width that represent digits, letters or other punctuation symbols to identify an item or object. Barcode by itself is not a system but an identification tool that provides an accurate and timely support of data requirement for sophisticated management systems.

Bar code is a predefined format of dark bars and white spaces. Structured to contain a specific piece of information. It allows real-time data to be collected accurately and rapidly. Combination of barcode technology with computer and application software improves performance, productivity and profitability. Originally barcode stored data in width and spacing of printed parallel lines. In other words we can say that barcode are series of black and white bars arranged in a pre-defined form to represent known coded information. A linear barcode is a binary code (1s and 0s).The line and space are of various thicknesses and printed in different combinations .A device known as barcode scanner reads this code. The most common is laser barcode scanner .Bars are darker and non –reflective element of barcode. The gaps are white and known as inter character gaps .The space is known as reflective element of barcode. Each barcode represent a number .A special pattern of bars and spaces use to identify the beginning of a barcode symbol is known as start character. A special pattern of bars and spaces used to identify the end of a barcode symbol is known as stop character.

In other words we can say that Barcodes are self-contained machine-readable identification labels with information encoded in a series of black bars and white spaces of varying widths that represent digits, and other punctuation symbols. These are readable only by a scanner.

OBJECTIVES OF BARCODING

The main objectives of barcoding documents in a library are:

To achieve accuracy

Time saving of users

To reduce overall cost

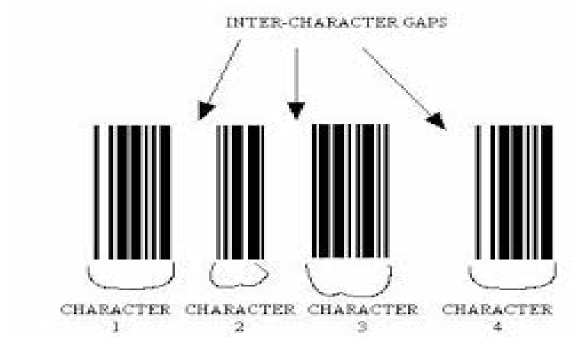
To make stock verification an easy process

To Improve operational efficiency

SYMBOLOGIES

The mapping between messages and barcode is called a symbology. The symbology is a language used to represent or arrange the bars and spaces. It defines the technical details of a particular type of barcode: the width of the bars, character set, method of encoding, checksum specifications, etc. The specification of an symbology includes the encoding of the single digit /character of the message as well as the start and stop markers into bars and space ,the size of the quit zone required to be before and after the barcode as well as the compilation of a checksum.

Since this arrangement can be varied to suit the different applications, there evolved a number of symbologies over the years. There are more than fifty different coding symbologies. Some of the popular symbologies areas are as follows:



Continuous Symbology

Linear symbologies can be classified mainly by two properties:

1.Continuous vs. discrete

2.Two-width vs. many width

Some of the common formats are:

1. Universal Product Code: US standard to encode only digits, UPC-A to encode 12 digits or UPC-E to encode 6 digits. It is the common code extensively used in retail trade. Its standardization in a form that allows many organizations throughout the world to interpret the same data is its prominent advantages. It also uses the space efficiently to record the data. Its limitation is that it can only record certain length of numbers.

2. Interleaved 2 of 5 (I 2 of 5): Supports only numeric characters but can be used for variable length. It is very compact. But it can only record numbers. The code represents the number of

even length. It is possible to scan only a part of the barcode and obtain something that looks like a valid result.

3. Code 39 (Code 3 of 9): Encodes capital alphabets, numerical and few special characters like $, +, %. Asterisk (*) must be used as the start and stop character. Lowercase alphabets cannot be encoded. It is alpha and numeric and can represent even some special characters such as ' $ ',' / ', '. ', ': ', ' + ', ' – ', ' % ' and can enclose ' space '. The code can be of any length. It can enclose all the capital letters of the alphabets but lower case letters can't be enclosed. The code 3 of 9 is always started / ended with an asterisk (*), known as start / stop character. Bars and spaces are used to encode an individual character. 5 bars and 4 spaces, three of which are wide, represent each character and six are narrow.

4. European Article Number (EAN): European code to encode digits, available in two variations: EAN-8 to encode 8 digits and EAN-13 to encode 13 digits. The EAN is only numeric but Code Bar is having facilities to enclose ' $ ', ' / ', '. ', ': ', '+ ', '– ', '% 'in addition to numerals. It is available in two variations: EAN 8 to encode 8 digits and EAN 13 to encode 13 digits

5. Code 128: Encodes both the lower and the upper case letters, numeric and special characters found on the keyboard. It is a continuous alphanumeric symbology of variable length encoding full 128 ASCII character set. Every symbol starts and stops with a unique start/stop character.

6.Coda bar: Encodes only numeric and few special characters and is the most widely used coding format. Generally, libraries use this symbology to encode books and borrower cards. It is a discrete, self-checking numeric symbology including six other characters and four unique start/stop characters. Each character has three bars and four spaces. It encodes only numeric and few special characters and is most widely used coding symbology. Generally libraries use this symbology to encode books and borrowers card.

7.Code 49: Code 49 is a first two-dimensional barcode symbology. It is a multi-row, continuous and variable length symbology encoding the full ASCII 128 character set. Each row is composed of 18 bars and 17 spaces. Each row contains a row number and the last row contains information regarding the row number in the symbol.

BASIC REQUIREMENTS FOR BARCODE APPLICATION

Implementing barcodes in library applications following hardware and software are required:

- Inventory Control
- Barcode Scanner;
- Decoder;
- Printer;
- Printing Software;
- Communication Software;
- Database of Library Holdings;
- Library Software; and
- Membership Database;
- Personal Computers,(PCs)

USE OF BARCODE SCANNERS

Barcode scanner is a device used to extract information optically from the barcode .Barcode scanners are of various types .These may be hand –held or fixed type. Barcode symbols consist of series of vertical dark bars separated by light spaces. When illuminated reflected light is detected by electro optical sensor .The intensity of reflected light from the dark bars is less than that of spaces (white lines) .Reflected light is converted into electronical voltage signals.

Hand Held Linear Scanners

The decoder converts this data into the character data representation of the symbol's code .

Different Type of Barcodes

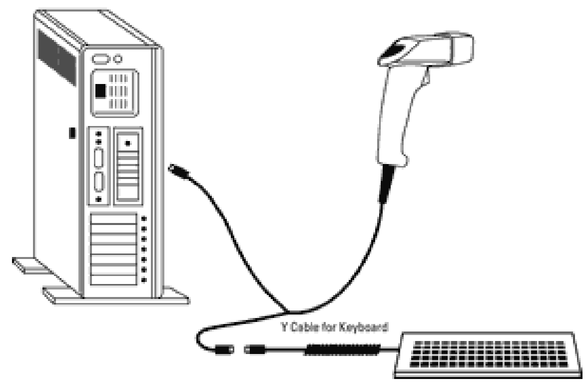
Connecting the Scanner –Keyboard Wedge

1.Turn off power before connecting the scanner

2.Remove the keyboard connector from the PC.

3.Connect the cable's modular connector to the scanner.

4.Connect the male connector to the keyboard port in the PC and the female connector to the keyboard cable .You may need to use the Din/Mini Din adapter (included) to match your keyboard connectors.



Connecting the Scanner

WORKING OF BARCODE SYSTEM

Barcode technology works in the same way as a keyboard. As pressing a key sends a signal containing a character code to the computer, reading a barcode results in the same kind of signals being sent to the processor. The barcode, in effect, acts as a unique control number, which is associated with a record giving appropriate details of individual items. While scanning, the light is reflected from the barcode and the pick up optical device receives less light from the dark bars than from the spaces between them. The signals received through this process are than converted into a form, which can be recognized by the computer (Chandok, Seema, 1998), (David J. Collins and Nancy N. Whipple).

ADVANTAGES OF USING BARODE TECHNOLOGY

Application of barcode technology is made in the libraries with a view to automate the data entry process of circulation system. The use of barcode technology increases efficiency and eliminates human errors as in case of manual data entry It Increases the speed of operation;

It has got the following advantages :

- It Increased accuracy of data input (error free)
- It Improves efficiency of the staff and quality of services;
- Rapid access to total production costs
- It Increased user satisfaction and hence improves the image of the library;
- Reliable statistics for Management Information System (MIS) and management
- control;
- Real time data collection
- Aid effective management of resources and inventories
- Highest degree of reliability;
- Saves the time of borrower;
- Perfect entry and retrieval of data;
- Labor savings by avoiding manual system
- Low labor cost
- Improves information availability and data integrity.

PRINTING OF BARCODE LABELS

The barcode labels require high quality if printing. Defects in printing will lead to wrong reading of data. It is of utmost importance that barcode labels have high-contrast, well dimensioned bars and spaces. Important considerations for printing barcode labels is that high quality paper, free from imperfections is essential.

Barcode Printer

USE OF BARCODE TECHNOLOGY IN LIBRARIES

Barcode is coded information in the form of bars that can be read by a special type of image scanner(barcode scanner). Image scanner also called scanner converts any printed image into electronic form by shining light into the image and sensing the intensity of light reflection at a point. This device read barcode, which are patterns of printed bars that appear on the barcode labels pasted on the book. The barcode identify the book and the barcode reader /scanner emits a beam of light –frequently a laser beam- that is reflected by the barcode image by recognizing bars. The white spaces reflect light, which are translated into relevant signals for the computer to read, without the risk of human error. After detector has identified the barcode, it converts the individual bar patterns into numeric digit-code that computer can understood.

Computerised circulation system and application of barcode

Before discussing of barcode based circulation system, it is necessary to study the difficulties experienced in the manual system so that the usefulness of barcode technology can be appreciated:

Some of the difficulties in the manual system area:

1. It is difficult to know the status of a particular book.

2. Providing reservation for books is a tedious job.

3. It is cumbersome to ascertain that to whom a particular book has been issued.

4.To provide a clearance certificate to a particular reader is quite difficult since the counter assistant will have to verify borrower’s record and other documents to ascertain whether a particular book is pending against the borrower or not.

5. Charging and discharging of books are time consuming, as stamping of due / return date and the work of making other entries are to be carried out.

In a manual system it is difficult to ascertain whether a particular book is issued or not and hence reserving a book becomes a cumbersome job. Such problems do not exist with the computers. The database is always ready for any query. Thus, with ease, the entire operation can take place without any loss of information and control.

One of the useful applications of barcode system is in the computerized circulation system. In computerized circulation system the borrower presents before the counter assistant his library card and the book(s) to be borrowed. The circulation assistant inputs the identity number of the borrower through keyboard and activates his database record. Depending upon permissibility the document's accession number is entered in the computer and the book is issued to the borrower. It is the computer software, which computes the due date for return, fine and makes reservations against books. Due to normal distribution system the charging and discharging of books is a time consuming process, as stamping of due dates and other data entry work have to be carried out. But in barcoded environment, when a user goes to the circulation counter, the counter staff scans his/her identity card and activates the borrowing status. If the computer permits the borrowing facility, the document is scanned for accession number and is issued to the user without any delay.

Use of barcode system for Security Check

The barcoded identity card will also perform the security check at the gate and allow only authorized persons to enter in libraries.

This is the checking system when a user leaves the library with the issued document. For this purpose, barcode technology can be effectively used and a terminal can be installed on the gate. Since charging/discharging is done online, the whole database is automatically updated. When borrower leaves the library, accession number of the document carried by the user will again be scanned at the gate. In case of issued document the computer will approve the exit. But, in case, someone is carrying a document that has not been issued, the computer will give an alarm and a message to the immediate effect.

Identification of membership at the gate

We know very well that in libraries entry is restricted to their members only. Thus, a person is deputed on the gate as gateman or security guard to check identity cards of each person entering the library. If the members are provided barcoded identity cards, then this checking becomes very easy. A barcode scanner is installed at the gate of the library and every person entering the library has to place his/her identity card on the scanner. If the person is not a member of the library, the computer will give the alarm and thus restrict the entry and the identification of unauthorized entry will be made.

Use of barcode system for monitoring Attendance

The barcode technology could be used for monitoring the attendance of the users. Under this process, the identity cards of the user have to be barcoded with their library codes and a barcode scanner is installed at the gate of the organization. Every user has to get his/her identity card scanned at the gate while entering. The system will maintain the statistics of users of the library.

Under the manual system most of the libraries maintain gate register wherein members are requested to enter his/her details and mark their signature as a proof of their visit to the library. It is time consuming and users show indifference towards entering their particulars. When users are provided with barcoded identity cards, it is possible to overcome all these difficulties. Thus, user statistics are useful for various purposes, particularly for improvement in library services and control.

Issue of No Dues Certificate

No dues certificate is issued when any member leaves the organistation/institution and his/her membership is cancelled and the library issues no dues certificate. This process is time consuming and error prone in a manual system. In an automated system using barcode technology the member surrenders his/her identity card and the counter staff scan it. The automation package will search the database for any document issued in his/her name. If nothing is due, no dues certificate will be printed.

For Stock Verification and cross- checking

In this system every book in the library is barcoded, stock verification of the books can also be easily performed with the help of barcode system. Stock verification and cross checking is a very tedious and time-consuming job in libraries. During stock verification the users are restricted to use the library facility. Here barcode technologies used very effectively, and it is quicker and error free. Under this process, all the documents in the library are scanned and data is gathered in the hand held terminal or in the computer. Once all the documents in the library are scanned with the help of barcode scanner, it is compared with the database of the total documents. If it does not tally, it will give the details of documents of which accession number has not been scanned. In this way number of missing books can be found out and print out for the same can be taken.

CONCLUSION

Implications of automated and barcode technology is one of the best techniques to minimize the time taken at the circulation center. Barcoding by itself is not system but an identification tool that provides an accurate and timely support of the data requirement for the sophisticated management systems. Barcode usage increases accuracy in the data collection, save time of the users and the staff and improves efficiency in various library operations. Every library needs the application of new technology to develop its existing methods. This time thus saved can be utilized for developing advance and additional techniques in the library. It minimizes errors and increases the efficiency at the circulation desk. It also reduces the operational cost by eliminating book cards and book pockets. Barcoded labels with both accession and call numbers on it can also be used as a book tag. Contribution of barcode technology with computer and application software improves performance and efficiency in various library operations.

REFERENCE

1. Anil Singh(2002). Application of Bar Code Technology in Libraries. Library Herald. .40, (1), 43-47.

2. Barcode basics, http://www.makebarcode.com/info/info.html

3. Bhaskar Raj, A.S.(1995). The barcode technology and applications. Electronics For You, April, 99-105.

4.Gample, S R and Wadyane, H S. (1993). Using Barcode for Circulation in the Central Library of IIT Bombay. Annals of Library Science and Documentation. .40, (1),12-20.

5.Jeevan J (2000). Barcoding for faster library transactions. DESIDOC Bulletin of Information Technology, 20, (2), 15-19.

6.Katna, A.K. (1996) On designing an automated circulation system for Indian environment. Program, 30(2), 171 -175.

7Lam, K.T, Issues in Library Automation, http://ihome. ust. hk/-Ibl kt/diploma/libauto/ Iibauto.html 5.

8.Library automation Q & A: Barcodes smart and dumb, http://libraryautomation.com/ 1barcodes_smarCand_dumb.html

9.Manjunath, G K & Pujar, S M.(2002).Barcoding for Library Documents, Planning,Techniques and Tools. Annals of Library and Information Studies .49, (4) ,119-125.

10.Misra, K N (1995). Use of Bar Code Devices in Library Management. Paper presented in XX IASLIC Conference, Lucknow

11.Patel, Dharmista R(1996). Barcode System in Libraries - its Uses and Importance. Annals of Library Science and Documentation. 1996,43, (1)p.1-10.

12.Pradeep, C. & Rama Reddy, E. Applications of barcode technology for library operations-experiences at IGM library, University of Hyderabad. University News, 36(35), 6-9.

13.Ramesh, L S R C V & Vali Hussain, Mohd(1997). Barcode System in Libraries: a Modernized Concept in Practice. ILA Bulletin. 33, (1-2), 1-4.

14.Roger C. Palmer :The Bar Code Book: Fifth Edition - A Comprehensive Guide To Reading, Printing, Specifying, Evaluating, And Using Bar Code and Other Machine-Readable Symbols (Paperback)

15.Sambasivan, K(1997). Use of Bar Codes in Libraries. International Library Movement.19, (3), 149-56.

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Electronic Funds Transfer (EFT)

Electronic Funds Transfer (EFT) is a system of transferring money from one bank account directly to another without any paper money changing hands. One of the most widely-used EFT programs is direct deposit, through which payroll is deposited straight into an employee's bank account. However, EFT refers to any transfer of funds initiated through an electronic terminal, including credit card, ATM, Fedwire and point-of-sale (POS) transactions. It is used for both credit transfers, such as payroll payments, and for debit transfers, such as mortgage payments.

How EFT works

Transactions are processed by the bank through the Automated Clearing House (ACH) network, the secure transfer system that connects all U.S. financial institutions. For payments, funds are transferred electronically from one bank account to the billing company's bank, usually less than a day after the scheduled payment date.

The ACH Network operates as a batch processing system. Financial institutions accumulate ACH transactions throughout the day, which are handled via batch processing later on. According to NACHA, which creates payment and financial messaging rules and standards, the ACH Network handles 24 billion EFTs each year, accounting for more than $41 trillion transferred. The ACH Network is one of the largest and most reliable payment systems in the world, according to the association.

To complete an EFT, the receiving party must provide the following information:

- The name of the bank receiving funds
- The type of account receiving funds (e.g., checking or savings)
- The bank’s ABA routing number

- The recipient's account number

The growing popularity of EFT for online bill payment is paving the way for paperless transactions where checks, stamps, envelopes and paper bills are obsolete. The benefits of EFT include reduced administrative costs, increased efficiency, simplified bookkeeping, and greater security. However, the number of companies who send and receive bills through the Internet is still relatively small.

Types of EFTs

The most common types of EFTs include:

- **Direct deposit**: Enables businesses to pay employees. During the employee onboarding process, new employees typically specify the financial institution to receive the direct deposit payments.
- **Wire transfers**: Used for non-regular payments, such as the down payment on a house.
- **Automated Teller Machines (ATMs)**: Allows cash withdrawals and deposits, fund transfers and checking of account balances at multiple locations, such as branch locations, retail stores, shopping malls and airports.
- **Debit cards:** Allows users to pay for transactions and have those funds deducted from the account linked to the card.
- **Pay-by-phone systems**: Allows users to pay bills or transfer money over the phone.
- **Online banking**: Available via personal computer, tablet or smartphone. Using online banking, users can access accounts to make payments, transfer funds and check balances.

Regulations

The U.S. Government monitors EFT compliance through Regulation E of the Federal Reserve Board, which implements the Electronic Funds Transfer Act (EFTA). The EFTA was passed by the U.S. Congress in 1978 to protect consumers engaging in EFTs. Regulation E governs financial transactions with electronic payment services, specifically with regard to disclosure of information, consumer liability, error resolution, record retention and receipts at electronic terminals.

Consumers can sue for damages in court if financial institutions break laws established by the EFTA. For example, if ATM card is reported as stolen and the financial institution failed to prevent a transfer, the card's owner is entitled to the money lost.

Users can't be forced to use EFTs to make or to receive a payment, except for overdraft checking fees. When a checking account is overdrawn, the financial institution can use EFTs to deduct overdraft fees from the consumer's account. With a few exceptions, employers can require that employees are paid by EFT. Employees can choose the financial institution to receive the funds.

If an ATM or debit card is lost or stolen and reported to the financial institution before any transactions take place, the card's owner is not held responsible for any subsequent transactions. Depending on when the card is reported stolen or lost, the card's owner could be liable for between $50 and an unlimited amount of charges.

EFTs usually settle on the next business day, but can take longer during bank holidays. International transactions (IATs) and high-value transactions above $25,000 are not eligible for same-day processing.

WIKIPEDIA

Automated teller machine

An NCR Personas 75-Series interior, multi-function ATM in the United States

An **automated teller machine** (**ATM**) is an electronic telecommunications device that enables customers of financial institutions to perform financial transactions, such as cash withdrawals, deposits, transfer funds, or obtaining account information, at any time and without the need for direct interaction with bank staff.

ATMs are known by a variety of names, including **automatic teller machine** in the United States[1][2][3] (**ATM**, American, British, Australian, Malaysian, South African, Singaporean, Indian, Maldivian, Hiberno, Philippines and Sri Lankan English), often redundantly **ATM machine**, **automated banking machine** (**ABM**, Canadian English[4][5]). In British English, the terms **cash point, cash mashine** and **"hole in the wall"** are most widely used.[6] Other terms include **cashline**, **nibank**, **cash machine**, **tyme machine**, **cash dispenser**, **bankomat** or **bancomat**. Many ATMs have a sign above them, indicating the name of the bank or organisation that owns the ATM, and possibly including the networks to which it can connect. In Canada, ABM that are not operated by a financial institution are known as "white-label ABMs".

According to the ATM Industry Association (ATMIA),[7] there are now close to 3.5 million ATMs installed worldwide.[8] However, the use of ATMs is gradually declining – most notably in retail precincts.[9]

On most modern ATMs, customers are identified by inserting a plastic ATM card (or some other acceptable payment card) into the ATM, with authentication being by the customer entering a personal identification number (PIN) which must match the PIN stored in the chip on the card (if the card is so equipped) or in the issuing financial institution's database.

Smaller indoor ATMs dispense money inside convenience stores and other busy areas, such as this off-premises Wincor Nixdorf mono-function ATM in Sweden.

Using an ATM, customers can access their bank deposit or credit accounts in order to make a variety of financial transactions such as cash withdrawals, check balances, or credit mobile phones. ATMs can be used to withdraw cash in a foreign country. If the currency being withdrawn from the ATM is different from that in which the bank account is denominated, the money will be converted at the financial institution's exchange rate.[10]

Contents

History

An old Nixdorf ATM

The idea of out-of-hours cash distribution developed from bankers' needs in Asia (Japan), Europe (Sweden and the United Kingdom) and North America (the United States).[11][12][13] Little is known of the Japanese device other than it was called "Computer Loan Machine" and supplied cash as a three-month loan at 5% p.a. after inserting a credit card. The device was operational in 1966.[14][15]

Adrian Ashfield invented the basic idea of a card combining the key and user's identity in February 1962. This was granted UK Patent 959,713 for "Access Controller" in June 1964 and assigned to W. S. Atkins & Partners who employed Ashfield. He was paid ten shillings for this, the standard sum for all patents. It was originally intended to dispense petrol but the patent covered all uses.

In the US patent record, Luther George Simjian has been credited with developing a "prior art device". Specifically his 132nd patent (US3079603), which was first filed on 30 June 1960 (and granted 26 February 1963). The roll-out of this machine, called Bankograph, was delayed by a couple of years, due in part to Simjian's Reflectone Electronics Inc. being acquired by Universal Match Corporation.[16] An experimental Bankograph was installed in New York City in 1961 by the City Bank of New York, but removed after six months due to the lack of customer acceptance. The Bankograph was an automated envelope deposit machine (accepting coins, cash and cheques) and did not have cash dispensing features.[17][18]

It is widely accepted that the first cash machine was put into use by Barclays Bank in its Enfield Town branch in North London, United Kingdom, on 27 June 1967.[19] This machine was inaugurated by English comedy actor Reg Varney.[20] This instance of the invention is credited to the engineering team led by John Shepherd-Barron of printing firm De La Rue,[21] who was awarded an OBE in the 2005 New Year Honours.[22][23] Transactions were initiated by inserting paper cheques issued by a teller or cashier, marked with carbon-14 for machine readability and security, which in a later model were matched with a six-digit personal identification number (PIN).[21][24] Shepherd-Barron stated; "It struck me there must be a way I could get my own money, anywhere in the world or the UK. I hit upon the idea of a chocolate bar dispenser, but replacing chocolate with cash."[21]

The Barclays–De La Rue machine (called De La Rue Automatic Cash System or DACS)[25] beat the Swedish saving banks' and a company called Metior's machine (a device called Bankomat) by a mere nine days and Westminster Bank's–Smith Industries–Chubb system (called Chubb MD2) by a month.[26] The online version of the Swedish machine is listed to have been operational on 6 May 1968, while claiming to be the first online ATM in the world (ahead of a similar claim by IBM and Lloyds Bank in 1971).[27] The collaboration of a small start-up called Speytec and Midland Bank developed a fourth machine which was marketed after 1969 in Europe and the US by the Burroughs Corporation. The patent for this device (GB1329964) was filed in September 1969 (and granted in 1973) by John David Edwards, Leonard Perkins, John Henry Donald, Peter Lee Chappell, Sean Benjamin Newcombe & Malcom David Roe.

Actor Reg Varney using the world's first cash machine in Enfield Town, north London on 27 June 1967

Both the DACS and MD2 accepted only a single-use token or voucher which was retained by the machine, while the Speytec worked with a card with a magnetic stripe at the back. They used principles including Carbon-14 and low-coercivity magnetism in order to make fraud more difficult.

Sberbank ATM in Tolyatti, Russia

The idea of a PIN stored on the card was developed by a group of engineers working at Smiths Group on the Chubb MD2 in 1965 and which has been credited to James Goodfellow (patent GB1197183 filed on 2 May 1966 with Anthony Davies). The essence of this system was that it enabled the verification of the customer with the debited account without human intervention. This patent is also the earliest instance of a complete "currency dispenser system" in the patent record. This patent was filed on 5 March 1968 in the US (US 3543904) and granted on 1 December 1970. It had a profound influence on the industry as a whole. Not only did future entrants into the cash dispenser market such as NCR Corporation and IBM licence Goodfellow's PIN system, but a number of later patents reference this patent as "Prior Art Device".[28]

Propagation

Devices designed by British (i.e. Chubb, De La Rue) and Swedish (i.e. Asea Meteor) quickly spread out. For example, given its link with Barclays, Bank of Scotland deployed a DACS in 1968 under the 'Scotcash' brand. Customers were given personal code numbers to activate the machines, similar to the modern PIN. They were also supplied with £10 vouchers. These were fed into the machine, and the corresponding amount debited from the customer's account.

A Chubb-made ATM appeared in Sydney in 1969. This was the first ATM installed in Australia. The machine only dispensed $25 at a time and the bank card itself would be mailed to the user after the bank had processed the withdrawal.

Asea Metior's Bankomat was the first ATM installed in Spain on January 9, 1969 in downtown Madrid by Banesto. This device dispensed 1,000 peseta bills (1 to 5 max). Each user had to introduce a security personal key using a combination of the ten numeric buttons.[29] In March of the same year an ad with the instructions to use the Bancomat was published in the same newspaper.[30]

Docutel in the United States (1969)

After looking firsthand at the experiences in Europe, in 1968 the ATM was pioneered in the U.S. by Donald Wetzel, who was a department head at a company called Docutel.[23] Docutel was a subsidiary of Recognition Equipment Inc of Dallas, Texas, which was producing optical scanning equipment and had instructed Docutel to explore automated baggage handling and automated gasoline pumps.[31] In 1969, a venture capital consortium purchased Docutel with the aim of bringing its ATM to market without delay. By 1974, Docutel had acquired 70 percent of the U.S. market; but as a result of the early 1970s worldwide recession and its reliance on a single product line, Docutel lost its independence and was forced to merge with the U.S. subsidiary of Olivetti.

Wetzel was recognised by the United States Patent Office as having invented the ATM in the form of U.S. Patent # 3,761,682; the application had been filed in October 1971 and the patent was granted in 1973. However, the U.S. patent record cites at least three previous applications from Docutel, all relevant to the development of the ATM and where Wetzel does not figure, namely US Patent # 3,662,343, U.S. Patent # 3651976 and U.S. Patent # 3,68,569. These patents are all credited to Kenneth S. Goldstein, MR Karecki, TR Barnes, GR Chastian and John D. White.

Play media

1969 ABC news report on the introduction of ATMs in Sydney, Australia. People could only receive AUS $25 at a time and the bank card was sent back to the user at a later date. This was a Chubb machine

On September 2, 1969, Chemical Bank installed the first ATM in the U.S. at its branch in Rockville Centre, New York. The first ATMs were designed to dispense a fixed amount of cash when a user inserted a specially coded card.[32] A Chemical Bank advertisement boasted "On Sept. 2 our bank will open at 9:00 and never close again."[33] Chemical's ATM, initially known as a Docuteller was designed by Donald Wetzel and his company Docutel. Chemical executives were initially hesitant about the electronic banking transition given the high cost of the early machines. Additionally, executives were concerned that customers would resist having machines handling their money.[34] In 1995, the Smithsonian National Museum of American History recognised Docutel and Wetzel as the inventors of the networked ATM.[35]

Continued improvements

The first modern ATM was an IBM 2984 and came into use at Lloyds Bank, High Street, Brentwood, Essex, UK in December 1972. The IBM 2984 was designed at the request of Lloyds Bank. The 2984 Cash Issuing Terminal was the first true ATM, similar in function to today's machines and named by Lloyds Bank: Cashpoint. Cashpoint is still a registered trademark of Lloyds Banking Group in the UK, but is often used as a generic trademark to refer to ATMs of all UK banks. All were online and issued a variable amount which was immediately deducted from the account. A small number of 2984s were supplied to a U.S. bank. A couple of well known historical models of ATMs include the IBM 3614, IBM 3624 and 473x series, Diebold 10xx and TABS 9000 series, NCR 1780 and earlier NCR 770 series.

The first switching system to enable shared automated teller machines between banks went into production operation on February 3, 1979 in Denver, Colorado, in an effort by Colorado National Bank of Denver and Kranzley and Company of Cherry Hill, New Jersey.[36]

The newest ATM at Royal Bank of Scotland allows customers to withdraw cash up to £100 without a card by inputting a six-digit code requested through their smartphones.[37]

Location

ATMs can be placed at any location but are most often placed near or inside banks, shopping centers/malls, airports, railway stations, metro stations, grocery stores, petrol/gas stations, restaurants, and other locations. ATMs are also found on cruise ships and on some US Navy ships, where sailors can draw out their pay.[38]

ATMs may be on- and off-premises. On-premises ATMs are typically more advanced, multi-function machines that complement a bank branch's capabilities, and are thus more expensive. Off-premises machines are deployed by financial institutions and Independent Sales Organisations (ISOs) where there is a simple need for cash, so they are generally cheaper single function devices.

In the US, Canada and some Gulf countries, banks may have drive-thru lanes providing access to ATMs using an automobile.

In recent times, countries like India and some countries in Africa are installing ATMs in rural areas, which are solar powered.[39]

Financial networks

An ATM in the Netherlands. The logos of a number of interbank networks to which it is connected are shown.

Most ATMs are connected to interbank networks, enabling people to withdraw and deposit money from machines not belonging to the bank where they have their accounts or in the countries where their accounts are held (enabling cash withdrawals in local currency). Some examples of interbank networks include NYCE, PULSE, PLUS, Cirrus, AFFN, Interac, Interswitch, STAR, LINK, MegaLink and BancNet.

ATMs rely on authorization of a financial transaction by the card issuer or other authorizing institution on a communications network. This is often performed through an ISO 8583 messaging system.

Many banks charge ATM usage fees. In some cases, these fees are charged solely to users who are not customers of the bank where the ATM is installed; in other cases, they apply to all users.

In order to allow a more diverse range of devices to attach to their networks, some interbank networks have passed rules expanding the definition of an ATM to be a terminal that either has the vault within its footprint or utilises the vault or cash drawer within the merchant establishment, which allows for the use of a scrip cash dispenser.

A Diebold 1063ix with a dial-up modem visible at the base

ATMs typically connect directly to their host or ATM Controller on either ADSL or dial-up modem over a telephone line or directly on a leased line. Leased lines are preferable to plain old telephone service (POTS) lines because they require less time to establish a connection. Less-trafficked machines will usually rely on a dial-up modem on a POTS line rather than using a leased line, since a leased line may be comparatively more expensive to operate compared to a POTS line. That dilemma may be solved as high-speed Internet VPN connections become more ubiquitous. Common lower-level layer communication protocols used by ATMs to communicate back to the bank include SNA over SDLC, TC500 over Async, X.25, and TCP/IP over Ethernet.

In addition to methods employed for transaction security and secrecy, all communications traffic between the ATM and the Transaction Processor may also be encrypted using methods such as SSL.[40]

Global use

There are no hard international or government-compiled numbers totaling the complete number of ATMs in use worldwide. Estimates developed by ATMIA place the number of ATMs currently in use at 3 million units, or approximately 1 ATM per 3000 people in the world.[41][42]

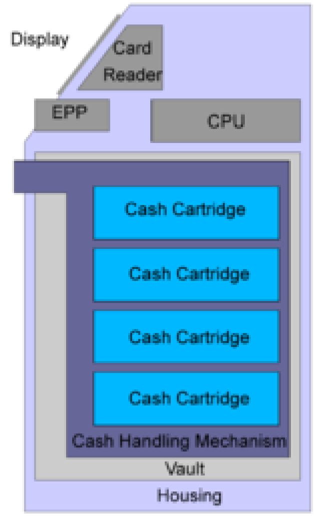
To simplify the analysis of ATM usage around the world, financial institutions generally divide the world into seven regions, due to the penetration rates, usage statistics, and features deployed. Four regions (USA, Canada, Europe, and Japan) have high numbers of ATMs per million people.[43][44] Despite the large number of ATMs, there is additional demand for machines in the Asia/Pacific area as well as in Latin America.[45][46] Macau may have the highest density of ATMs at 254 ATMs per 100,000 adults.[47] ATMs have yet to reach high numbers in the Near East and Africa.[48]

The world's highest ATM is located at the Khunjerab Pass in Pakistan. Installed at an elevation of 15,397 feet by the National Bank of Pakistan, it is designed to work in temperatures of up to -40 degree Celsius.[49]

Hardware

An ATM is typically made up of the following devices:

- CPU (to control the user interface and transaction devices)
- Magnetic or chip card reader (to identify the customer)
- PIN pad EEP4 (similar in layout to a touch tone or calculator keypad), manufactured as part of a secure enclosure
- Secure cryptoprocessor, generally within a secure enclosure
- Display (used by the customer for performing the transaction)
- Function key buttons (usually close to the display) or a touchscreen (used to select the various aspects of the transaction)
- Record printer (to provide the customer with a record of the transaction)
- Vault (to store the parts of the machinery requiring restricted access)
- Housing (for aesthetics and to attach signage to)
- Sensors and indicators



A block diagram of an ATM

Due to heavier computing demands and the falling price of personal computer–like architectures, ATMs have moved away from custom hardware architectures using microcontrollers or application-specific integrated circuits and have adopted the hardware architecture of a personal computer, such as USB connections for peripherals, Ethernet and IP communications, and use personal computer operating systems.

Business owners often lease ATMs from service providers. However, based on the economies of scale, the price of equipment has dropped to the point where many business owners are simply paying for ATMs using a credit card.

New ADA voice and text-to-speech guidelines imposed in 2010, but required by March 2012[50] have forced many ATM owners to either upgrade non-compliant machines or dispose them if they are not upgradable, and purchase new compliant equipment. This has created an avenue for hackers and thieves to obtain ATM hardware at junkyards from improperly disposed decommissioned machines.[51]

The vault of an ATM is within the footprint of the device itself and is where items of value are kept. Scrip cash dispensers do not incorporate a vault.


Two Loomis employees refilling an ATM at the Downtown Seattle REI

Mechanisms found inside the vault may include:

- Dispensing mechanism (to provide cash or other items of value)
- Deposit mechanism including a cheque processing module and bulk note acceptor (to allow the customer to make deposits)
- Security sensors (magnetic, thermal, seismic, gas)
- Locks (to ensure controlled access to the contents of the vault)
- Journaling systems; many are electronic (a sealed flash memory device based on in-house standards) or a solid-state device (an actual printer) which accrues all records of activity including access timestamps, number of notes dispensed, etc. This is considered sensitive data and is secured in similar fashion to the cash as it is a similar liability

ATM vaults are supplied by manufacturers in several grades. Factors influencing vault grade selection include cost, weight, regulatory requirements, ATM type, operator risk avoidance practices and internal volume requirements.[52] Industry standard vault configurations include Underwriters Laboratories UL-291 "Business Hours" and Level 1 Safes,[53] RAL TL-30 derivatives,[54] and CEN EN 1143-1 - CEN III and CEN IV.[55][56]

ATM manufacturers recommend that a vault be attached to the floor to prevent theft,[57] though there is a record of a theft conducted by tunnelling into an ATM floor.[58]

Software

With the migration to commodity Personal Computer hardware, standard commercial "off-the-shelf" operating systems and programming environments can be used inside of ATMs. Typical platforms previously used in ATM development include RMX or OS/2.

A Wincor Nixdorf ATM running Windows 2000

Today, the vast majority of ATMs worldwide use a Microsoft Windows operating system, primarily Windows XP Professional or Windows XP Embedded. In early 2014, 95% of ATMs were running Windows XP.[59] A small number of deployments may still be running older versions of the Windows OS, such as Windows NT, Windows CE, or Windows 2000.

There is a computer industry security view that general public desktop operating systems(os) have greater risks as operating systems for cash dispensing machines than other types of operating systems like (secure) real-time operating systems (RTOS). RISKS Digest has many articles about ATM operating system vulnerabilities.[60]

Linux is also finding some reception in the ATM marketplace. An example of this is Banrisul, the largest bank in the south of Brazil, which has replaced the MS-DOS operating systems in its ATMs with Linux. Banco do Brasil is also migrating ATMs to Linux. Indian-based Vortex Engineering is manufacturing ATMs which operate only with Linux. Common application layer transaction protocols, such as Diebold 91x (911 or 912) and NCR NDC or NDC+ provide emulation of older generations of hardware on newer platforms with incremental extensions made over time to address new capabilities, although companies like NCR continuously improve these protocols issuing newer versions (e.g. NCR's AANDC v3.x.y, where x.y are subversions). Most major ATM manufacturers provide software packages that implement these protocols. Newer protocols such as IFX have yet to find wide acceptance by transaction processors.[61]

With the move to a more standardised software base, financial institutions have been increasingly interested in the ability to pick and choose the application programs that drive their equipment. WOSA/XFS, now known as CEN XFS (or simply XFS), provides a common API for accessing and manipulating the various devices of an ATM. J/XFS is a Java implementation of the CEN XFS API.

While the perceived benefit of XFS is similar to the Java's "Write once, run anywhere" mantra, often different ATM hardware vendors have different interpretations of the XFS standard. The result of these differences in interpretation means that ATM applications typically use a middleware to even out the differences among various platforms.

With the onset of Windows operating systems and XFS on ATMs, the software applications have the ability to become more intelligent. This has created a new breed of ATM applications commonly referred to as programmable applications. These types of applications allows for an entirely new host of applications in which the ATM terminal can do more than only communicate with the ATM switch. It is now empowered to connected to other content servers and video banking systems.

Notable ATM software that operates on XFS platforms include Triton PRISM, Diebold Agilis EmPower, NCR APTRA Edge, Absolute Systems AbsoluteINTERACT, KAL Kalignite Software Platform, Phoenix Interactive VISTAatm, Wincor Nixdorf ProTopas, Euronet EFTS and Intertech inter-ATM.

With the move of ATMs to industry-standard computing environments, concern has risen about the integrity of the ATM's software stack.[62]

Security

Security, as it relates to ATMs, has several dimensions. ATMs also provide a practical demonstration of a number of security systems and concepts operating together and how various security concerns are addressed.

Physical

Early ATM security focused on making the terminals invulnerable to physical attack; they were effectively safes with dispenser mechanisms. A number of attacks resulted, with thieves attempting to steal entire machines by ram-raiding.[63] Since the late 1990s, criminal groups operating in Japan improved ram-raiding by stealing and using a truck loaded with heavy construction machinery to effectively demolish or uproot an entire ATM and any housing to steal its cash.

A Wincor Nixdorf Procash 2100xe Frontload that was opened with an angle grinder.

Another attack method, *plofkraak*, is to seal all openings of the ATM with silicone and fill the vault with a combustible gas or to place an explosive inside, attached, or near the machine. This gas or explosive is ignited and the vault is opened or distorted by the force of the resulting explosion and the criminals can break in.[64] This type of theft has occurred in the Netherlands, Belgium, France, Denmark, Germany and Australia.[65][66] These types of attacks can be prevented by a number of gas explosion prevention devices also known as gas suppression system. These systems use explosive gas detection sensor to detect explosive gas and to neutralise it by releasing a special explosion suppression chemical which changes the composition of the explosive gas and renders it ineffective.

Several attacks in the UK (at least one of which was successful) have involved digging a concealed tunnel under the ATM and cutting through the reinforced base to remove the money.[58]

Modern ATM physical security, per other modern money-handling security, concentrates on denying the use of the money inside the machine to a thief, by using diferent types of Intelligent Banknote Neutralisation Systems

A common method is to simply rob the staff filling the machine with money. To avoid this, the schedule for filling them is kept secret, varying and random. The money is often kept in cassettes, which will dye the money if incorrectly opened.

Transactional secrecy and integrity

The security of ATM transactions relies mostly on the integrity of the secure cryptoprocessor: the ATM often uses general commodity components that sometimes are not considered to be "trusted systems".

Encryption of personal information, required by law in many jurisdictions, is used to prevent fraud. Sensitive data in ATM transactions are usually encrypted with DES, but transaction processors now usually require the use of Triple DES.[67] Remote Key Loading techniques may be used to ensure the secrecy of the initialisation of the encryption keys in the ATM. Message Authentication Code (MAC) or Partial MAC may also be used to ensure messages have not been tampered with while in transit between the ATM and the financial network.

Customer identity integrity

There have also been a number of incidents of fraud by Man-in-the-middle attacks, where criminals have attached fake keypads or card readers to existing machines. These have then been used to record customers' PINs and bank card information in order to gain unauthorised access to their accounts. Various ATM manufacturers have put in place countermeasures to protect the equipment they manufacture from these threats.[68][69]

A BTMU ATM with a palm scanner (to the right of the screen)

Alternative methods to verify cardholder identities have been tested and deployed in some countries, such as finger and palm vein patterns,[70] iris, and facial recognition technologies. Cheaper mass-produced equipment has been developed and is being installed in machines globally that detect the presence of foreign objects on the front of ATMs, current tests have shown 99% detection success for all types of skimming devices.[71]

Device operation integrity

ATMs that are exposed to the outside must be vandal- and weather- resistant.

Openings on the customer side of ATMs are often covered by mechanical shutters to prevent tampering with the mechanisms when they are not in use. Alarm sensors are placed inside ATMs and their servicing areas to alert their operators when doors have been opened by unauthorised personnel.

To protect against hackers, ATMs have a built-in firewall. Once the firewall has detected malicious attempts to break into the machine remotely, the firewall locks down the machine.

Rules are usually set by the government or ATM operating body that dictate what happens when integrity systems fail. Depending on the jurisdiction, a bank may or may not be liable when an attempt is made to dispense a customer's money from an ATM and the money either gets outside of the ATM's vault, or was exposed in a non-secure fashion, or they are unable to determine the state of the money after a failed transaction.[72] Customers often commented that it is difficult to recover money lost in this way, but this is often complicated by the policies regarding suspicious activities typical of the criminal element.[73]

Customer security


Dunbar armored personnel watching over ATMs that have been installed in a van

In some countries, multiple security cameras and security guards are a common feature.[74] In the United States, The New York State Comptroller's Office has advised the New York State Department of Banking to have more thorough safety inspections of ATMs in high crime areas.[75]

Consultants of ATM operators assert that the issue of customer security should have more focus by the banking industry;[76] it has been suggested that efforts are now more concentrated on the preventive measure of deterrent legislation than on the problem of ongoing forced withdrawals.[77]

At least as far back as July 30, 1986, consultants of the industry have advised for the adoption of an emergency PIN system for ATMs, where the user is able to send a silent alarm in response to a threat.[78] Legislative efforts to require an emergency PIN system have appeared in Illinois,[79] Kansas[80] and Georgia,[81] but none have succeeded yet. In January 2009, Senate Bill 1355 was proposed in the Illinois Senate that revisits the issue of the reverse emergency PIN system.[82] The bill is again supported by the police and denied by the banking lobby.[83]

In 1998, three towns outside Cleveland, Ohio, in response to an ATM crime wave, adopted legislation requiring that an emergency telephone number switch be installed at all outdoor ATMs within their jurisdiction. In the wake of a homicide in Sharon Hill, Pennsylvania, the city council passed an ATM security bill as well.

In China and elsewhere, many efforts to promote security have been made. On-premises ATMs are often located inside the bank's lobby, which may be accessible 24 hours a day. These lobbies have extensive security camera coverage, a courtesy telephone for consulting with the bank staff, and a security guard on the premises. Bank lobbies that are not guarded 24 hours a day may also have secure doors that can only be opened from outside by swiping the bank card against a wall-mounted scanner, allowing the bank to identify which card enters the building. Most ATMs will also display on-screen safety warnings and may also be fitted with convex mirrors above the display allowing the user to see what is happening behind them.

As of 2013, the only claim available about the extent of ATM-connected homicides is that they range from 500 to 1,000 per year in the US, covering only cases where the victim had an ATM card and the card was used by the killer after the known time of death.[84]

Jackpotting

The term *jackpotting* is used to describe one method criminals utilize to steal money from an ATM. The thieves gain physical access through a small hole drilled in the machine. They disconnect the existing hard drive and connect an external drive using an industrial endoscope. They then depress an internal button that reboots the device so that it is now under the control of the external drive. They can then have the ATM dispense all of its cash.[85]

Uses

Originally developed as cash dispensers, ATMs have evolved to include many other bank-related functions:

Two NCR Personas 84 ATMs at a bank in Jersey dispensing two types of pound sterling banknotes: Bank of England on the left, and States of Jersey on the right.

- Paying routine bills, fees, and taxes (utilities, phone bills, social security, legal fees, income taxes, etc.)
- Printing bank statements
- Updating passbooks
- Cash advances
- Cheque Processing Module
- Paying (in full or partially) the credit balance on a card linked to a specific current account.
- Transferring money between linked accounts (such as transferring between accounts)
- Deposit currency recognition, acceptance, and recycling[86][87]

In some countries, especially those which benefit from a fully integrated cross-bank network (e.g.: Multibanco in Portugal), ATMs include many functions that are not directly related to the management of one's own bank account, such as:

Gold vending ATM in New York City.

- Loading monetary value into stored value cards
- Adding pre-paid cell phone / mobile phone credit.
- Purchasing
  - Concert tickets
  - Gold[88]
  - Lottery tickets
  - Movie tickets
  - Postage stamps.
  - Train tickets
  - Shopping mall gift certificates.
- Donating to charities[89]

Increasingly, banks are seeking to use the ATM as a sales device to deliver pre approved loans and targeted advertising using products such as ITM (the Intelligent Teller Machine) from Aptra Relate from NCR.[90] ATMs can also act as an advertising channel for other companies.[91]*

However, several different ATM technologies have not yet reached worldwide acceptance, such as:

- Videoconferencing with human tellers, known as video tellers[92]
- Biometrics, where authorization of transactions is based on the scanning of a customer's fingerprint, iris, face, etc.[93][94][95]
- Cheque/cash Acceptance, where the machine accepts and recognises cheques and/or currency without using envelopes[96] Expected to grow in importance in the US through Check 21 legislation.
- Bar code scanning[97]
- On-demand printing of "items of value" (such as movie tickets, traveler's cheques, etc.)
- Dispensing additional media (such as phone cards)
- Co-ordination of ATMs with mobile phones[98]
- Integration with non-banking equipment[99][100]
- Games and promotional features[101]

- CRM through the ATM

Videoconferencing teller machines are currently referred to as Interactive Teller Machines. Benton Smith, in the Idaho Business Review writes "The software that allows interactive teller machines to function was created by a Salt Lake City-based company called uGenius, a producer of video banking software. NCR, a leading manufacturer of ATMs, acquired uGenius in 2013 and married its own ATM hardware with uGenius' video software."[102]

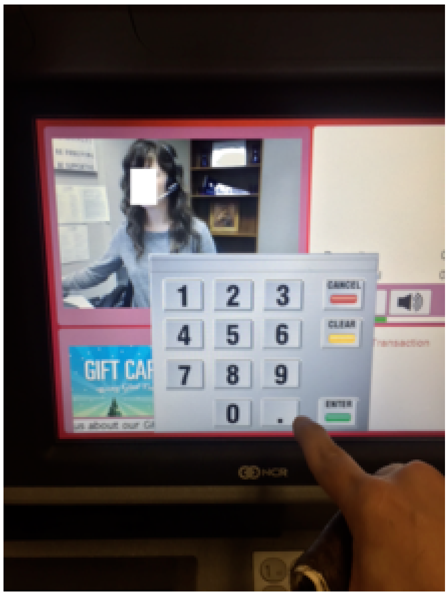
A South Korean ATM with mobile bank port and bar code reader

Reliability

Before an ATM is placed in a public place, it typically has undergone extensive testing with both test money and the backend computer systems that allow it to perform transactions. Banking customers also have come to expect high reliability in their ATMs,[103] which provides incentives to ATM providers to minimise machine and network failures. Financial consequences of incorrect machine operation also provide high degrees of incentive to minimise malfunctions.[104]

ATMs and the supporting electronic financial networks are generally very reliable, with industry benchmarks typically producing 98.25% customer availability for ATMs[105] and up to 99.999% availability for host systems that manage the networks of ATMs. If ATM networks do go out of service, customers could be left without the ability to make transactions until the beginning of their bank's next time of opening hours.

An ATM running Microsoft Windows that has crashed due to a peripheral component failure



A NCR Interactive Teller Machine running uGenius software.

This said, not all errors are to the detriment of customers; there have been cases of machines giving out money without debiting the account, or giving out higher value notes as a result of incorrect denomination of banknote being loaded in the money cassettes.[106] The result of receiving too much money may be influenced by the card holder agreement in place between the customer and the bank.[107][108]

Errors that can occur may be mechanical (such as card transport mechanisms; keypads; hard disk failures; envelope deposit mechanisms); software (such as operating system; device driver; application); communications; or purely down to operator error

To aid in reliability, some ATMs print each transaction to a roll-paper journal that is stored inside the ATM, which allows its users and the related financial institutions to settle things based on the records in the journal in case there is a dispute. In some cases, transactions are posted to an electronic journal to remove the cost of supplying journal paper to the ATM and for more convenient searching of data.

Improper money checking can cause the possibility of a customer receiving counterfeit banknotes from an ATM. While bank personnel are generally trained better at spotting and removing counterfeit cash,[109][110] the resulting ATM money supplies used by banks provide no guarantee for proper banknotes, as the Federal Criminal Police Office of Germany has confirmed that there are regularly incidents of false banknotes having been dispensed through ATMs.[111] Some ATMs may be stocked and wholly owned by outside companies, which can further complicate this problem. Bill validation technology can be used by ATM providers to help ensure the authenticity of the cash before it is stocked in the machine; those with cash recycling capabilities include this capability.[112]

Fraud

As with any device containing objects of value, ATMs and the systems they depend on to function are the targets of fraud. Fraud against ATMs and people's attempts to use them takes several forms.

ATM lineup

The first known instance of a fake ATM was installed at a shopping mall in Manchester, Connecticut in 1993. By modifying the inner workings of a Fujitsu model 7020 ATM, a criminal gang known as the Bucklands Boys stole information from cards inserted into the machine by customers.[113]

WAVY-TV reported an incident in Virginia Beach in September 2006 where a hacker, who had probably obtained a factory-default administrator password for a filling station's white-label ATM, caused the unit to assume it was loaded with US$5 bills instead of $20s, enabling himself—and many subsequent customers—to walk away with four times the money withdrawn from their accounts.[114] This type of scam was featured on the TV series *The Real Hustle*.

Some ATMs may display warning messages to customers to be vigilant of possible tampering.

ATM behaviour can change during what is called "stand-in" time, where the bank's cash dispensing network is unable to access databases that contain account information (possibly for database maintenance). In order to give customers access to cash, customers may be allowed to withdraw cash up to a certain amount that may be less than their usual daily withdrawal limit, but may still exceed the amount of available money in their accounts, which could result in fraud if the customers intentionally withdraw more money than what they had in their accounts.[115]

Card fraud

In an attempt to prevent criminals from shoulder surfing the customer's personal identification number (PIN), some banks draw privacy areas on the floor.

For a low-tech form of fraud, the easiest is to simply steal a customer's card along with its PIN. A later variant of this approach is to trap the card inside of the ATM's card reader with a device often referred to as a Lebanese loop. When the customer gets frustrated by not getting the card back and walks away from the machine, the criminal is able to remove the card and withdraw cash from the customer's account, using the card and its PIN.

Banknotes from an ATM robbery made unusable withred paint

This type of fraud has spread globally. Although somewhat replaced in terms of volume by skimming incidents, a re-emergence of card trapping has been noticed in regions such as Europe, where EMV chip and PIN cards have increased in circulation.[116]

Another simple form of fraud involves attempting to get the customer's bank to issue a new card and its PIN and stealing them from their mail.[117]

By contrast, a newer high-tech method of operating, sometimes called **card skimming** or **card cloning**, involves the installation of a magnetic card reader over the real ATM's card slot and the use of a wireless surveillance camera or a modified digital camera or a false PIN keypad to observe the user's PIN. Card data is then cloned into a duplicate card and the criminal attempts a standard cash withdrawal. The availability of low-cost commodity wireless cameras, keypads, card readers, and card writers has made it a relatively simple form of fraud, with comparatively low risk to the fraudsters.[118]

In an attempt to stop these practices, countermeasures against card cloning have been developed by the banking industry, in particular by the use of smart cards which cannot easily be copied or spoofed by unauthenticated devices, and by attempting to make the outside of their ATMs tamper evident. Older chip-card security systems include the French Carte Bleue, Visa Cash, Mondex, Blue from American Express[119] and EMV '96 or EMV 3.11. The most actively developed form of smart card security in the industry today is known as EMV 2000 or EMV 4.x.

EMV is widely used in the UK (Chip and PIN) and other parts of Europe, but when it is not available in a specific area, ATMs must fall back to using the easy–to–copy magnetic stripe to perform transactions. This fallback behaviour can be exploited.[120] However, the fallback option has been removed on the ATMs of some UK banks, meaning if the chip is not read, the transaction will be declined.

Card cloning and skimming can be detected by the implementation of magnetic card reader heads and firmware that can read a signature embedded in all magnetic stripes during the card production process. This signature, known as a "MagnePrint" or "BluPrint", can be used in conjunction with common two-factor authentication schemes used in ATM, debit/retail point-of-sale and prepaid card applications.

The concept and various methods of copying the contents of an ATM card's magnetic stripe onto a duplicate card to access other people's financial information was well known in the hacking communities by late 1990.[121]

In 1996, Andrew Stone, a computer security consultant from Hampshire in the UK, was convicted of stealing more than £1 million by pointing high-definition video cameras at ATMs from a considerable distance and recording the card numbers, expiry dates, etc. from the embossed detail on the ATM cards along with video footage of the PINs being entered. After getting all the information from the videotapes, he was able to produce clone cards which not only allowed him to withdraw the full daily limit for each account, but also allowed him to sidestep withdrawal limits by using multiple copied cards. In court, it was shown that he could withdraw as much as £10,000 per hour by using this method. Stone was sentenced to five years and six months in prison.[122]

Related devices

A talking ATM is a type of ATM that provides audible instructions so that people who cannot read a screen can independently use the machine, therefore effectively eliminating the need for assistance from an external, potentially malevolent source. All audible information is delivered privately through a standard headphone jack on the face of the machine. Alternatively, some banks such as the Nordea and Swedbank use a built-in external speaker which may be invoked by pressing the talk button on the keypad.[123] Information is delivered to the customer either through pre-recorded sound files or via text-to-speech speech synthesis.

A postal interactive kiosk may share many components of an ATM (including a vault), but it only dispenses items related to postage.[124][125]

A scrip cash dispenser may have many components in common with an ATM, but it lacks the ability to dispense physical cash and consequently requires no vault. Instead, the customer requests a withdrawal transaction from the machine, which prints a receipt. The customer then takes this receipt to a nearby sales clerk, who then exchanges it for cash from the till.[126]

A teller assist unit (TAU) is distinct in that it is designed to be operated solely by trained personnel and not by the general public, does integrate directly into interbank networks, and usually is controlled by a computer that is not directly integrated into the overall construction of the unit.

A Web ATM is an online interface for ATM card banking that uses a smart card reader. All the usual ATM functions are available, except for withdrawing cash. Most banks in Taiwan provide these online services.[127][128]

See also

- ATM Industry Association (ATMIA)
- Automated cash handling
- Banknote counter
- Cash register
- EFTPOS
- Electronic funds transfer
- Financial cryptography
- Key management
- Payroll
- Phantom withdrawal
- RAS syndrome
- Security of Automated Teller Machines
- Self service
- Teller system
- Verification and validation

References

1. *Merriam-Webster Dictionary* (http://www.merriam-webster.com/dictionary/automatic%20teller%20machine). Springfield, MA: Merriam-Webster. Archived (https://web.archive.org/web/20170812213416/https://www.merriam-webster.com/dictionary/automatic%20teller%20machine) from the original on 12 August 2017. Retrieved 7 January 2017.
2. "training.gov.au - FNSRTS307A - Maintain Automatic Teller Machine (ATM) services" (https://training.gov.au/Training/Details/FNSRTS307A). Archived (https://web.archive.org/web/20140407070931/https://training.gov.au/Training/Details/FNSRTS307A) from the original on 7 April 2014.
3. Cambridge Dictionary *Automatic Teller Machine* (http://dictionary.cambridge.org/dictionary/british/automatic-teller-machine) Archived (https://web.archive.org/web/20140407090534/http://dictionary.cambridge.org/dictionary/british/automatic-teller-machine) 7 April 2014 at the Wayback Machine.
4. "Interac FAQ" (http://www.interac.ca/en/faq/faq/136-what-is-interac-cash-2.html). Interac Association. Retrieved January 28, 2018.
5. Automatic Bank Machine definition from a Canadian bank, *Scotiabank*. (http://www.scotiabank.com/ca/en/0,,316,00.html)
6. *Merriam-Webster Dictionary* (http://www.merriam-webster.com/dictionary/cash%20machine). Springfield, MA: Merriam-Webster. Archived (https://web.archive.org/web/20170109113711/https://www.merriam-webster.com/dictionary/cash%20machine) from the original on 9 January 2017. Retrieved 7 January 2017.
7. "ATM Industry Association" (https://www.atmia.com/). Archived (https://web.archive.org/web/20151016073750/https://www.atmia.com/) from the original on 16 October 2015.
8. "3 Million ATMs Worldwide By 2015: ATM Association" (http://www.cutimes.com/2014/07/28/3-million-atms-worldwide-by-2015-atm-association). Archived (https://web.archive.org/web/20150626074837/http://www.cutimes.com/2014/07/28/3-million-atms-worldwide-by-2015-atm-association) from the original on 26 June 2015.
9. Shopping centres prepare to go cashless as ATMs disappear (http://www.theage.com.au/business/property/shopping-centres-prepare-to-go-cashless-as-atms-disappear-20171130-gzvtk8.html) Archived (https://web.archive.org/web/20171204065719/http://www.theage.com.au/business/property/shopping-centres-prepare-to-go-cashless-as-atms-disappear-20171130-gzvtk8.html) 4 December 2017 at the Wayback Machine.
10. Schlichter, Sarah (2007-02-05). "Using ATM's abroad - Travel - Travel Tips - msnbc.com" (http://www.msnbc.msn.com/id/16994358/). MSNBC. Retrieved 2011-02-11.
11. "A Brief History of the ATM" (https://www.theatlantic.com/technology/archive/2015/03/a-brief-history-of-the-atm/388547/). The Atlantic. 26 March 2015. Archived (https://web.archive.org/web/20150428065642/http://www.theatlantic.com/technology/archive/2015/03/a-brief-history-of-the-atm/388547/) from the original on 28 April 2015. Retrieved 26 April 2015.
12. "How the ATM Revolutionized the Banking Business" (https://www.bloomberg.com/news/2013-03-27/how-the-atm-revolutionized-the-banking-business.html). Bloomberg. 27 March 2013. Archived (https://web.archive.org/web/20140209154037/http://www.bloomberg.com/news/2013-03-27/how-the-atm-revolutionized-the-banking-business.html) from the original on 9 February 2014.
13. "ATMIA 50th Anniversary Factsheet" (https://www.atmia.com/files/50th%20Anniversary/50th_ATM_Anniversary_Fact_Sheet_-_06272016.pdf) (PDF). *www.atmia.com*. ATM Industry Association. October 2015. Archived (https://web.archive.org/web/20160818110157/https://www.atmia.com/files/50th%20Anniversary/50th_ATM_Anniversary_Fact_Sheet_-_06272016.pdf) (PDF) from the original on 18 August 2016. Retrieved 29 June 2016.
14. 'Fast Machine With a Buck',"Pacific Star and Stripes", 7 July 1966

15. 'Instant Cash with a Credit Card', "ABA Banking Journal", January 1967
16. 'Universal Match Maps Acquisition', *The New York Times*, 22 March 1961
17. 'Machine Accepts Bank Deposits', *The New York Times*, 12 April 1961
18. "From punchcard to prestaging: 50 years of ATM innovation" (https://web.archive.org/web/20130815222832/http://www.atmmarketplace.com/article/217157/From-punchcard-to-prestaging-50-years-of-ATM-innovation). ATM Marketplace. 31 July 2013. Archived from the original (http://www.atmmarketplace.com/article/217157/From-punchcard-to-prestaging-50-years-of-ATM-innovation) on 15 August 2013. Retrieved 27 September 2013.
19. Batiz-Lazo, Bernardo; Reid, Robert J. K. (30 June 2008). "Evidence from the Patent Record on the Development of Cash Dispensing Technology" (http://mpra.ub.uni-muenchen.de/9461/1/MPRA_paper_9461.pdf) (PDF). Munich Personal RePEc Archive. p. 4. Archived (https://web.archive.org/web/20150904045127/https://mpra.ub.uni-muenchen.de/9461/1/MPRA_paper_9461.pdf) (PDF) from the original on 4 September 2015. Retrieved 27 April 2015.
20. "Enfield's cash gift to the world" (http://www.bbc.co.uk/london/content/articles/2007/06/26/cash_machine_feature.shtml). BBC London. 27 June 2007. Archived (https://web.archive.org/web/20151103030534/http://www.bbc.co.uk/london/content/articles/2007/06/26/cash_machine_feature.shtml) from the original on 3 November 2015.
21. Milligan, Brian (25 June 2007). "The man who invented the cash machine" (http://news.bbc.co.uk/2/hi/business/6230194.stm). BBC News. Archived (https://web.archive.org/web/20091226192112/http://news.bbc.co.uk/2/hi/business/6230194.stm) from the original on 26 December 2009. Retrieved 26 April 2010.
22. "ATM inventor honoured" (http://news.bbc.co.uk/2/hi/uk_news/scotland/4135269.stm). BBC News. 31 December 2004. Archived (https://web.archive.org/web/20100608040555/http://news.bbc.co.uk/2/hi/uk_news/scotland/4135269.stm) from the original on 8 June 2010. Retrieved 26 April 2010.
23. Harper, Tom; Batiz-Lazo, Bernardo (2013). *Cash Box: The Invention and Globalization of the ATM* (https://www.amazon.com/Cash-Box-Invention-Globalization-ATM/dp/1935497626/ref=sr_1_3?s=books&ie=UTF8&qid=1467220875&sr=1-3&keywords=Cash+box). Networld Media Group. ISBN 1935497626.
24. "ATM inventor John Shepherd-Barron dies at age of 84 on 20th May 2010" (http://latimesblogs.latimes.com/afterword/2010/05/atm-inventor-john-shepherdbarron-dies-at-84.html). Los Angeles Times. 19 May 2010. Archived (https://web.archive.org/web/20100523172520/http://latimesblogs.latimes.com/afterword/2010/05/atm-inventor-john-shepherdbarron-dies-at-84.html) from the original on 23 May 2010.
25. Mary Bellis. The ATM of John Shepherd Barron (http://inventors.about.com/od/astartinventions/a/atm_2.htm) About.com. Retrieved 2011-04-29.
26. B. Batiz-Lazo. "The emergence and evolution of ATM networks in the UK, c. 1967-2000" (https://ideas.repec.org/p/pra/mprapa/3689.html). Business History, 2009 (51:1). Taylor and Francis, 2009. Archived (https://web.archive.org/web/20141103165250/https://ideas.repec.org/p/pra/mprapa/3689.html) from the original on 3 November 2014.
27. B. Batiz-Lazo, T. Karlsson and B. Thodenius. "The origins of the cashless society: cash dispensers, direct to account payments and the development of on-line real-time networks, c. 1965-1985" (http://www.ebhsoc.org/journal/index.php/journal/article/view/274). Essays in Economic and Business History 2014 (32). The Economic and Business History Society, 2014. Archived (https://web.archive.org/web/20140714184815/http://www.ebhsoc.org/journal/index.php/journal/article/view/274) from the original on 14 July 2014.
28. B. Batiz-Lazo and R. J. K. Reid. "Evidence from the patent record on the development of cash dispensing technology" (https://ideas.repec.org/p/pra/mprapa/9461.html). History of Telecommunications Conference, 2008. Histelcon 2008. IEEE. Archived (https://web.archive.org/web/20141103165602/https://ideas.repec.org/p/pra/mprapa/9461.html) from the original on 3 November 2014.
29. Marino Gomez-Santos (9 January 1969). "Bancomat (In Spanish)" (http://hemeroteca.abc.es/nav/Navigate.exe/hemeroteca/madrid/abc/1969/01/09/048.html). ABC. Archived (https://web.archive.org/web/20140811221708/http://hemeroteca.abc.es/nav/Navigate.exe/hemeroteca/madrid/abc/1969/01/09/048.html) from the original on 11 August 2014.
30. "Bancomat Banesto (commercial ad with instructions for use in Spanish)" (http://hemeroteca.abc.es/nav/Navigate.exe/hemeroteca/madrid/abc/1969/03/18/058.html). ABC. 18 March 1969. Archived (https://web.archive.org/web/20140811221714/http://hemeroteca.abc.es/nav/Navigate.exe/hemeroteca/madrid/abc/1969/03/18/058.html) from the original on 11 August 2014.
31. Essinger, James (1987). *ATM Networks: Their Organization, Security and Future*. Elsevier International.
32. Kirkpatrick, Rob (2009). *1969: The Year Everything Changed* (https://books.google.com/books?id=XZMrIchANY4C&pg=PA266). Skyhorse Publishing Inc. p. 266. ISBN 9781602393660. Archived (https://web.archive.org/web/20111225211738/http://books.google.com/books?id=XZMrIchANY4C&pg=PA266) from the original on 25 December 2011.

33. *Popular Mechanics - Google Books* (https://books.google.com/books?id=BtEDAAAAMBAJ&lpg=PA84&pg=PA84). Books.google.com. Archived (https://web.archive.org/web/20111225214202/http://books.google.com/books?id=BtEDAAAAMBAJ&lpg=PA84&pg=PA84) from the original on 25 December 2011. Retrieved 11 February 2011.
34. "Interview with Mr. Don Wetzel" (http://americanhistory.si.edu/collections/comphist/wetzel.htm). Americanhistory.si.edu. Archived (https://web.archive.org/web/20110220214346/http://americanhistory.si.edu/collections/comphist/wetzel.htm) from the original on 20 February 2011. Retrieved 2011-02-11.
35. "Automatic teller machine" (http://www.thocp.net/hardware/atm.htm). *The History of Computing Project*. Thocp.net. 17 April 2006. Archived (https://web.archive.org/web/20110220215034/http://www.thocp.net/hardware/atm.htm) from the original on 20 February 2011. Retrieved 2011-02-11.
36. personal knowledge of William Patterson who was there supporting the network
37. "ATMs to operate without a card" (http://www.bbc.co.uk/news/business-18409560). *BBC News*. 12 June 2012. Archived (https://web.archive.org/web/20120613035141/http://www.bbc.co.uk/news/business-18409560) from the original on 13 June 2012.
38. Overview: Navy Cash/Marine Cash: Programs and Systems: Financial Management Service (http://fms.treas.gov/navycash/index.html) Archived (https://web.archive.org/web/20130303190236/http://www.fms.treas.gov/navycash/index.html) 3 March 2013 at the Wayback Machine. Fms.treas.gov. Retrieved on 2013-08-02.
39. NT, Balanarayan (14 March 2010). "The nano of ATMs for rural masses comes to town" (http://www.dnaindia.com/bangalore/report-the-nano-of-atms-for-rural-masses-comes-to-town-1358865). *Daily News and Analysis*. Bangalore. Archived (https://web.archive.org/web/20150525014956/http://www.dnaindia.com/bangalore/report-the-nano-of-atms-for-rural-masses-comes-to-town-1358865) from the original on 25 May 2015. Retrieved 24 May 2015.
40. [1] (http://www.ebcvg.com/press.php?id=794) Archived (https://web.archive.org/web/20151016073750/http://www.ebcvg.com/press.php?id=794) 16 October 2015 at the Wayback Machine.
41. "ATM Industry Association Global ATM Clock" (https://web.archive.org/web/20110913131331/http://www.atmia.com/mig/globalatmclock/). Atmia.com. Archived from the original (http://www.atmia.com/mig/globalatmclock/) on 13 September 2011. Retrieved 2011-09-15.
42. "A million new ATMs installed in the last five years" (https://www.rbrlondon.com/about/G20_Press_Release_091015.pdf) (PDF). rbrlondon.com. Archived (https://web.archive.org/web/20161223062608/https://www.rbrlondon.com/about/G20_Press_Release_091015.pdf) (PDF) from the original on 23 December 2016. Retrieved 22 December 2016.
43. "Archived copy" (https://web.archive.org/web/20061005015130/http://www.interac.org/en_n3_31_abmstats.html). Archived from the original (http://www.interac.org/en_n3_31_abmstats.html) on 5 October 2006. Retrieved 2006-08-11.
44. "Statistics on payment and settlement systems in selected countries - Figures for 2004" (http://www.bis.org/publ/cpss74.htm). Bis.org. 2006-03-31. Archived (https://web.archive.org/web/20110117150724/http://www.bis.org/publ/cpss74.htm) from the original on 17 January 2011. Retrieved 2011-02-11.
45. "Central bank payment system information" (http://www.bis.org/cpss/paysysinfo.htm). Bis.org. 2001-02-05. Archived (https://web.archive.org/web/20110116023617/http://www.bis.org/cpss/paysysinfo.htm) from the original on 16 January 2011. Retrieved 2011-02-11.
46. "EIU.com" (http://www.eiu.com/site_info.asp?info_name=eiu_Visa_accessing_payments_systems_Latin_America). EIU.com. Archived (https://web.archive.org/web/20131111073605/http://www.eiu.com/site_info.asp?info_name=eiu_Visa_accessing_payments_systems_Latin_America) from the original on 11 November 2013. Retrieved 19 February 2014.
47. Fraiser, Naill (5 May 2017). "ATM withdrawals in Macau top HK$10 billion a month, as authorities ensure machines never run dry, source says" (http://www.scmp.com/news/hong-kong/economy/article/2093202/atm-withdrawals-macau-top-hk10-billion-month-authorities). *South China Morning Post*. Archived (https://web.archive.org/web/20170505170051/http://www.scmp.com/news/hong-kong/economy/article/2093202/atm-withdrawals-macau-top-hk10-billion-month-authorities) from the original on 5 May 2017. Retrieved 5 May 2017.
48. "Archived copy" (http://www.bis.org/events/cbcd06e.pdf) (PDF). Archived (https://web.archive.org/web/20060824121535/http://www.bis.org/events/cbcd06e.pdf) (PDF) from the original on 24 August 2006. Retrieved 11 August 2006.
49. "NBP installs 'World's Highest ATM' in Pakistan" (https://en.dailypakistan.com.pk/pakistan/nbp-installs-worlds-highest-atm-in-pakistan/). *Daily Pakistan*. Archived (https://web.archive.org/web/20170427004627/https://en.dailypakistan.com.pk/pakistan/nbp-installs-worlds-highest-atm-in-pakistan/) from the original on 27 April 2017. Retrieved 26 April 2017.

50. "Summary of New 2010 Americans with Disabilities Act (ADA) ATM Standards" (https://www.firstdata.com/downloads/thought-leadership/atm_ada_accessibility.pdf) (PDF). firstdata.com. Archived (https://web.archive.org/web/20140611031808/http://www.firstdata.com/downloads/thought-leadership/atm_ada_accessibility.pdf) (PDF) from the original on 11 June 2014. Retrieved 7 March 2014.
51. "How to Properly Dispose of Decommissioned ATM" (http://www.atmdepot.com/discarding-atms/). ATMDepot.com. Archived (https://web.archive.org/web/20140308045303/http://www.atmdepot.com/discarding-atms/) from the original on 8 March 2014. Retrieved 7 March 2014.
52. "ATM ATM Frequently Asked Questions" (http://www.atmdepot.com/help.aspx#f4). Atmdepot.com. Archived (https://web.archive.org/web/20091019065405/http://www.atmdepot.com/help.aspx#f4) from the original on 19 October 2009. Retrieved 11 February 2011.
53. "Scope for UL 291" (https://web.archive.org/web/20110105114749/http://ulstandardsinfonet.ul.com/scopes/scopes.asp?fn=0291.html). Ulstandardsinfonet.ul.com. 21 December 2004. Archived from the original (http://ulstandardsinfonet.ul.com/scopes/scopes.asp?fn=0291.html) on 5 January 2011. Retrieved 11 February 2011.
54. [2] (http://www.ncr.com/en/products/hardware/hw_atm_p75_ts_product.htm) Archived (https://web.archive.org/web/20061122113838/http://www.ncr.com/en/products/hardware/hw_atm_p75_ts_product.htm) 22 November 2006 at the Wayback Machine.
55. "Home" (http://www.cenorm.be/catweb/13.310.htm).
56. "BSI: Standards, Training, Testing, Assessment & Certification" (https://web.archive.org/web/20071012163647/http://bsonline.bsi-global.com/search/item/1928003). Bsonline.bsi-global.com. Archived from the original (http://www.bsonline.bsi-global.com/search/item/1928003) on 12 October 2007. Retrieved 2011-02-11.
57. "Triton Systems | ATM manufacturer" (http://www.tritonatm.com/en/service/manuals/07100-00008F%20(9100UsrMan(5.0)).pdf) (PDF). Tritonatm.com. 2010-11-17. Retrieved 2011-02-11.
58. "Thieves dig 100ft tunnel to steal cash in Levenshulme" (http://www.bbc.co.uk/news/uk-england-manchester-16556547). BBC. 14 January 2012. Archived (https://web.archive.org/web/20120114052858/http://www.bbc.co.uk/news/uk-england-manchester-16556547) from the original on 14 January 2012. Retrieved 2 January 2012.
59. "The death of Windows XP will impact 95 percent of the world's ATMs" (https://www.theverge.com/2014/1/20/5326772/windows-xp-powers-95-percent-of-atms-worldwide). *The Verge*. Archived (https://web.archive.org/web/20171204090736/https://www.theverge.com/2014/1/20/5326772/windows-xp-powers-95-percent-of-atms-worldwide) from the original on 4 December 2017. Retrieved 23 January 2018.
60. "Risks search results for "cash machine"" (http://catless.ncl.ac.uk/php/risks/search.php?query=cash+machine).
61. "Messaging standard to give multiple channels a common language" (https://web.archive.org/web/20090329032543/http://www.selfserviceworld.com/article.php?id=1252). selfserviceworld.com. Archived from the original (http://www.selfserviceworld.com/article.php?id=1252) on 29 March 2009. Retrieved 2011-02-11.
62. "Technology News: Security: Windows Cash Machine Worm Generates Concern" (http://www.technewsworld.com/story/32350.html). Technewsworld.com. Archived (https://web.archive.org/web/20120318100752/http://www.technewsworld.com/story/32350.html) from the original on 18 March 2012. Retrieved 11 February 2011.
63. "Things to Keep in Mind when Opting for Free ATM Placements" (http://www.obstructedtechnology.org/tech-news/things-to-keep-in-mind-when-opting-for-free-atm-placements.html). Archived (https://web.archive.org/web/20151121090102/http://www.obstructedtechnology.org/tech-news/things-to-keep-in-mind-when-opting-for-free-atm-placements.html) from the original on 21 November 2015. Retrieved 15 September 2015.
64. "ATM bombings up 3000%" (http://www.news24.com/SouthAfrica/News/ATM-bombings-up-3000-20080712). News24. 12 July 2008. Archived (https://web.archive.org/web/20120114174333/http://www.news24.com/SouthAfrica/News/ATM-bombings-up-3000-20080712) from the original on 14 January 2012. Retrieved 7 April 2011.
65. "Dutch blaggers explode ATMs" (https://www.theregister.co.uk/2006/03/14/exploding_atm_attack/). Archived (https://web.archive.org/web/20170810130621/https://www.theregister.co.uk/2006/03/14/exploding_atm_attack/) from the original on 10 August 2017.
66. "Attacks on banks devised in Europe - National" (http://www.smh.com.au/news/national/attacks-on-banks-devised-in-europe/2008/11/25/1227491548435.html/). Sydney Morning Herald. 25 November 2008. Archived (https://web.archive.org/web/20110629151743/http://www.smh.com.au/news/national/attacks-on-banks-devised-in-europe/2008/11/25/1227491548435.html/) from the original on 29 June 2011. Retrieved 11 February 2011.
67. [3] (http://www.atmmarketplace.com/research.htm?article_id=25059&pavilion=126&step=story) Archived (https://web.archive.org/web/20061012175105/http://www.atmmarketplace.com/research.htm?article_id=25059&pavilion=126&step=story) 12 October 2006 at the Wayback Machine.

68. "The No. 1 ATM security concern" (http://www.atmmarketplace.com/article.php?id=7000&na=1). ATM Marketplace. Retrieved 2011-02-11.
69. "Diebold ATM Fraud" (http://buy.cuna.org/download/diebold_fraudpaper.pdf) (PDF). Archived (https://web.archive.org/web/20090930071206/http://buy.cuna.org/download/diebold_fraudpaper.pdf) (PDF) from the original on 30 September 2009. Retrieved 11 February 2011.
70. [4] (http://www.ibia.org/biometrics/industrynews_view.asp?id=30) Archived (https://web.archive.org/web/20150503140906/http://www.ibia.org/biometrics/industrynews_view.asp?id=30) 3 May 2015 at the Wayback Machine.
71. [5] (http://www.ibia.org/biometrics/industrynews_view.asp?id=103) Archived (https://web.archive.org/web/20150501175306/http://www.ibia.org/biometrics/industrynews_view.asp?id=103) 1 May 2015 at the Wayback Machine.
72. "Kilpailu- ja kuluttajavirasto" (http://www.kuluttajavirasto.fi/user_nf/default_mag.asp?id=12263&lmf=11440&mode=readdoc&tmf=11440). *Kilpailu- ja kuluttajavirasto*.
73. "Banking" (http://moneycentral.msn.com/content/Banking/P57803.asp). Moneycentral.msn.com. Archived (https://web.archive.org/web/20080417111312/http://moneycentral.msn.com/content/Banking/P57803.asp) from the original on 17 April 2008. Retrieved 11 February 2011.
74. "NYSBD - Text of the ATM Safety Act" (https://web.archive.org/web/20110410044556/http://www.banking.state.ny.us/legal/atmsafe.htm). Banking.state.ny.us. 1997-06-01. Archived from the original (http://www.banking.state.ny.us/legal/atmsafe.htm) on 10 April 2011. Retrieved 2011-02-11.
75. "DiNapoli Calls for Better Oversight of Bank ATMs" (https://web.archive.org/web/20110610044250/http://www.osc.state.ny.us/press/releases/oct07/100407.htm). Osc.state.ny.us. 2007-10-04. Archived from the original (http://www.osc.state.ny.us/press/releases/oct07/100407.htm) on 10 June 2011. Retrieved 2011-02-11.
76. [6] (http://www.atmmarketplace.com/research.htm?article_id=5171&pavilion=4&step=story) Archived (https://web.archive.org/web/20060509230352/http://www.atmmarketplace.com/research.htm?article_id=5171&pavilion=4&step=story) 9 May 2006 at the Wayback Machine.
77. [7] (http://www.atmmarketplace.com/news_story.htm?i=20479) Archived (https://web.archive.org/web/20060509230332/http://www.atmmarketplace.com/news_story.htm?i=20479) 9 May 2006 at the Wayback Machine.
78. Representative Mario Biaggi, Congressional Record, July 30, 1986, Page 18232 et seq.
79. "ATM Report" (https://web.archive.org/web/20101104220104/http://www.obre.state.il.us/AGENCY/News/atmrpt.htm). Obre.state.il.us. Archived from the original (http://www.obre.state.il.us/AGENCY/News/atmrpt.htm) on 4 November 2010. Retrieved 2011-02-11.
80. Credit Union tech-talk news and technology resource (http://www.cunews.com/newsletters/2004216.htm) Archived (https://web.archive.org/web/20151016073753/https://www.cunews.com/newsletters/2004216.htm) 16 October 2015 at the Wayback Machine.. Cunews.com. Retrieved on 2013-08-02.
81. "sb379_SB_379_PF_2.html" (https://web.archive.org/web/20100831204344/http://www.legis.state.ga.us/legis/2005_06/versions/sb379_SB_379_PF_2.htm). Legis.state.ga.us. Archived from the original (http://www.legis.state.ga.us/legis/2005_06/versions/sb379_SB_379_PF_2.htm) on 31 August 2010. Retrieved 2011-02-11.
82. "Illinois General Assembly - Bill Status for SB1355" (http://www.ilga.gov/legislation/BillStatus.asp?DocNum=1355&GAID=10&DocTypeID=SB&LegId=42570&SessionID=76&GA=96). Ilga.gov. Archived (https://web.archive.org/web/20101111052035/http://www.ilga.gov/legislation/BillStatus.asp?DocNum=1355&GAID=10&DocTypeID=SB&LegId=42570&SessionID=76&GA=96) from the original on 11 November 2010. Retrieved 11 February 2011.
83. Kravetz, Andy (18 February 2009). "ATM software aimed at reversing crime - Peoria, IL" (http://www.pjstar.com/news/x1745367387/ATM-software-aimed-at-reversing-crime). pjstar.com. Archived (https://web.archive.org/web/20110118225019/http://www.pjstar.com/news/x1745367387/ATM-software-aimed-at-reversing-crime) from the original on 18 January 2011. Retrieved 11 February 2011.
84. Could Reverse PIN Save Lives at ATM? (http://www.wctv.tv/home/headlines/Could_Reverse_Pin_Save_Lives_at_ATM_152336195.html) Archived (https://web.archive.org/web/20141013150036/http://www.wctv.tv/home/headlines/Could_Reverse_Pin_Save_Lives_at_ATM_152336195.html) 13 October 2014 at the Wayback Machine.. Wctv.tv. Retrieved on 2013-08-02.
85. "ATM makers warn of 'jackpotting' hacks on U.S. machines" (https://www.reuters.com/article/us-cyber-atms-usa/atm-makers-warn-of-jackpotting-hacks-on-u-s-machines-idUSKBN1FG0WU). *Reuters*. January 27, 2018. Retrieved 2018-01-28.
86. "Rising interest rates, gas prices hit vault-cash providers" (https://web.archive.org/web/20090329032548/http://www.selfserviceworld.com/article.php?id=15827&site=5&prc=). selfserviceworld.com. Archived from the original (http://www.selfserviceworld.com/article.php?id=15827&site=5&prc=) on 29 March 2009. Retrieved 2011-02-11.

87. "NCR and Fujitsu Develop Cash Deposit and Bill Recycling Module for ATMs : Fujitsu Global" (http://www.fujitsu.com/global/news/pr/archives/month/2004/20040318.html). Fujitsu.com. Archived (https://web.archive.org/web/20120403043533/http://www.fujitsu.com/global/news/pr/archives/month/2004/20040318.html) from the original on 3 April 2012. Retrieved 11 February 2011.
88. Lynn, Matthew, "What will replace the dollar as global currency?: Gold? Renminbi? Maybe commodities?" (http://www.marketwatch.com/story/what-will-replace-the-dollar-as-global-currency-2011-07-07?link=home_carousel) Archived (https://web.archive.org/web/20110710020119/http://www.marketwatch.com/story/what-will-replace-the-dollar-as-global-currency-2011-07-07?link=home_carousel) 10 July 2011 at the Wayback Machine., *MarketWatch*, July 7, 2011 12:00 a.m. EDT. Retrieved 2011-07-07.
89. Harvey, Rachel (10 January 2006). "Asia-Pacific | Indonesians make ATM sacrifices" (http://news.bbc.co.uk/1/hi/world/asia-pacific/4597692.stm). BBC News. Archived (https://web.archive.org/web/20090115100724/http://news.bbc.co.uk/1/hi/world/asia-pacific/4597692.stm) from the original on 15 January 2009. Retrieved 11 February 2011.
90. "Wincor Nixdorf Germany" (http://www.wincor-nixdorf.com/internet/se/Products/Software/Banking/MultiChannel/ProSales/index.html) (in German). Wincor-nixdorf.com. Archived (https://web.archive.org/web/20070927225539/http://www.wincor-nixdorf.com/internet/se/Products/Software/Banking/MultiChannel/ProSales/index.html) from the original on 27 September 2007. Retrieved 11 February 2011.
91. "ATM:ad First For Comic Relief" (http://www.creativematch.co.uk/?action=viewnews&ni=90724). creativematch. 10 March 2005. Archived (https://web.archive.org/web/20110929024028/http://www.creativematch.co.uk/?action=viewnews&ni=90724) from the original on 29 September 2011. Retrieved 11 February 2011.
92. Fernandes, Deirdre (5 September 2013). "Boston customers test new video ATMs" (https://www.bostonglobe.com/business/2013/09/05/some-boston-bank-customers-test-new-video-atms/wvmEyd9cVzwvzCa9dZpN0M/story.html). *The Boston Globe*. Archived (https://web.archive.org/web/20131014174136/http://www.bostonglobe.com/business/2013/09/05/some-boston-bank-customers-test-new-video-atms/wvmEyd9cVzwvzCa9dZpN0M/story.html) from the original on 14 October 2013. Retrieved 13 October 2013.
93. "Japan Post to go with fingerprints for ATMs | The Japan Times Online" (http://search.japantimes.co.jp/cgi-bin/nn20060806a5.html). Search.japantimes.co.jp. 6 August 2006. Archived (https://web.archive.org/web/20100815053800/http://search.japantimes.co.jp/cgi-bin/nn20060806a5.html) from the original on 15 August 2010. Retrieved 11 February 2011.
94. " "Place Your Hand on the Scanner" | Science and Technology | Trends in Japan" (http://web-japan.org/trends/science/sci050510.html). Web Japan. 10 May 2005. Archived (https://web.archive.org/web/20110903234941/http://web-japan.org/trends/science/sci050510.html) from the original on 3 September 2011. Retrieved 11 February 2011.
95. Mastrull, Diane (11 November 1996). "Sensar has its eye on the prize with $42 million Japanese deal | Philadelphia Business Journal" (http://www.bizjournals.com/philadelphia/stories/1996/11/11/story4.html). Bizjournals.com. Archived (https://web.archive.org/web/20120417080504/http://www.bizjournals.com/philadelphia/stories/1996/11/11/story4.html) from the original on 17 April 2012. Retrieved 11 February 2011.
96. "BAI Banking Strategies Magazine - Articles Online" (https://web.archive.org/web/20080511163800/http://www.bai.org/nl/v1/N20/articles/V1_N20_01.asp?WT.mc_id=BSRDI_ARTICLEARCHIVE_V1_N20_01). Bai.org. 2011-02-01. Archived from the original (http://www.bai.org/nl/v1/N20/articles/V1_N20_01.asp?WT.mc_id=BSRDI_ARTICLEARCHIVE_V1_N20_01) on 11 May 2008. Retrieved 2011-02-11.
97. "The Check is NOT in the Mail" (https://web.archive.org/web/20101212031915/http://accurapid.com/journal/16brasbank.htm). Accurapid.com. Archived from the original (http://accurapid.com/journal/16brasbank.htm) on 12 December 2010. Retrieved 2011-02-11.
98. "Japanese bank to allow cellphone ATM access" (https://www.engadget.com/2006/01/27/japanese-bank-to-allow-cellphone-atm-access/). Engadget. Archived (https://web.archive.org/web/20110629123757/http://www.engadget.com/2006/01/27/japanese-bank-to-allow-cellphone-atm-access/) from the original on 29 June 2011. Retrieved 11 February 2011.
99. "Industrial Automated Gas Pumping Station and ATM MCF547x ColdFire Solutions By Freescale" (http://www.freescale.com/webapp/sps/site/application.jsp?nodeId=02430ZR8tt8105). Freescale.com. Archived (https://web.archive.org/web/20120316101446/http://www.freescale.com/webapp/sps/site/application.jsp?nodeId=02430ZR8tt8105) from the original on 16 March 2012. Retrieved 11 February 2011.
100. "NRT Technology Corporation - Gaming and casino solutions: QuickJack" (https://web.archive.org/web/20090528091753/http://www.nrtpos.com/html/gamingquickjack.shtml). Nrtpos.com. Archived from the original (http://www.nrtpos.com/html/gamingquickjack.shtml) on 28 May 2009. Retrieved 2011-02-11.

101. "Business | Bank puts the 'fun' into 'funds'" (http://news.bbc.co.uk/1/hi/business/4700053.stm). BBC News. 20 July 2005. Archived (https://web.archive.org/web/20090115110125/http://news.bbc.co.uk/1/hi/business/4700053.stm) from the original on 15 January 2009. Retrieved 11 February 2011.
102. Smith, Benton Alexander (June 16 2016). "Interactive teller machines allow tellers to work remotely" (https://idahobusinessreview.com/2016/06/16/interactive-teller-machines-allow-tellers-to-work-remotely/). *The Idaho Business Review*. Check date values in: |date= (help)
103. "Barking Up the Wrong Tree – Factors Influencing Customer Satisfaction in Retail Banking in the UK - Page 5" (http://www.managementjournals.com/journals/marketing/article27-p5.htm). Managementjournals.com. Archived (https://web.archive.org/web/20110116061441/http://www.managementjournals.com/journals/marketing/article27-p5.htm) from the original on 16 January 2011. Retrieved 11 February 2011.
104. Rebecca Allison (2003-01-16). "ATM gives out free cash and lands family in court | UK news" (https://www.theguardian.com/uk_news/story/0,3604,875749,00.html). London: The Guardian. Retrieved 2011-02-11.
105. [8] (http://www.ncr.com/en/self-service/services_v_1.pdf) Archived (https://web.archive.org/web/20061122012524/http://www.ncr.com/en/self-service/services_v_1.pdf) 22 November 2006 at the Wayback Machine.
106. "Double money in cash point error" (http://news.bbc.co.uk/1/hi/england/tyne/3667279.stm). *BBC News*. 28 April 2004. Archived (https://web.archive.org/web/20090115111715/http://news.bbc.co.uk/1/hi/england/tyne/3667279.stm) from the original on 15 January 2009.
107. "Archived copy" (http://www.rbcroyalbank.com/cards/documentation/ch_agreements/ch_agree_client.html). Archived (https://web.archive.org/web/20060628204818/http://www.rbcroyalbank.com/cards/documentation/ch_agreements/ch_agree_client.html) from the original on 28 June 2006. Retrieved 5 August 2006.
108. "Europe | Mad rush to faulty ATM in France" (http://news.bbc.co.uk/1/hi/world/europe/4552288.stm). BBC News. 23 December 2005. Archived (https://web.archive.org/web/20090115044752/http://news.bbc.co.uk/1/hi/world/europe/4552288.stm) from the original on 15 January 2009. Retrieved 11 February 2011.
109. [9] (http://www.ottawabusinessjournal.com/286598582617402.php) Archived (https://web.archive.org/web/20150910100650/http://www.ottawabusinessjournal.com/286598582617402.php) 10 September 2015 at the Wayback Machine.
110. "Materials- Bank Notes- Bank of Canada" (https://wayback.archive-it.org/all/20080511084240/http://www.bankofcanada.ca/en/banknotes/education/index.htm). Bankofcanada.ca. Archived from the original (http://www.bankofcanada.ca/en/banknotes/education/index.htm) on 11 May 2008. Retrieved 11 February 2011.
111. "Falschgeld: Blüten aus dem Geldautomat? - Wirtschaft" (http://www.stern.de/wirtschaft/geldanlage/:Falschgeld-Bl%FCten-Geldautomat/523625.html). Stern.De. 2004-05-05. Retrieved 2011-02-11.
112. "Wincor Nixdorf Germany" (http://www.wincor-nixdorf.com/internet/com/Products/CashSystems/CashRecycling/ProCash3100/index.html) (in German). Wincor-nixdorf.com. Archived (https://web.archive.org/web/20070927225656/http://www.wincor-nixdorf.com/internet/com/Products/CashSystems/CashRecycling/ProCash3100/index.html) from the original on 27 September 2007. Retrieved 11 February 2011.
113. Patton, Phil. "1.05: The Bucklands Boys and Other Tales of the ATM" (https://www.wired.com/wired/archive/1.05/atm_pr.html). Wired.com. Archived (https://web.archive.org/web/20101029073146/http://www.wired.com/wired/archive/1.05/atm_pr.html) from the original on 29 October 2010. Retrieved 11 February 2011.
114. "Video" (http://www.cnn.com/video/player/player.html?url=/video/tech/2006/09/14/owens.va.atm.scam.wavy). Cnn.com. 6 June 2005. Archived (https://web.archive.org/web/20121109222545/http://www.cnn.com/video/player/player.html?url=%2Fvideo%2Ftech%2F2006%2F09%2F14%2Fowens.va.atm.scam.wavy) from the original on 9 November 2012. Retrieved 11 February 2011.
115. "Kennison v Daire [1986] HCA 4; (1986) 160 CLR 129 (20 February 1986)" (http://www.austlii.edu.au/au/cases/cth/HCA/1986/4.html). Austlii.edu.au. 1986-02-20. Retrieved 2011-02-11.
116. "ATM Security Issues & ATM Fraud Issues by Geography | ATMSecurity.com ATM Security news ATM Security issues ATM fraud info ATM" (http://www.atmsecurity.com/articles/atm-fraud/atm-security-issues-atm-fraud-issues-by-geography.html). Atmsecurity.com. 4 March 2009. Archived (https://web.archive.org/web/20101024215333/http://www.atmsecurity.com/articles/atm-fraud/atm-security-issues-atm-fraud-issues-by-geography.html) from the original on 24 October 2010. Retrieved 11 February 2011.
117. "Archived copy" (https://web.archive.org/web/20080724213440/http://venus.soci.niu.edu/~cudigest/phracks/phrack-08). Archived from the original (http://venus.soci.niu.edu/~cudigest/phracks/phrack-08) on 24 July 2008. Retrieved 2008-03-13.
118. snopes (29 March 2016). "Skimming with ATM Cameras : snopes.com" (http://www.snopes.com/crime/warnings/atmcamera.asp). *snopes*.

119. "What the Hell Do Smart Cards Do?" (http://www.fastcompany.com/magazine/56/wth.html). Fast Company. 28 February 2002. Archived (https://web.archive.org/web/20100701223645/http://www.fastcompany.com/magazine/56/wth.html) from the original on 1 July 2010. Retrieved 11 February 2011.
120. "Tamil Nadu / Chennai News : Four more held in fake credit card racket case" (http://www.hindu.com/2006/05/19/stories/2006051920380300.htm). Chennai, India: The Hindu. 19 May 2006. Archived (https://web.archive.org/web/20110810232850/http://www.hindu.com/2006/05/19/stories/2006051920380300.htm) from the original on 10 August 2011. Retrieved 11 February 2011.
121. Fredric L. Rice, Organised Crime Civilian Response. "Phrack Classic Volume Three, Issue 32, File #1 of XX Phrack Classic Newsletter Issue XXXII" (http://www.skepticfiles.org/hacker/phrack32.htm). Skepticfiles.org. Archived (https://web.archive.org/web/20101121231232/http://www.skepticfiles.org/hacker/phrack32.htm) from the original on 21 November 2010. Retrieved 11 February 2011.
122. Stephen Castell. "Seeking after the truth in computer evidence: any proof of ATM fraud? — ITNOW" (http://itnow.oxfordjournals.org/cgi/content/abstract/38/6/17). Itnow.oxfordjournals.org. Archived (https://web.archive.org/web/20071012184756/http://itnow.oxfordjournals.org/cgi/content/abstract/38/6/17) from the original on 12 October 2007. Retrieved 11 February 2011.
123. pepsi says: (25 January 2011). "Why is there braille on drive-up ATMs?" (http://zidbits.com/2011/01/25/why-is-there-braille-on-drive-up-atm-machines/). Zidbits. Archived (https://web.archive.org/web/20110129211251/http://zidbits.com/2011/01/25/why-is-there-braille-on-drive-up-atm-machines/) from the original on 29 January 2011. Retrieved 11 February 2011.
124. "Postal Service Mailing Kiosks Now In Every State" (https://web.archive.org/web/20110103030043/http://www.usps.com/communications/news/press/2004/pr04_098.htm). Usps.com. 2004-12-30. Archived from the original (http://www.usps.com/communications/news/press/2004/pr04_098.htm) on 3 January 2011. Retrieved 2011-02-11.
125. Automated Postal Centers (http://www.lunewsviews.com/apc.htm) Archived (https://web.archive.org/web/20160413211117/http://www.lunewsviews.com/apc.htm) 13 April 2016 at the Wayback Machine.. Lunewsviews.com. Retrieved on 2013-08-02.
126. "About Script ATMs: How Do Cashless ATMs Work? - What is Scrip, or Cashless ATMs?" (http://www.atmscrip.com/what_is_scrip.html). Atmscrip.com. Archived (https://web.archive.org/web/20110324150807/http://www.atmscrip.com/what_is_scrip.html) from the original on 24 March 2011. Retrieved 11 February 2011.
127. "Megabank WebATM" (https://netbank.megabank.com.tw/natm/). Archived (https://web.archive.org/web/20150319155928/https://netbank.megabank.com.tw/natm/) from the original on 19 March 2015.
128. "Post Office Bank WebATM" (https://webatm.post.gov.tw/postatm/index1.jsp). Archived (https://web.archive.org/web/20150409144215/https://webatm.post.gov.tw/postatm/index1.jsp) from the original on 9 April 2015.

Further reading

- Brain, Marshall *Marshall Brain's More How Stuff Works*, John Wiley and Sons Ltd, New York, October 2002, ISBN 0-7645-6711-X
- Donley, Richard *Everything has its price*, Fireside Books /Simon & Schuster, New Jersey, March 1995, ISBN 0-671-89559-1
- Guile, Bruce R., Quinn, James Brian *Managing Innovation Cases from the Services Industries*, National Academy Press, Washington (D.C.), January 1988, ISBN 0-309-03926-6
- Hillier, David *Money Transmission and the Payments Market*, Financial World Publishing, Kent UK, January 2002, ISBN 0-85297-643-7
- IESNA Committee *Lighting for Automatic Teller Machines*, Illuminating Engineering Society of North America, January 1997, ISBN 0-87995-122-2
- Ikenson, Ben *Patents: Ingenious Inventions How They Work and How They Came to Be*, Gina Black Dog & Leventhal Publishers, Inc., April 2004, ISBN 1-57912-367-8
- Mcall, Susan *Resolution of Banking Disputes*, Sweet & Maxwell, Ltd., December 1990, ISBN 0-85121-644-7
- Peterson, Kirk *Automated Teller Machine as a National Bank under the Federal Law*, William S. Hein & Co., Inc., August 1987, ISBN 0-89941-587-3
- Schneier, Bruce (January 2004). *Secrets and Lies: Digital Security in a Networked World*. John Wiley & Sons. ISBN 0-471-45380-3.
- Zotti, Ed *Triumph of the Straight Dope*, Random House, February 1999, ISBN 0-345-42008-X
- *The Fraudsters - How Con Artists Steal Your Money* (ISBN 978-1-903582-82-4) by Eamon Dillon, published September 2008 by Merlin Publishing

External links

- *The Money Machines* An account of US cash machine history; By Ellen Florian, Fortune.com
- Automated teller machine at Curlie (based on DMOZ)
- World Map and Chart of Automated Teller Machines per 100,000 Adults by Lebanese-economy-forum, World Bank data

Retrieved from "https://en.wikipedia.org/w/index.php?title=Automated_teller_machine&oldid=831421378"

New Jersey Institute of Technology

The Design of a Digital Satellite Set-Top Box

Table of Contents

General Description

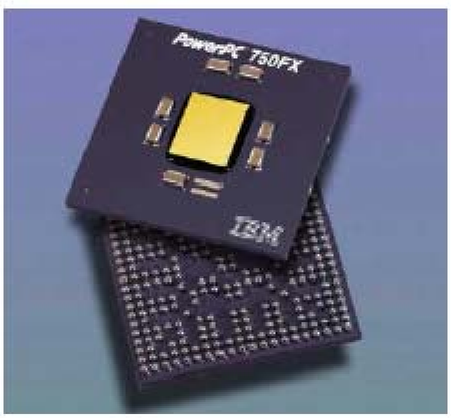
At the early stages of this project, I asked myself what are Digital Set-top boxes, STB herein? Never mind ever thinking of the design of one. Reading Gerald O'Driscoll's "The Essential Guide to Digital Set-top Boxes and Interactive TV" provided me with a robust fundamental understanding of STBs in terms of their functionality. In his book, a STB is defined as "a consumer electronics device used to decode and tune digital signals and convert them to a format that is understood by your television." Their primary features may be classified as follows: (1) decodes the incoming digital signal; (2) verifies access rights and security levels; (3) displays cinema-quality pictures on your TV set; (4) outputs digital surround sound; and (5) processes and renders Internet and interactive TV services. In a Satellite set-top box, the tuner receives the satellite's transmission and extracts a particular channel. A demodulator then receives the signal and converts it into binary format. It may also perform an error check at this stage as well. Once cleared, the binary signal is sent to a demultiplexer where audio, video, and data are isolated from the signal, and subsequently sent to the appropriate decoder. The demultiplexer may also determine access rights to the various services. The decoders' functions are to transform their respective incoming binary stream into the proper viewable television format.

The building blocks of a digital broadcasting system essentially consists of receiving digital signals, compression and encoding, modulation, conditional access system, network transmission technologies and network management. On the receiving end the main components of the STB are:

- system bus,
- tuner(s),

- modulators and demodulators,
- demultiplexer and decryptor,
- decoders,
- graphics processor,
- CPU and memory
- storage devices,
- physical interfaces, and
- physical characteristics. **[1]**

All of the primary components of the design will be connected on a system board. The bus that will be used is the Intel based PCI. The system bus will have the same width as the processor -- 32 bits. The bus speed will be able to support 133 MHz, since the design does not include Intel's NetBurst micro-architecture, which could have meant greater speeds.



An IBM copper-based 750FX Power PC processor will lay at the heart of the design. In terms of functionality and processing, the CPU is the most important element of a digital set-top box. The general functions that the processor will provide are:

- initializes the various set-top hardware components;
- processes a range of Internet and interactive TV applications;
- monitors and manages hardware interrupts;
- fetches data and instructions from memory; and
- runs various programs.

The tuner in this design will be able to access QAM-, OFDM-, and QPSK-based networks. In addition to receiving inputs from digital networks, the tuner will be able to of tuning analog broadcasts as well. Tuners may be summed up by the three categories below:

- **Broadcast In-band (IB) Tuner.** Once the signal arrives from the physical transmission media, the IB tuner will isolate a physical channel from a multiplex of channels and convert to baseband. The term baseband is used to describe a single channel or digital signal, extracted from a broadband signal which is basically a stream of multiple channels.

- **Out of Band (OOB) Tuner.** This type of tuner facilitates the transfer of data between the head-end systems and the set-top box. They are widely used in cable set top boxes for providing subscribers with a medley of interactive services.

- **Return Path Tuner.** This tuner allows a subscriber to activate the return path and send data back to the interactive services provider.

The demodulator will receive the baseband output signal from the tuner and sample and convert it to a digital binary signal. This binary signal has audio, video, and data components. After the streams are checked for errors they are forwarded to the demultiplexer. A modulator reverses the action of a demodulator, but is used to send signals out from the set-top box.

MPEG-2 data packets will consist of a Packet ID (PID) that would identify a packet as containing audio, video, or interactive service formats. Each format is sent to a specific decoder that would have the capability to decode that specific format. A video decoder will translate the video packets into a sequence of pictures to be displayed on the television set. The compressed audio bit-stream will be decoded by the audio decoder. Once the MPEG-2 stream is translated it will be presented to a set of speakers. Finally, a data decoder will decode the data.

The second processor used in the design will be dedicated to graphics. The graphics processor will render a range of Internet file formats and interactive TV file formats. Once it is rendered, the graphics file will overlay the standard video display on TV.

Memory, obviously, is needed in the design. Most of the elements within the STB will need memory to be able to perform their tasks. The graphics engine, video decoder, and the descrambler will all require a certain amount of memory to fulfill their specific functions. SRAM will be used to support time critical tasks such as MPEG processing and DRAM for interactive applications.

Hard disks will also be included in the design for user memory space, since the ability to locally store and retrieve information is one of the most important concerns for a customer with digital TV service. The disk interface technology that will be incorporated into this design is Small Computer Systems Interface (SCSI); also know as "skuzzy". Though they are more expensive, in general, skuzzy hard drives would offer subscribers with faster access and data retrieval times than the competition brand of hard drives – Integrated Drive Electronics (IDE).

As far as physical interfaces for the STB, there is a wide range of available choices. They are classified in the following categories:

- modems,
- high-speed multimedia interfaces,
- RS232,
- common interface,
- TV and VCR interfaces,
- smart card readers,
- remote controls,
- IR blasters, and
- wireless keyboards.

A modem will be incorporated into the design to facilitate the implementation of two-way interactive services. Once connected and activated, the modem is able to utilize the return path for various uses, such as:

- sending requests to Web servers on the Internet,
- enabling set-top users to upload files and send e-mail; and
- facilitating two-way interactive TV services, such as video on demand.

This STB will incorporate a high speed multimedia interface. It will be able to communicate in real time with devices, such as camcorders, DVDs, CD players, and musical keyboards. An IEEE 1284 Parallel Port will be included for high-speed bidirectional interface to a printer. Apple Computers' IEEE 1394 or FireWire Bus Interface Standard will also be included in the design. This networking standard will connect high bandwidth consumer electronic devices such as an STB. It will offer plug-and play technology which would allow consumer connected devices to be automatically configured.

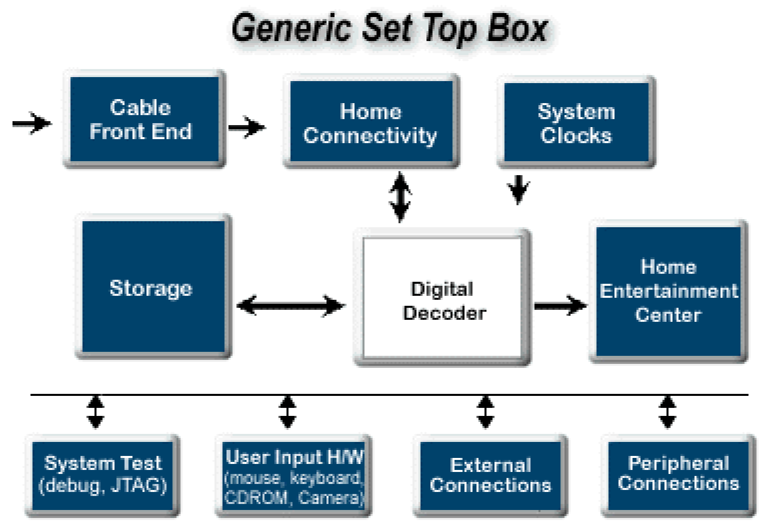
An RS-232 interface port will be equipped in the design of the STP for serial communications. It will use a D connector with 9 pins and allows connectivity to serial printers, computers, and standard telephone modems.

PCMCIA (Personal Computer Memory Card International Association) card will be used, and is best described as a credit card sized peripheral which has various uses:

- extending the set-top memory capabilities;
- storing and decrypting CAs for multiple service providers;
- adding hard disk space to the set-top box; and
- adding new tuners to the set top box.

These cards are sometimes referred to as point of deployment (POD) modules. It will be made into a separate unit from the STB itself. This will theoretically make the STP interchangeable, which means that it could be sole in the retail channel. **[6]**

TVs and VCRs will be able to communicate with the STB through two outputs Scart connectors, which will use female-type connectors with 21 pins.



A Smart Card Reader will be deployed for authorization to various digital television services and for e-commerce applications. Remote controls and wireless keyboards will be included in the STB package for the subscriber's convenience and comfort. A generic layout of an entire Set-top Box system is furnished above as an overview (Source: Texas Instruments).

Component List & Cost

The table below furnishes all of the components used for the design discussed in the instant report. It also includes the manufacturer, model number, cost, and a technical resource for the product. Each color represents a specific portion of the STB.

	Manufacturer	Model No.	Cost	Technical Resource
Microprocessor	IBM	Power	$95	microprocessor
MPEG-2 MP@ML Decoder	Altera	CS6651	$7.60	mpeg-2 decoder
Smart Card Reader	Utimaco	Cardman 8630	$5.00	smart card reader
MPEG-2 Demux	Phillips Semiconductor	--	$1.73	mpeg-2 demux
Memory	Micron Technologies	MT48LC128M4A2	$9.00	sdram
A/D Demod	Pentek	Model 6210	$1	a/d demod
Audio Power Amplifier	Texas Instruments	TPA1517	$0.75	amplifier
PCMCIA	Hirose Electronic Co. Ltd.		$2.10	pcmcia
Power Distribution Switch	National Semiconductor	LM3525	$5.30	power switch
IEEE 1394 (Link Layer)	Texas Instruments		$4.99	1394 Link
IEEE 1394 (Physical Layer)	Texas Instruments		$4.99	1394 physical
Audio DACs	Burr-Brown	PCM1733	$9.00	audio dac
Phase-Locked Loop	Motorola	MC44BC374T	$0.70	pll
Graphics Contoller	Intel	82810	$180	graphics controller
HDD	Comp USA		$80	
NTSC/PAL Decoder	Texas Instruments	TVP5145PFP	$10	ntsc/pal decoder
Video ADC	Texas Instruments	TVP5145	$10	video adc
NTSC/PAL Encoder	Texas Instruments	TYP6000C	$23	
Audio Preamplifier	Texas Instruments	TL071	$2	audio preamp
Power Management	Texas Instruments	TPPM0302	$12	power management
RS-232 Drivers/Receivers	Texas Instruments	MAX232	$6	IEEE rs232

Table 1: *Components & cost used in the design of Digital Set-Top Box*

Detailed Description

The entire block diagram is furnished here for an overall view of the set-top box design discussed in this paper. This will proceed with a meticulous description of each component within the system.

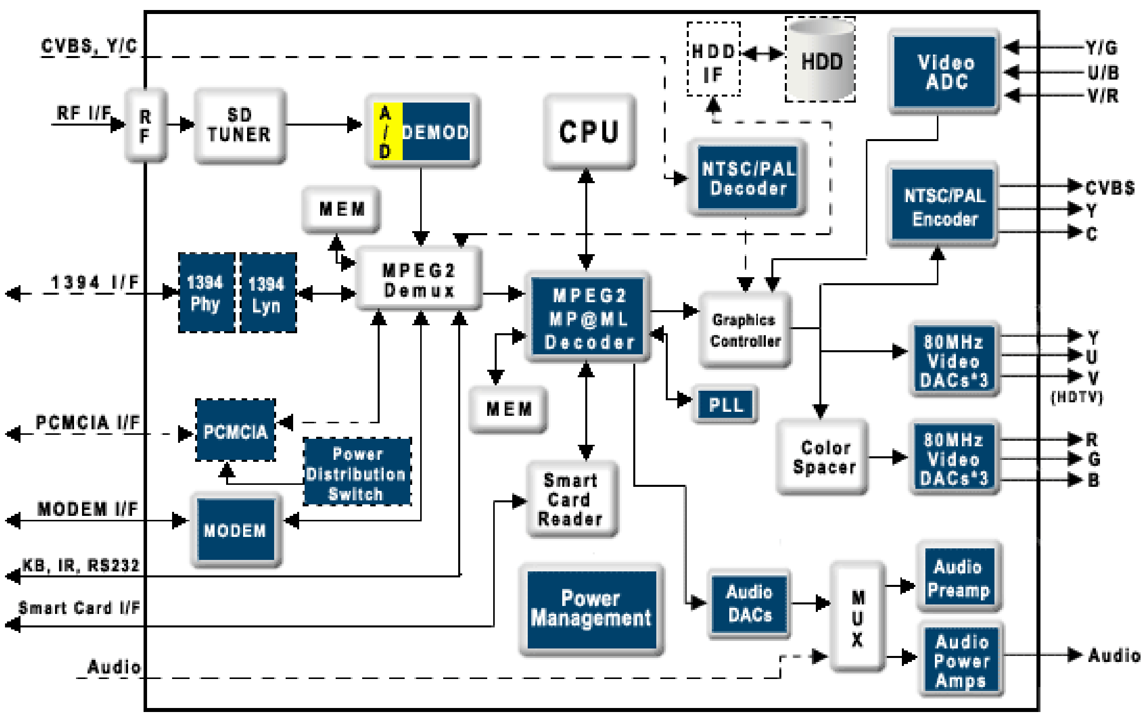


Figure : *Block Diagram of Satellite Set-top Box (Source: Texas Instruments)*

Microprocessor: IBM PowerPC 750 FX

The PowerPC 750FX RISC Microprocessor is capable of delivering the resources for a high performance application such as a set-top-box, while keeping power consumption at a minimum. IBM has also included on-board Error Correction Circuitry (ECC). This processor's resume is very impressive:

- Branch Processing Unit
  - Four instructions fetched per clock
  - One branch processed per cycle

  - Up to one speculative stream in execution, one additional speculative stream in fetch
  - 512-entry branch history table (BHT) for dynamic prediction
  - 64-entry, 4-way set associative branch target instruction cache (BTIC) for eliminating branch delay slots

- Decode
  - Register file access
  - Forward control
  - Partial instruction decode

- Load/store unit
  - One cycle load or store cache access
  - Effective address generation
  - Hits under miss (one outstanding miss)
  - Single-cycle misaligned access within double-word boundary
  - Hits under miss (one outstanding miss)
  - Single-cycle misaligned access within double-word boundary
  - Alignment, zero padding, sign extend for integer register file
  - Floating-point internal format conversion (alignment, normalization)
  - Sequencing for load/store multiples and string operations
  - Store gathering
  - Cache and TLB instructions
  - Big and little-endian byte addressing supported
  - Misaligned little-endian support in hardware

- Dispatch unit
  - Full hardware detection of dependencies (resolved in the execution units)
  - Full hardware detection of – Dispatch two instructions to six independent units (system, branch, load/store, fixed-point unit 1, fixed-point unit 2 or floating-point)
  - 4-stage pipeline: fetch, dispatch, execute, and complete
  - Serialization control (predispatch, postdispatch, execution, serialization)

- Fixed-point units
  - Fixed-point unit 1 (FXU1): multiply, divide, shift, rotate, arithmetic, logical
  - Fixed-point unit 2 (FXU2): shift, rotate, arithmetic, logical
  - Single-cycle arithmetic, shift, rotate, logical
  - Multiply and divide support (multi-cycle)
  - Early out multiply
  - Thirty-two 32-bit general purpose registers

- Floating-point unit
  - Support for IEEE-754 standard single and double-precision floating-point arithmetic
  - Optimized for single-precision multiply/add
  - Thirty-two, 64-bit floating point registers
  - Enhanced reciprocal estimates
  - 3-cycle latency, 1-cycle throughput, single-precision multiply-add
  - 3-cycle latency, 1-cycle throughput, double-precision add
  - 4-cycle latency, 2-cycle throughput, double-precision multiply-add
  - Hardware support for divide
  - Hardware support for denormalized numbers
  - Time deterministic non-IEEE mode

- System unit
  - Executes CR logical instructions and miscellaneous system instructions
  - Special register transfer instructions

- L1 Cache structure
  - 32K, 32-byte line, 8-way set associative instruction cache
  - 32K, 32-byte line, 8-way set associative data cache
  - Single-cycle cache access
  - Pseudo-LRU replacement
  - Copy-back or write-through data cache (on a page per page basis)
  - Parity on L1 tags and arrays
  - 3-state (MEI) memory coherency
  - Hardware support for data coherency
  - Non-blocking instruction cache (one outstanding miss)
  - Non-blocking data cache (two outstanding misses)
  - No snooping of instruction cache

- Memory management unit
  - 64 entry, 2-way set associative instruction TLB (total 128)
  - 64 entry, 2-way set associative data TLB (total 128)
  - Hardware reload for TLBs
  - 8 instruction BATs and 8 data BATs

  - Virtual memory support for up to 4 terabytes (252) virtual memory
  - Real memory support for up to 4 gigabytes (232) of physical memory
  - Support for big/little-endian addressing

- Dual PLLs
  - Allows seamless frequency switching

- Level 2 (L2) cache
  - Internal L2 cache controller and 4K-entry tags: 512KB data SRAMs
  - Two-way set-associative, supports locking by way
  - Copy-back or write-through data cache on a page basis, or for all L2
  - 64-byte sectored line size
  - L2 frequency at core speed
  - ECC protection on SRAM array
  - Parity on L2 tags
  - Supports up to 2 outstanding misses (1 data and 1 instruction)
  - Supports up to 2 outstanding misses (2 data)

- Power
  - Low power consumption with low voltage application at lower frequency
  - Dynamic power management
  - 3 static power save modes (doze, nap, and sleep)
  - Thermal Assist Unit (TAU)

- Bus interface
  - 32-bit address bus
  - 64-bit data bus (also supports 32-bit mode)
  - Enhanced 60x bus: pipelines consecutive reads to a depth of 2
  - Core-to-bus frequency multipliers of 3.5x, 4x, 4.5x, 5x, 5.5x, 6x, 6.5x, 7x, 7.5x, 8x, 8.5x, 9x, 9.5x, 10x, 11x, 12x, 13x, 14x, 15x, 16x, 17x, 18x, 19x, and 20x supported
  - Supports 1.8V, 2.5V, or 3.3V I/O modes

- Reliability and serviceability
  - Parity checking on 60x busses
  - ECC checking on L2 cache

- Parity on the L1 arrays
- Parity on the L1 and L2 tags

- Testability
  - LSSD scan design
  - Powerful diagnostic and test interface through Common On-Chip Processor (COP) and IEEE 1149.1 (JTAG) interface

The 750 FX's block diagram is illustrated here for a simplified overall visual of this processor.

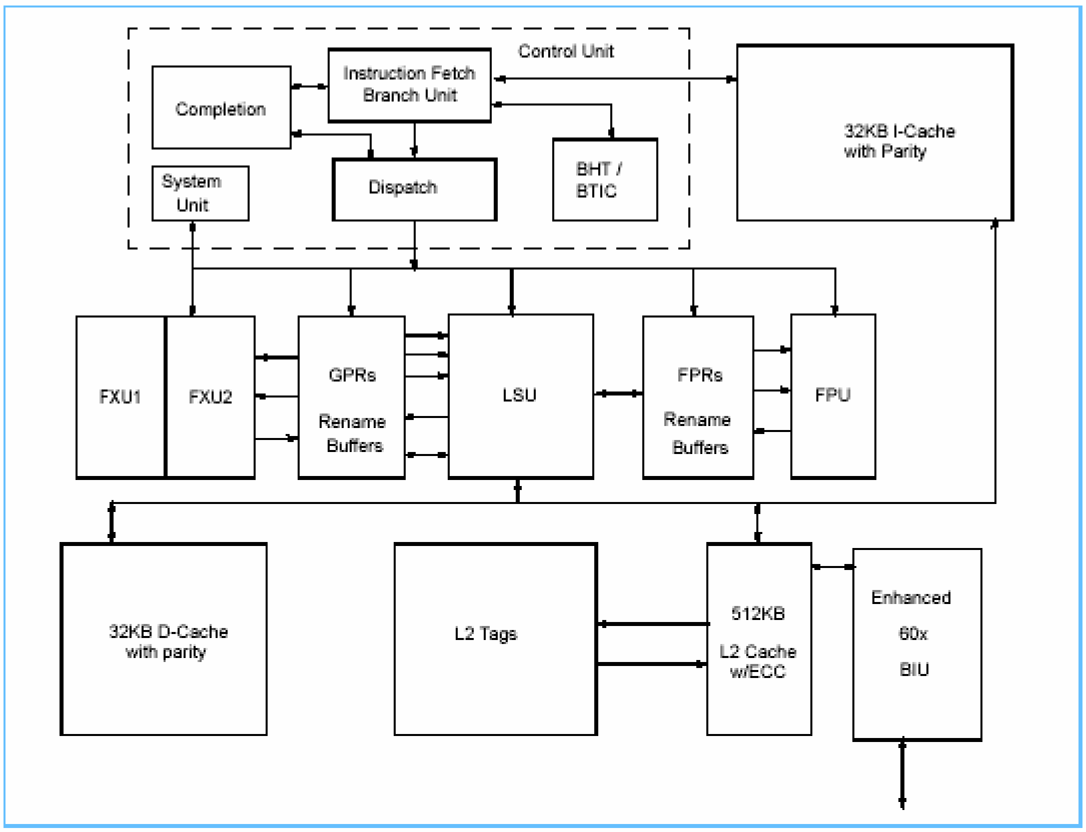


Figure: *Block Diagram of the PowerPC 750 FX*

Graphics Processor: NVIDIA GeForce4 MX

The NVIDIA GeForce4 MX is an outstanding graphics processor with 32MB of DDR memory. It delivers 1.1 billion textured pixels per second. Its performance was pioneered on high-end scientific and engineering workstations. Gaming, which has become the greatest interest in today's households, is of the utmost quality with hardware transform and lighting (T&L), per-pixel shading and drop-dead gorgeous effects at high resolutions, the NVIDIA GeForce4 MX takes over the transform and lighting calculation functions from the CPU, enabling more robust collision detection, better path algorithms and more realistic physics. **[11]**

MPEG-2 Decoder: Altera CS6651

The MPEG2 (Motion Pictures Expert Group) methodology provides compression of TV quality digital video. Because it provides such good compression, it has become the standard for digital TV via satellite. **[3]** The MPEG-2 used in the instant design has the following features:

- Supports progressive scan and interlaced streams
- ISO/IEC 13818-2 (H.262)-compliant
- Main profile at main level (MP@ML)-compliant
- Decodes ISO/IEC11172-2 (MPEG1)
  - Constrained parameter bit streams
- High-performance solution for MPEG2 decoding
  - Supports input bit rates up to 30 Mbits/sec
  - Real time decode and display of MP@ML using a single 27-MHz clock
- Supports PAL and NTSC standard definition television (SDTV) resolutions and frame rates
- Bit stream error detection and recovery
- Glueless interface to external SDRAM
- Capable of standalone stream decoding or host central processing unit (CPU) - controlled operation.
- Fully synchronous design with host shutdown and restart control

This Altera MPEG-2 decoder is definitely a good fit for this high performance application. The block diagram is furnished below:

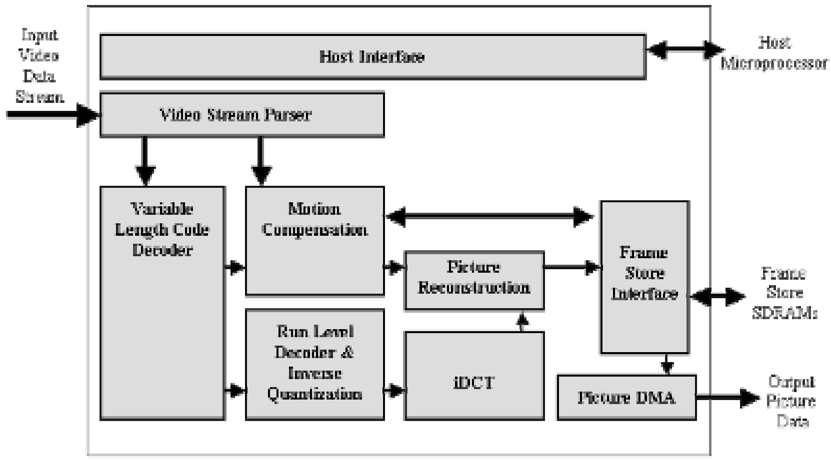


Figure: MPEG-2 decoder Block Diagram (Source: Altera)

The CS6651 MPEG-2 decoder is capable of decoding video streams at the MP@ML standard. Pictures are decoded from the video stream and output in the correct display order when the decoder is in default mode. Audio/video synchronization, pan-and-scan and letterbox conversion and various other modes is done by a host CPU. A highly configurable pixel stream direct memory access (DMA) engine provides the output from the core. This engine allows adjustable output video component sequencing and provides external logic with control over the display of the picture. To meet the bandwidth requirements of MP@ML decoding, a dedicated SDRAM chip is used. This is a commodity 64-Mbit SDRAM in 2Mx32 configuration.

MPEG2 DeMux: Phillips Semiconductors

An MPEG2 DeMux accepts the digital stream output from the A/D converter, and extracts the system clock reference from the pack header. Using a function that measures progress, the system reference clock is reported. All of the above information is stored in a table that is updated as new stream IDs are found. A progress report is sent to notify the application, which in turn either pre-determines what elementary streams needs to be sent to the audio and video decoders, or selects the stream on the fly using the progress report's information.

Power Distribution Switch: National Semiconductor LM3525

National's LM3525 provides Universal Serial Bus standard power switch and over-current protection for all host port applications. A 1 ms delay on fault flag output prevents erroneous overcurrent. This is due to the inrush currents during the hot-plug events. Its features are:

- 1 ms Fault Flag Delay During Hot-Plug Events
- Smooth Turn-On Eliminates Inrush Induced Voltage Drop
- UL Recognized Component: REF # 205202
- 1A Nominal Short Circuit Output Current Protects Notebook PC Power Supplies
- Thermal Shutdown Protects Device in Direct Short Condition
- 500mA Minimum Continuous Load Current
- Small SO-8 Package Minimizes Board Space
- 2.7V to 5.5V Input Voltage Range
- Switch Resistance <= 120 mΩ Max. at V_{IN} = 5V
- 1µA Max Standby Current
- 100 µA Max Operating Current
- Undervoltage Lockout (UVLO)

IEEE 1394 Link Layer Controller: Texas Instruments TSB12LV26

This device is compliant with the PCI Local Bus Specification, PCI Bus Power Management Interface Specification, IEEE Std 1394-1995, and 1394 Open Host Controller Interface Specification. This chip provides the IEEE 1394 link function and is compatible with high serial bus data rates.

IEEE 1394 Physical Layer Controller: Texas Instruments TSB12LV26

This will provide the digital and analog transceiver functions needed to implement a one-port node in a cable-based IEEE 1394 network. The cable port incorporates one differential line transceiver. As discussed in class, this will eliminate noise transmission. The transceiver includes circuitry to monitor the line conditions as needed for determining connection status, for initialization and arbitration, and for packet reception and transmission. The TSB41AB1 is designed to interface with the TSB12LV26 link layer controller.

Tuner Infineon TAIFUN TUA6034

This tuner is the industry's first single chip triple-band tuner integrated circuit (IC) for all global broadcast standards. Infineon's integrated device will reduce the number of ICs that would be used and simplifies the design of the RF (radio frequency) front-end. **[9]**

Audio DACs: Phillips Semiconductor UDA1350AH [10]

The primary features of the Phillips Audio DAC are:

- 2.7 to 3.6 V power supply
- Integrated digital filter and Digital-to-Analog Converter (DAC)
- Master-mode data output interface for off-chip sound processing
- $256f_s$ system clock output
- 20-bit data-path in interpolator
- High performance
- No analog post filtering required for DAC
- Pre-emphasis information of IEC 958 input bit stream available in L3 interface register and on pins

Phase-Locked Loop: Motorola MC44BC374T

In Motorola's PLL version, block diagram provided below, the channel is set by an I2C compatible bus receiver. The PLL tunes the modulator over the full UHF range. The three main sections illustrated in the block diagram below are:

(1) A high speed I2C compatible bus section.

(2) A PLL section to synthesize the UHF/VHF output channel frequency from an integrated UHF oscillator, divided for VHF output.

(3) A modulator section, which accepts audio and video inputs, then uses them to modulate the UHF/VHF carrier.

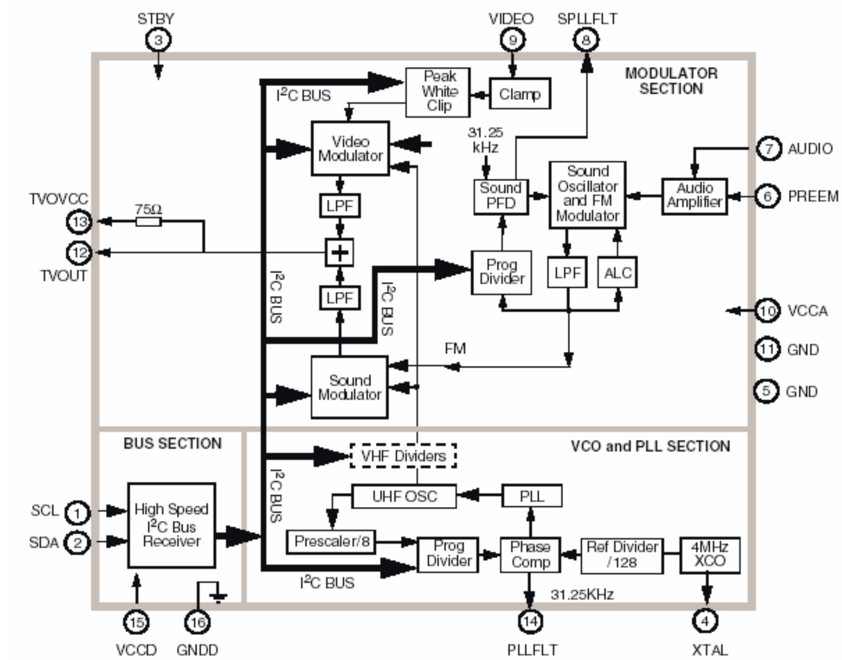
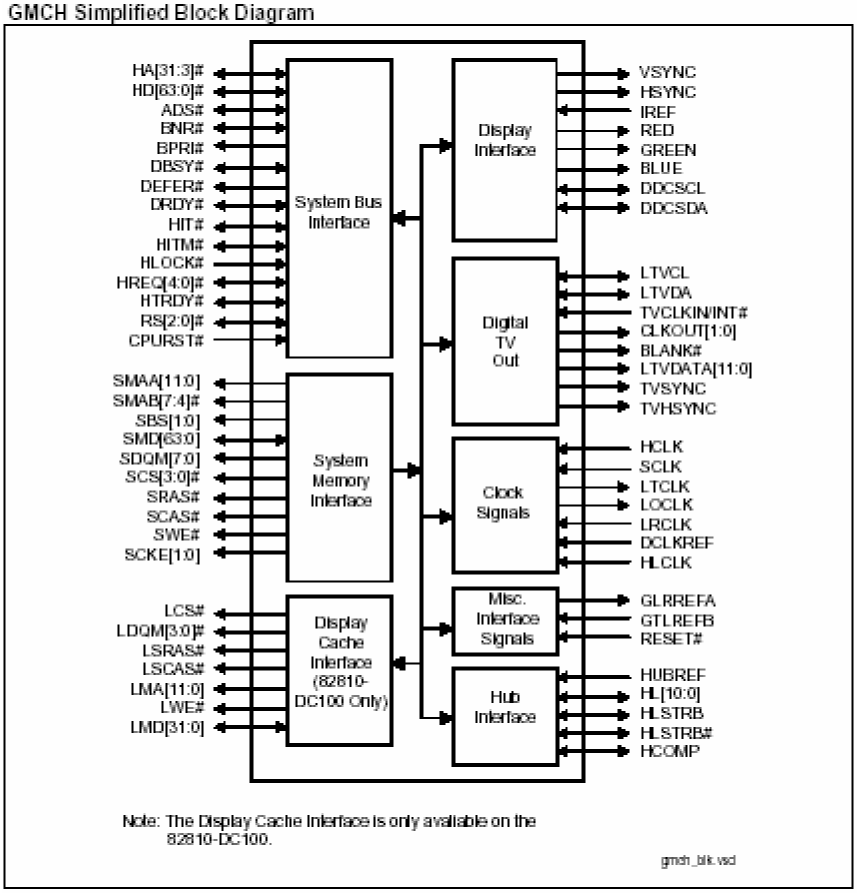


Figure: Phase-Locked Loop Block Diagram (Source: Motorola)

Graphic Controller: Intel 82810

This specific graphics controller by Intel is primary product features include Processor/Host bus support, integrated DRAM controller, integrated graphics controller, 3D graphic visual enhancements, 3D graphic texture enhancements, digital video output, display, 2D graphics, Arithmetic Stretch Blitter Video, integrated graphics memory controller, display cache interface, arbitration scheme and concurrency, data buffering, power management functions, supporting I/O bridge and packaging/power. It will act as the interface in between the MPEG-2 decoder, NTSC/PAL decoder, Video ADC, NTSC/PAL Encoder, Video DACs and Color Spacer. Its block diagram is provided:

GMCH Simplified Block Diagram



NTSC/PAL Decoder: Texas Instruments TVP5145PFP

This is a single-chip digital video decoder that converts baseband analog NTSC, PAL, and SECAM video into digital component video. It supports analog component, composite, and S-video inputs are supported. “Line-locked sampling is square-pixel or ITU-R BT.601 (27 MHz). The output formats can be 20-/16-bit or 10-/8-bit 4:2:2, or 10-/8-bit ITU-R BT.656 with embedded synchronization. The TVP5145 device utilizes Texas Instruments’ patented technology for locking to weak, noisy, or unstable signals, and a chroma frequency control output is generated for synchronizing downstream video encoders.

NTSC/PAL Encoder: Texas Instruments TYP6000C

Reverses the actions of the NTSC/PAL Decoder.

Power Management: Texas Instruments TPPM0302

The power manager is a low-dropout regulator with auxiliary power management that provides a constant 3.3-V supply at the output with the capability of driving a 400-mA load. It will provide a regulated power output for the STB, since it has multi input sources and would require a constant voltages source with a low-dropout voltage.

SDRAM: Micron Technologies MT48LC128M4A2

SDRAM is needed to support the MPEG2 Decoder and Demux. Four Micron Technologies 512 MB SDRAM (32 Meg X 4 banks) would suffice to store all of the tables for the Demux and also meet all other storing requirements. This RAM is fully synchronous (positive edge triggered). It has internal pipelined operation. In other words, the column address can be changed every clock cycle. This particular RAM has internal banks for hiding row access/precharge. Auto Precharge including concurrent auto precharge, self refresh and auto refresh modes are also included, which is vital for DRAM performance.

Operating System/System Platform

In order to be consistent with IBM efforts of supporting Linux, a Linux based operating system to be used as the brain of this IBM-based set top box is chosen. Otherwise, Power TV's latest operating systems for STBs would have been the best choice. Monta Vista's Linux Professional Edition embedded operating system and development platform is chosen for this STB design.

Enabling Linux

Linux is becoming the favorite among consumer products. "Linux held 27% share of server operating-system software sold in 2000, increasing from 24% in 1999 and 17% in 1998." Source: International Data Corp. Since reducing costs is the primary goal of manufacturers, they consider Linux as an alternate to currently available proprietary operating systems. As Linux become more and more popular, an increased number of applications will be developed.

Linux Advantages

Between 1999 and 2005, Linux's Compound Annual Growth Rate will be in the order of 50%. It is very easy to integrate, reliable, and stable making it extremely attractive to developers. Its kernel requires minute memory space and best of all it is an open-source code, which issues designer with flexibility to designers since products can be created on various platforms. This means that many developers will continually improve the operating system code.

The open source drivers may be leveraged and thus issuing additional cost savings. Prior to Linux, non-recoverable expenses, per copy charges for a proprietary operating system, and associated device drivers were being paid. With Linux, set-top box manufacturers can use Linux as a leverage for open source drivers at no cost. From the internet and the numerous applications point of view, Linux will also provide Internet plug-ins and applications such as web browsers and media players. In addition, there are not any licenses' issues with Linux; it may be openly shared within a company.

Development Tools and Support

At one time there was a lack of Linux support on an enterprise level; companies exist now that will provide support and help developers in there every day issues.

Conclusion

In summary, Linux provides 100% open source technology, no run-time royalties, unrestricted and free access to source code, completely open source OS and open APIs, and no dependence on single sources for proprietary technology. While other operating systems will continue to be available, designers now have an additional choice as they develop their future products. A summary of Linux's features is given below. **[2]**

Highlights

- Linux 2.4 Kernel
- Linux, Solarix and VMWare hosts
- CPU support for x86/IA-32, Power PC, StrongARM, XScale, MIPS, SH, ARM, and Xtensa*
- Supports 80 + Reference and COTS Boards
- Development and configuration tools
- MontaVista Preemptible Kernel
- MontaVista Real-Time Scheduler
- Rich Networking
- Develop Integrated Development environment
- Legacy VxWorks and pSOS emulation/porting tools

Cross Development Hosts

- Red Hat 7.2, 7.3
- Yellow Dog (Mac or other PPC)
- Solarix 7.0, 8.0 (SPARC)
- SuSE 7.3
- Mandrake 8.1
- Windows NT/2000 with VMWare 3.0

Middleware and APIs

Middleware will be used in this design. It is used to isolate set-top application programs from the details of the hardware and the network. This would allow application's to operate transparently across the network without concern of anything else. Thus, the complexity of development is reduced because applications can be written to take advantage of a common API.

Presentation and application virtual machines will be put in place to avoid the recreation of content specifically for proprietary platforms. The virtual machine will act as a self-contained environment that behaves as if it is a separate STB. Thus, enabling it to serve as the run-time environment for interactive STB applications. This will allow programmers to develop STB applications independent of the actual hardware architecture used.

Future Enhancements

The present urge to converge computers, communications and entertainment is motivating cable, telecommunications, hardware and software companies to flock to set-top box deployment, which is considered the "new future gateway to the home." This raises several questions; the ease of competing services; standards for interoperability; the freedom to purchase devices.

On-line services, banking, home security, telephony, interactive video are what is integrated into STBs. An STB's purpose is moving towards a one-stop solution for all household needs. Distributing media like cable, telephone lines and satellite dishes to be integrated and creating connectivity at the same time is the future. “The set-top box will support the ’intelligent agents’ that guides users through the maze of choices. The set-top industry may itself develop into a mediating force as technology and rules governing interconnection develop. This race to define the personality and functionality of future STBs has begun. **[4]**

Time to Market

Time to market is a critical topic when it comes to STBs. Companies with the most effective Rapid Development Lifecycles methodology will win the market. This comes with one constraint of course -- Cost! This is a cost sensitive area. You can pump the largest number of STBs out, but with what price? There has to be some balance between time to market and expense. It will not be effective if a company’s set-top box is in stores the quickest, but cost much more than its competitor’s. On the other hand, it does not make sense to have the least development cost but with the longest time to market. There must be some balance.

References

[1] http://www.itvdictionary.com/set-top_box.html
[2] http://www-3.ibm.com/chips/techlib.html
[3] http://www.erg.abdn.ac.uk/public_html/research/future-net/digital-video/mpeg2.html
[4] http://www.citi.columbia.edu
[5] O’Driscol, Gerald, “The Essential Guide to Digital Set-top Boxes and Interactive TV”
[6] http://www.scmmicro.com
[7] http://www.powertv.com/ProductsandServices/Overview320.pdf
[8] http://www.national.com/pf/LM/LM3525.html#General%20Description
[9] http://www.dtvprofessional.com/2001/08_aug/news/cw_infineon_ic.htm
[10] http://www.semiconductors.philips.com/acrobat/datasheets/UDA1350AH_2.pdf

CHAPTER – VIII

CABLE TELEVISION AND DIRECT-TO-HOME TELEVISION SERVICES – A COMPARATIVE ANALYSIS

CHAPTER VIII

CABLE TELEVISION AND DIRECT – TO – HOME TELEVISION SERVICES – A COMPARITIVE ANALYSIS

8.1 INTRODUCTION

The growth potential of the broadcasting sector is fuelled by convergence of technologies. Since 1990s, there has been a transformation in the role of the Government from being the major service providers in this sector to that of a facilitator. However, there is a need to maintain the momentum of growth and promote development and employment generation within the sector. There is also a need to ensure free flow of information, safeguard freedom of speech and expression as well as enhance the reach of broadcasting to the inaccessible areas within the country.

In the wake of the opening up of the earth and skies to private operators, India is all set to see a "War of the accesses". With very few large players, a wide spread Geography and an unorganized cable operator set-up, the options between DTH and cable as access modes are both set to woo the ever increasingly discerning Indian consumer.[1]

Today, India is the third largest Television market after China and USA.[2] The television subscriber base has grown at over 34 per cent per year for the last 20 years and the service providers have also increased to commensurate this growth.[3] At present subscribers in India can view television content through three main modes, given below:

- Cable Television - Presently both analog/ non-digital and digital
- Direct- To-Home Television (DTH) - Digital
- Internet Protocol Television (IPTV) – Digital

[1] The war of accesses, Retrieved from http://www.indiantelevision.com/special/sperep/htm
[2] TRAI Annual Report 2011-12 Available at http://www.trai.gov.in/content/Annual report
[3] Ibid.,

8.2 CABLE TELEVISION

Cable TV, sometimes called *CATV,* is a system of delivering the TV signal to home receivers by way of a coaxial cable rather than over the air by radio wave propagation. A cable TV company collects all the available signals and programs and frequency-multiplexes them on a single coaxial cable that is fed to the homes of subscribers. A special cable decoder box is used to receive the cable signals, select the desired channel, and feed a signal to the TV set. Today, most TV reception is by way of a cable connection instead of an antenna.[4]

Cable Television was born in the late 1940s in Pennsylvania, US. It was then known as Community Antenna Television (CATV).[5] An antenna was erected on a pole on a mountain top and television broadcasting was commenced from three Philadelphia stations though with weak signals. The mountain antenna was connected to an appliance store via a cable and modified signal boosters, which was connected with the mountain antennae to both the store and the subscribers' homes. Cable TV is a popular and widely used service in the United States. More than 80 percent of U.S. homes have cable TV service.

8.2.1 Modern Cable TV Systems

Today, cable TV companies, generally referred to as multiple (cable) systems operators (MSOs), collect signals and programs from many sources, multiplex them, and distribute them to subscribers. The main building or facility is called the headend. The antennas receive local TV stations and other nearby stations plus the special cable channel signals distributed by satellite. The cable companies use parabolic dishes to pick-up the so-called premium cable channels. A cable TV company uses many TV antennas and receivers to

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[4] http://www.Televisionhighered.mcgrawhill.com/sites/dl/free/…/chapter23_Television.pdf

[5] Sanjit Kumar Roy, Indian Cable TV Industry Changing Dynamics, "Indian Entertainment Industry", ICFAI University Press 2007.

pick up the stations whose programming it will redistribute. These signals are then processed and combined or frequency-multiplexed onto a single cable.

The main output cable is called the trunk cable. In older systems it was a large, low loss coaxial cable. Newer systems use a fiber-optic cable. The trunk cable is usually buried and extended to surrounding areas. A junction box containing amplifiers takes the signal and redistributes it to smaller cables, called feeders, which go to specific areas and neighborhoods. From there the signals are again rejuvenated with amplifiers and sent to individual homes by coaxial cables called drops. The overall system is referred to as a hybrid fiber cable (HFC) system.

8.2.2 Growth of Cable Television in India

In India, television transmission started in 1959. A low power transmitter and twenty-one television sets were used for television broadcasting. The transmission was simple and terrestrial. Production, distribution and transmission of programs were controlled by Doordarshan. During this period there was only one channel and it was free. People required rooftop antennae to receive the signals directly from Doordarshan. The programs were mainly educational, social, political and non-commercial and were transmitted for a few hours only, in a few big cities. It also accepted advertisements for some programs.

Indian television viewers were looking for more varied entertainment other than what DD was providing at that point of time. Cable television came into existence in India in 1983 when Doordarshan started its services on cable networks in rural areas of Rajasthan. In 1989 few entrepreneurs setup small Cable TV Networks and started local video channels showing movies and music videos catering to a small neighborhood. Satellite television was introduced in India during 1991 with the live coverage of the Gulf War by

CNN and spread through the launch of channels from Zee and STAR groups.[6] It was then that cable services were offered to people at a price. The programs consisted of Hindi and English movies and some comedy serials as well as music and game shows.

8.2.3 Entry of Multi-System-Operators (MSO) in the Market

Initially, the broadcasters started by telecasting programs on channels which were free. During this period, a few of the broadcasters opted for pay channels, whereas, few of the channels remained Free-To-Air. They encrypted the content and provided the decoders to the cable operators at a price. The subscription-based model proved to be very effective and attractive, and more than half the "free to air" channels switched to the "pay" option. With the entry of foreign players in the market, MSOs came into the picture and they started giving signals to the viewers through the cable operators at a free. Now the television signal is passing through a chain consisting of the broadcasters, the MSOs and the cable operators to the final viewers. India today has a large broadcasting and distribution sector, comprising of 800 plus satellite TV channels, 6000 multi system operators (MSO), 26 pay broadcasters, 60000 local cable operators (LCO).[7]

8.2.4 Broadcaster

Broadcaster means a person or a group of persons, or body corporate, or any organization or body providing programming services and includes his or its authorized distribution agencies.

8.2.5 Multi-System-Operators (MSO)

Multi-System Operator means a cable operator who has been granted registration under rule 11 C and who receives a programming service from a broadcaster or its authorized agencies and re-transmits the same or transmits

[6] Restructuring of Cable TV services, TRAI, July 15, 2007.

[7] Monopoly/Market dominance in Cable TV services, Retrieved from, www.trai.gov.in, June 2013

his own programming service for simultaneous reception either by multiple subscribers directly or through one or more local cable operators and includes his authorized distribution agencies by whatever name called.[8]

Some of the prominent national MSOs are Siti cable, Digicable, Hathway, Datacom, IndusInd Media and Communication Limited and DEN Networks Limited. Some of the prominent MSOs that are operating in regional markets are ACT, Fastway, GTPL, KAL Cables (Sumangali), Ortel, Asianet, Tamil Nadu Arasu Cable TV (TACTV) Corporation Limited, Manthan, JAK communications and Darsh Digital. However, the majority of the remaining are small, local (city based) MSOs with a subscriber base of a few thousand.[9]

8.2.6 Cable Operators

Cable operator means any person who provides cable service through a cable television network or otherwise controls or is responsible for the management and operation of a cable television network and fulfills the prescribed eligibility criteria and conditions.

8.2.7 Analog Cable Television and Digital Cable Television

The existing cable TV system is predominately analog in nature. In case of analog cable TV system, the TV channels are sent in analog and unencrypted form. The analog cable TV system can carry up to 80-100 TV channels. In this system the consumers do not have an option to choose channels/services of their choice and pay accordingly; rather they have to pay for the entire bouquet of channels offered by the cable operator.

On the other hand, the capacity of a DAS is much higher than the existing analog cable TV system. A consumer under DAS will be able to choose channels/services of his choice and pay accordingly. A Set-Top-Box

[8]DAS License forms and procedures, Retrieved from, www.scatmag.com, January 2013.

[9] Multi System Operators in India: an industry perspective, http://www.dikshatech.com

(STB) is required along with the TV set for receiving the channels in DAS (Digital Addressable System).

DAS is a fully digital addressable system whereas CAS is not. In CAS (Conditional Access System) notified area, the free-to-air (FTA) channels are carried over the network in analog form while the pay channels are carried in encrypted and digitally modulated form for which a STB is required. While in DAS all the channels (pay as well as FTA) carried over the network are encrypted and digitally modulated and a STB is required for receiving both FTA and pay channels.

8.3 CABLE TELEVISION AND DTH SERVICES

Though DTH has emerged as an alternate to Cable TV and its subscriber base is growing at a faster rate compared to cable TV, the percentage of cable TV homes is significantly larger vis-à-vis DTH subscribers. Cable TV subscribers constitute approximately 60% of the total TV homes in the country, whereas the share of DTH is about 35%. DTH operates on a national basis and transmits all channels throughout the country irrespective of variations in demand of channels in different markets. Cable TV networks on the other hand operate on a regional basis and can choose channels to be supplied according to the demand in the area served. In the pay DTH sector, there are six major players providing services on a national basis. In contrast, Cable TV operators are limited in a particular area and in most cases the subscriber is served by a single local cable operator. On the technical front also, there are differences between DTH and cable TV in terms of the number of channels the platform can support, acquisition cost for the consumer, type of services supported *etc.*

TABLE 8.1

MARKET SHARE OF CABLE TELEVISION AND DIRECT-TO-HOME TELEVISION SERVICES IN INDIA

Cable Television		Direct-To-Home Television	
Multi-system-operators	**Market Share (%)**	**Service Providers**	**Market Share (%)**
Den Networks	**24**	Dish TV	**28**
Hathway	**19**	Tata Sky	**19**
Digicable	**17**	Airtel Digital TV	**19**
Siti Cable	**14**	Sun Direct	**13**
You Telecom	**3**	Videocon d2h	**13**
Other regional players	**9**	Reliance Big TV	**8**

Source: Credit Suisse report titled, Media Sector, dated April 16, 2013

From the above table it is clear that in all over India, the MSO Den Networks have highest market share of 24%. Whereas in DTH services, Dish TV has the highest market share of 28%.

TABLE 8.2

MAREKET SHARE OF CABLE TELEVISION AND DIRECT-TO-HOME TELEVISION IN VIRUDHUNAGAR DISTRICT

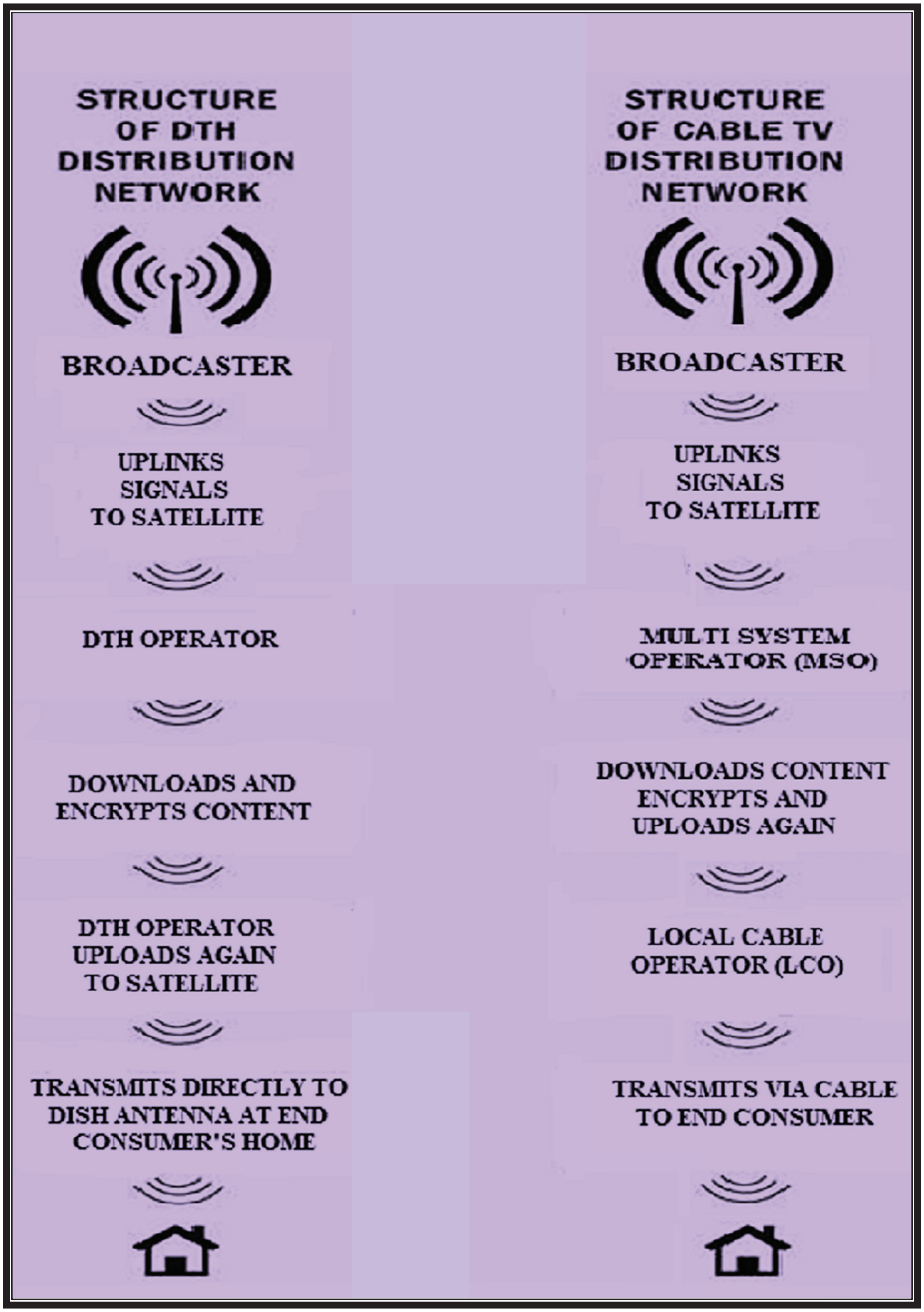
Competing Platform	Mark Share (%)
Cable Television	75.91
Direct-To-Home Television	24.09

Source: Unpublished document of TACTV

Table 8.2 discloses that the market share of cable Television (75.91%) is high compared to the market share of Direct- To- Home Television (24.09%) in Virudhunagar district.

FIGURE 8.1

STRUCTURE OF BOTH CABLE TV AND DTH SERVICES DISTRIBUTION NETWORK



Source: Outlook Business, June 22, 2013, p.74.

8.3.1 Digital Cable Television versus DTH services.

- Digital cable can receive up to 1000 channels compared to 400 channels on DTH services.
- Digital cable is more reliable as it does not face rain fade, cloud fade, snow fade, tree fade or wind fade, where those constraints are in DTH.
- Cable TV offers local channels which DTH cannot offer as yet.
- Cheap, free after sales service, unlike DTH, where most technical issues require a service engineer who comes at a price.

8.4 CABLE TELEVISION IN TAMILNADU

The Government of Tamil Nadu has incorporated Tamil Nadu Arasu Cable TV (TACTV) Corporation Ltd. on 02.09.2011 for distribution of cable TV in Tamil Nadu. It has taken over 27 Headends from the private MSOs. TACTV Corporation is providing cable TV services with most pay channels at a cost of Rs.70/- per month to the public through local cable operators. Prior to this, another MSO, M/s KAL (Sumangali) Cable, which is a subsidiary of the SUN group, had dominance in the cable TV services in Tamil Nadu. However, KAL Cable continues to be dominant in Chennai city, where TACTV has not been registered as an MSO under DAS. Interestingly, channels of the SUN group, an integrated player providing both broadcasting and distribution services, were not available on the TACTV network for quite some time. In this context, it merits mention that, in its recommendations on “Issues related to entry of certain entities into Broadcasting and Distribution activities” dated 28th December 2012, TRAI, inter alia, had recommended that the Central Government, State Governments and their entities should not be permitted to enter into the business of broadcasting and distribution of TV channels.

At present Tamil Nadu have approximately 14% of the total cable TV homes in the country.[10] This translates to approximately 1.3 crore cable TV homes in Tamil Nadu considering about 9.4 Crore cable TV homes in the country. According to the Information Technology Department of Tamil Nadu, the subscriber base of TACTV Corporation Limited was around 0.5 Crore on 30.04.2012 and is expected to increase to 1 Crore.[11]

8.5 CABLE TELEVISION IN VIRUDHUNAGAR DISTRICT

Tamil Nadu Arasu Cable TV (TACTV) Corporation Ltd. is providing cable TV services with most pay channels to the public of Virudhunagar district through 697 local cable operators. For the distribution of service, the control room is located at Sivakasi. TACTV Corporation also manages the localized content over the Virudhunagar district. The subscriber base of the Virudhunagar district is 1, 67,000 subscribers. Cable Television plays a dominant role in the Virudhunagar district compared to the DTH services. The market share of cable television is about 75.91% and the penetration of the DTH services in the market is 24.09%. Digital cable will be a game changer in the market in the near futures where the proportion of market share will change with the mandatory DAS.

8.6 ANALYTICAL FRAMEWORK

8.6.1 Garrett's Ranking Technique

In this study an attempt has been made to know the reasons for which the respondents have shifted to DTH services from cable television, the respondents are given the reasons and asked to rank them according to their

[10] Policy Note 2012-2013 released by Department of Information Technology, Government of Tamil Nadu.

[11]http://mib.nic.in/ShowContent.aspx?uid1=124&uid3=0&uid4=0&uid5=0&uid6=0&uid7=0 Retrieved on May 5, 2014.

choice. The order of merit given by the respondents (sample subscribers) was converted into ranks by using the formula.

$$\text{Percent position} = \frac{100\left(R_{ij} - 0.5\right)}{N_j}$$

R_{ij} = Rank given for ith factor by j^{th} individual

n_j = Number of constraints ranked by j^{th} individual

The present position of each rank thus obtained is converted into scores using the table given by Garrett ranking technique. The scores of individuals representing each reason are added together and divided by the total number of subscribers for whom the scores are added. The mean scores for all the reasons are analyzed in the ascending order, the ranks assigned and the important factors are identified.

8.6.2Wilcoxon signed ranks test

The Wilcoxon signed-ranks test is used to analyze the opinion of the subscribers before and after experiencing DTH services. The test begins with calculating the signed difference for each matched pair of observations. If the two observations in a pair are the same, it is dropped from the analysis. Next, the differences are rank-ordered according to their absolute size. If there are two pairs with identical absolute difference values, an average score is given to each of the pairs. Finally, the positive or negative sign is assigned to each rank score, and the scores for the positive and negative groups are separately totaled. The symbol T_p refers to the summed ranks for the positive differences, and the symbol T_n refers to the summed ranks for the negative differences. T represents the smaller T_p or T_n, and for small samples T is the test statistic. The null hypothesis is rejected if the calculated value of T is equal to or less than the critical T-value. Here, N represents the number of pairs. The hypothesis framed for the application of Wilcoxon signed-ranks test is as follows:

H_0 - There is no significant difference among the subscriber’s opinion after and before experiencing the DTH services.

8.7 REASONS FOR SHIFTING TO DTH SERVICES

The most popular and dominant platform is cable network in Virudhunagar district with the support of state government and antiquated analog transmission facilities. At this juncture, DTH services have entered the market and started challenging the entrenched cable TV services. Respondents may have shifted to DTH services because of various reasons such as picture clarity, flexible price, special offers, wireless service, poor service of cable operator *etc.* The respondents gave ranks to the reasons listed for changing to DTH services and the results are presented in Table 8.3.

TABLE 8.3

RANKS GIVEN TO THE REASONS FOR SHIFTING TO DTH SERVICES

Reasons for changing to DTH services	Ranking by the respondents							Total
	I	II	III	IV	V	VI	VII	
Picture clarity	251	134	35	32	50	8	20	**530**
Flexible price	41	51	136	93	79	66	64	**530**
Special offers	29	101	53	118	107	59	63	**530**
Wireless services	56	49	60	77	107	113	68	**530**
Poor service of the cable operator	106	112	63	48	59	74	68	**530**
Value-added-service	23	37	102	52	50	142	124	**530**
Channel packages	24	46	81	110	78	68	123	**530**
Total	**530**	**530**	**530**	**530**	**530**	**530**	**530**	

Source: Primary Data

For analyzing the various reasons for shifting to DTH services Garrett's ranking is used.

TABLE 8.4

GARRETT'S RANKING ANALYSIS

Reasons for changing to DTH services	Total Score	Average Score	Rank
Picture clarity	34675	65.42	**I**
Flexible price	25821	48.72	**III**
Special offers	25577	48.26	**IV**
Wireless service	24587	46.39	**V**
Poor service of the cable operator	27961	52.76	**II**
Value-added-service	22145	41.78	**VII**
Channel packages	23150	43.68	**VI**

Source: Primary Data

From the above analysis it is proved that, the primary purpose for changing to DTH service is 'picture clarity'. It ranks First with an average score 65.42 and the next purpose is 'poor service of the cable operator' which holds second rank with an average score 52.76. The third rank with an average score 48.72 is given to the 'flexible price'. The fourth place with an average score 48.26 is for 'special offers' and wireless service receives the fifth rank with an average score 46.39. The sixth and seventh rank is secured by channel packages and value-added-service with an average score 43.68 and 41.78 respectively.

8.8 COST OF SERVICE

The researcher has collected information to study whether DTH service is costlier than cable television. The data collected from the respondents have been showed in the Table 8.5.

TABLE 8.5

COST OF SERVICE – DTH vs. Cable Television

DTH not Costlier	No. of Respondents	Percentage
Yes	206	38.90
No	324	61.10
Total	**530**	**100**

Source: Primary Data

The above table shows that 324 (61.10%) respondents feel that, the DTH services are not a costlier service whereas 206 (38.90%) respondents have expressed that DTH services are costlier than cable television.

8.9 AVAILABILITY OF BOTH CABLE CONNECTION AND DTH SERVICES

Table 8.6 reveals the data regarding the availability of both cable connection and DTH services in the respondent's home.

TABLE 8.6

AVAILABILITY OF BOTH CABLE CONNECTION AND DTH SERVICES

Both Cable and DTH services	No. of Respondents	Percentage
Yes	216	40.80
No	314	59.20
Total	**530**	**100**

Source: Primary Data

The above table reveals that 216 (40.80%) have both cable connection and DTH services in their home and 314 (59.20%) respondents have only DTH services in their home.

8.9.1 REASONS TO HOLD BOTH THE DTH SEVICES AND CABLE CONNECTION

Table 8.7 shows the various reasons that have been pointed out by the respondents to hold both the DTH services and cable connection.

TABLE 8.7

REASONS TO HOLD BOTH THE DTH SERVICES AND CABLE CONNECTION

Reasons to hold both DTH services and cable connection	No. of Respondents	Percentage
Local channels	120	55.60
Optimality of cost	41	19.00
Afford to make late payment	29	13.40
To avoid momentary signal disruption	26	12.00
Total	**216**	**100**

Source: Primary Data

Out of 530 respondents, 120 (55.60%) holds both the services because they are interested to watch local channels in order update the local information and to know about the local events. Optimality of cost is the reason felt by the 41 (19%) respondents. In order to avoid the disconnection of DTH services because of late payment 29 (13.4%) respondents hold both the services. To avoid momentary signal disruption caused by the rain fade and other technical problems 26 (12%) respondents prefer to hold both the DTH services and cable connection in their home.

8.10 PROMISING ELEMENTS OF CABLE TELEVISION AND DTH SERVICES

Both the cable television and DTH services hold promising elements to attract the subscribers. Garrett's ranking technique is used to analyze the elements of both the cable television and DTH services and which are more promising from the subscribers' point of view. Table 8.6 shows the results of Garrett's ranking technique.

TABLE 8.8

PROMISING ELEMENTS OF CABLE TELEVISION AND DTH SERVICES

Elements	Cable Television			DTH services		
	Total Score	Mean score	Rank	Total Score	Mean score	Rank
Quality of service	22423	42.31	X	28455	53.69	IV
Effective complaint handling	24221	45.70	VIII	20506	38.69	XII
Worthiness of subscription	23283	43.93	IX	32428	61.18	I
After sales service	32015	60.41	I	26795	50.56	VII
Number of channels	25496	48.11	VI	29924	56.46	III
Choice of options	20568	38.81	XII	26657	50.29	VIII
Wireless connection	20606	38.88	XI	27204	51.33	VI
No interruption of services during rainy season	29840	56.30	III	22772	42.97	XI
Localized content	31555	59.54	II	25568	48.24	IX
Remainder about renewal of subscription	29407	55.48	IV	27308	51.52	V
Better service	26644	50.27	V	32268	60.88	II
Timely service	25283	47.70	VII	25285	47.71	X

Source: Primary Data

It is clear from the above table that the prime promising element of cable television and DTH services are After sales services and Worthiness of subscription with the mean score of 60.41 and 61.18 respectively. In case of cable television, Localized content remains as second promising element with an average score of 59.54. Better service is the second promising element of DTH services with the mean score of 60.88. No interruptions of services during rainy season have secured III and XI rank in case of cable television and DTH services respectively. When compared to DTH services, Cable television promising service in giving remainder about renewal of subscription. Number of channel is considered as third element in DTH services whereas it is considered as sixth element of cable television. Quality of DTH services secure fourth rank where it is considered tenth element in cable television. Cable television services handle the complaints effectively when it is compared to DTH services. Choice of options holds promise in DTH services. Timely services have secured seventh rank and tenth rank in case of cable television and DTH services with the mean score of 40.70 and 40.71 respectively.

8.11 RATING GIVEN BY THE SUBSCRIBERS REGARDING CABLE TELEVISION

This study attempts to compare the utilities and features of DTH services and the cable television. Therefore, the following 15 statements were framed. Table 8.7 shows the rating of the subscribers regarding cable television.

TABLE 8.9

RATING GIVEN BY THE SUBSCRIBERS REGARDING CABLE TELEVISION

OPINION	Rating					Mean Score	Standard Deviation
	5	4	3	2	1		
Long standing TV transmission service	102	268	136	15	9	3.83	0.82880
Application of latest technology	9	24	181	200	116	2.26	0.90891
Most popular transmission service	149	231	102	40	8	3.89	0.94945
Possibility of service from Himalayas to house boat in Kerala	16	44	160	211	99	2.37	0.97780
Suitable for dwellers in rented house	152	180	149	47	2	3.82	0.96169
Preferable service for employees in transferable post	26	55	137	231	81	2.46	1.02858
Suitable for the dwellers in multistoried building	43	61	156	192	78	2.62	1.11763
Not free from Wireless service	41	62	172	163	92	2.62	1.13315
Provider of multiple favorite channels	21	88	165	182	74	2.62	1.04214
Provider of pure digital viewing experience	15	39	184	178	114	2.36	0.99023
Provider of exclusive movie channels	5	55	136	202	132	2.24	0.97376
Fantastic and superb audio with stereo sound	141	125	111	124	29	3.42	1.25522
Highly advance payment option such as recharge card, online payment	22	37	182	200	89	2.44	0.98626
Complication handling with wire connections	151	163	81	110	25	3.58	1.23089
Clarity in vision with high quality picture	10	16	203	209	92	2.33	0.86141

Source: Primary Data

The highest rating given by the subscribers about cable television service is ‘Most popular transmission service’ with the mean score of 3.89, followed by ‘Long standing transmission service’ with an average score of 3.83. The lowest rating by the subscribers about cable television is ‘Provider of exclusive movie channels’ with the mean score of 2.24, followed by ‘Application of latest technology’ with an average score of 2.24. The highest variation in rating is exhibited by ‘Fantastic and superb audio with stereo sound’ with a standard deviation of 1.25522 and the lowest variation in rating is exhibited by ‘Long standing transmission service’ with a standard deviation of 0.82880. The study highlights that though the cable TV services are long lasted, the implication were arrived because of technology application and expectation of subscribers about the special features of the service providers.

8.12 RATING GIVEN BY THE SUBSCRIBERS REGARDING DTH SERVICES

DTH services being a pure technological alternative to cable television, it is necessary to compare its utilities and features with those of cable television. Table 8.10 shows the rating of the subscribers regarding DTH services.

TABLE 8.10

RATING GIVEN BY THE SUBSCRIBERS REGARDING DTH SERVICES

OPINION	Rating					Mean Score	Standard Deviation
	5	4	3	2	1		
Long standing TV transmission service	24	109	180	91	126	2.65	1.17851
Application of latest technology	173	232	109	9	7	4.40	0.84735
Most popular transmission service	41	95	152	179	63	2.75	1.11620
Possibility of service from Himalayas to house boat in Kerala	167	197	119	30	17	3.88	1.02106
Suitable for dwellers in rented house	152	180	149	47	2	3.82	0.96169
Preferable service for employees in transferable post	143	161	152	48	26	3.65	1.11512
Suitable for the dwellers in multistoried building	165	210	111	39	5	3.92	0.94672
Not free from Wireless service	74	257	138	39	22	3.61	0.95689
Provider of multiple favorite channels	110	200	100	65	55	3.67	0.93979
Provider of pure digital viewing experience	185	189	84	46	26	3.87	1.13212
Provider of exclusive movie channels	124	245	116	39	6	3.83	0.90722
Fantastic and superb audio with stereo sound	188	206	84	34	18	3.97	1.03747
Highly advance payment option such as recharge card, online payment	224	189	64	36	17	4.07	1.04927
Complication handling with wire connections	63	104	164	168	31	3.00	1.10678
Clarity in vision with high quality picture	161	209	85	68	7	3.85	1.03677

Source: Primary Data

The highest rating is given by the subscribers about DTH services is 'Application of latest technology' with the mean score of 4.40 followed by 'Highly advance payment option' with an average score of 4.07. The lowest rating is given by the subscribers is 'Long standing transmission service' with the mean score of 2.65 followed by 'Most popular transmission services' with an average score of 2.75. The highest variation in rating is exhibited by 'Long standing transmission service' with a standard deviation of 1.17851 and the lowest variation in rating was exhibited by 'Application of latest technology' with a standard deviation of 0.84735. It is found that there is difference in opinion of the subscribers before and after experiencing DTH services.

8.13 EXPERIRNCING OF DTH SERVICES

In order to compare and measure the subscriber's opinion before and after experiencing DTH services Wilcoxon Signed-Ranks Test has been used. For this purpose, 15 statements were framed to analyze the common situations prevailing between cable TV and DTH services. The following table shows the outcome of the analyses based on rating given by the subscribers.

TABLE 8.11

EXPERIRNCING OF DTH SERVICES

Statements	Score Before Experiencing	Score After Experiencing	Sign of Difference	Absolute Difference	Rank	Positive	Negative
Long standing TV transmission service	30660	21060	-	9600	8		8
Application of latest technology	18030	32175	+	14145	12	12	
Most popular transmission service	30945	21930	-	9015	5		5
Possibility of service from Himalayas to house boat in Kerala	18855	30855	+	12000	9	9	
Suitable for dwellers in rented house	300345	300345		0	-	-	-
Preferable service for employees in transferable post	19560	29055	+	9495	7	7	
Suitable for the dwellers in multistoried building	20835	20835		0	-	-	-
Not free from Wireless service	20805	28680	+	7875	4	4	
Provider of multiple favorite channels	20850	27525	+	6675	3	3	
Provider of pure digital viewing experience	21465	30765	+	9300	6	6	
Provider of exclusive movie channels	14805	30480	+	15675	13	13	
Fantastic and superb audio with stereo sound	27225	31530	+	4305	1	1	
Highly advance payment option such as recharge card, online payment	19395	32355	+	12960	11	11	
Complication handling with wire connections	28425	23850	-	4575	2		2
Clarity in vision with high quality picture	18495	30585	+	12090	10	10	
						T_P = 76	**T_n = 15**

Source: Primary Data

In the Wilcoxon signed-ranks test, T represents the smaller of T_p or T_n. Thus, the calculated value of T is 15. The null hypothesis framed for the purpose of application is as follows:

H_0 - There is no significant difference among the subscriber's opinion after and before experiencing the DTH services.

In this test, the null hypothesis is rejected if the calculated value of T is equal or less than the critical T – value. Since the selected null hypothesis entails the two tailed test, the Wilcoxon 'T' table value for two tailed test with 5% level of significance for N = 13 is 17. Here, N represents the number of pairs (the tied pair is discarded from the analysis). The calculated value T (15) is less than 17, the null hypothesis is rejected. Therefore, there is significant difference among the subscriber's opinion before and after experiencing the DTH services. The study also resulted that there is mutual opinion among the subscribers regarding 'not free from wireless service and 'suitable for dwellers in rented house'. It is found that there is negative rank for the opinion regarding long standing TV transmission service, most popular transmission service and complication handling with wire connection.

8.14 SCOPE FOR THE GROWTH OF DTH SERVICE

DTH service is a pure technical alternative to cable television available to the subscribers for receiving satellite channels in their homes. The respondents' views on the scope for the prominent position and growth of DTH services in future over the cable television have been show in the following table.

TABLE 8.12

SCOPE FOR THE GROWTH OF DTH SERVICES OVER CABLE TELEVISION

Scope for growth	Number of Respondents	Percentage
Yes	332	62.64
No	198	37.36
Total	**530**	**100**

Source: Primary Data

The above table reveals that 332 (61.25%) respondents have highlighted the scope of future growth and prominent position of DTH service over cable television and the remaining 198 (37.36%) respondents have negative opinion on the scope for the future growth of DTH services.

8.15 SUMMARY

Digitization of cable television in India is an important and necessary step for regulating cable television sector in India and to bring transparency in the system to benefit all stakeholders, including subscribers and cable operators. The Cable TV Networks (Regulation) Act, 1995, was amended to prescribe a nationwide, phased switchover to digital cable services by December 2014. Both, DTH operators and multi-system operators (MSOs) welcomed the move, believing it would create a level playing field as well as provide a never-before opportunity to lure existing cable subscribers to a higher tariff regime. Analysts and industry experts, meanwhile, looked forward to a revolution in TV viewing habits of Indians (the power to cherry-pick channels, better quality images, transparent billing, faster and better subscriber service) as well as a knock-down, drag-out battle between cable operators and DTH that would be as epic as the cola and detergent wars. But the experience in developed markets shows that not more than two platforms can co-exist. Again, this may take a while. The Indian television viewers will be the biggest beneficiaries if the rivalry between cable television and DTH develops into a healthy competition in improving the service standards in this crucial entertainment sector.

Though, digitization is not enforced in the study area, the foot prints of analog cable television plays a prominent position in providing services. The study discloses that the market share of cable television accounts 75.91%. Through analysis it is proved that, the primary purpose for changing to DTH service is 'picture clarity' which ranks First with an average score 65.42 and the next purpose is 'poor service of the cable operator' which holds second rank with an average score 52.76. The study also highlights that 61.10% of the respondents feel that, the DTH services are not a costlier service. Subscribers' interest on local channels is the main purpose for 120 respondents to hold both the cable television and DTH services. After sales service is the most promising element of cable television with an average score of 60.41 when compared to DTH services. Worthiness of subscription is the most promising element of DTH services with the mean score of 60.18 when is compared to cable television. With the help of Wilcoxon paired sign test, it is found that there is significant difference among the subscriber's opinion before and after experiencing the DTH services. When compared to the market share of cable television in the study areas, DTH services market share is not enough good. There are optimistic sign for growth of DTH services in the near future because there is significant change in the subscribers' opinion before and after experiencing DTH services. When the digitization is mandated in the Virudhunagar district, the competition will be crucial in the market between digital cable and DTH services.