Social Issues in Computing

Exploring the Ways Computers Affect Our Lives

Colin Edmonds

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This text is a work in progress – at this time, a "beta" version.

Special thanks to John Royce @ the Robert College library for his suggestions based on a first reading. The general idea for this book is based on my experience teaching an International Baccalaureate course about Social Issues in Computing called Information Technology for a Global Society. It was initially used as the textbook for a one semester course in the Spring of 2009. A series of slide presentations, one for almost each chapter was used as in-class lecture notes and this was accompanied by a large collection of videos from a variety of sources online.

For my family - the social issue above all others.

Social Issues in Computing

(Exploring the Ways Computers Affect Our Lives)

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(check www.cedmonds.net for updates)

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Before We Get Started …

Since 1984, I have spent a majority of my waking hours at a computer – these days, often at more than one computer at the same time. Back then, I volunteered to create a course that would act as the Lab Component of an EFL/ESL program for 7th graders. To run the program, we inherited a lab of 48K ZX Spectrum computers and no software. With close to zero experience using computers, (I had used a time share terminal once or twice in college in the mid 1970s), I ended up writing nearly 100 "drill and kill" exercises covering language skills such as past tense verb forms, word order, plural forms of nouns. (some are still online at cedmonds.net)

In the ensuing years, my teaching experience and tools moved to Apple IIes, then to Amiga 500s, early Macs and then to the first PCs. In the early 1990s, when my school bit the bullet and agreed to build a network, I was given the job. Those were the days of Windows 3.x and our Network Operating System was Novell Netware 3.x and then 4.x. I got myself certified as a CNA, and later picked up a slew of certificates from Microsoft. I continued teaching the EFL course, which by now had morphed into a "Basic Computer Skills" program for our entering class. I also taught entry level Programming, Web Technologies in addition to do stints as Computer Center Director, Educational Technology Coordinator and head of the Computer Sciences Department.

I began with 1200 bps dialup access to local BBSes and then, when the school worked out a special deal with the nearby university, graduated to text-based access to the Internet. For my international online presence, I created an account at the WELL and another at Compuserve. I recall concurrently also having access to TURPAK, the X.25 communications link from these parts before the Internet arrived.

I don't care an awful lot for TV, or even for watching movies. I would much rather be creating than consuming (and this goes for my other hobbies of cooking, playing the guitar and gardening as well). Most of my reading, I do at a computer or my PDA. I get my news primarily from the Net.

We each have our online favorites; below are some of mine. They have provided (and continue to do so) me with a great deal of the background that I have tried to include in this textbook. While some of them pop up here and then in the pages of the text, I include them here as suggestions for places that you might go for filling in the gaps.

In no particular order:

Craphound.com – When I first learned of Cory Doctorow, it was through a news article about how he had discovered the hard way what happens when you write a book and make it available online "for free" – I recall that he ended up getting charged a large sum for the excess bandwidth the public consumed while downloading his book <u>Down and Out in the Magic Kingdom</u>.

Wired.com – Before this corner of the world had acceptable download speeds, it was the print version of Wired magazine, and now it is a daily visit.

bOINGbOING.net – BB has to speak for itself – and of course, Cory Doctorow is a major contributor.

Rheingold.com – I first came across Tools for Thought when I was building my own skills for the ITGS course I taught for a few years. His is a great mind and the site is one of those like the above that leads to more and more and more knowledge.

Edutopia.org – The George Lucas Educational Foundation site that, again, leads to all sorts of additional chances to learn more.

The MacArthur Foundation's Digital Media and Learning resources at macfound.org

Less so now than before, but still, ISTE at iste.org

Hall Davidson, who I belatedly discovered, at http://www.halldavidson.net/

From Now On – Jamie McKenize's site dedicated to educational technology at fno.org

I make some use of youtube and would probably make more of it if it were not filter-blocked at the national level in Turkey. We can get there from here using anonymizers/proxies but the bandwidth is seriously degraded as a result. (At least one benefit has occurred as a result: everyone under the age of 25 here knows how to set up the software that allows this!)

If and when I have the time to try to learn something new, one of the first places I have gone to since the days it was backed by Intel, is the collection of free online computer learning resources at intelligentedu.com

The Internet Archive at archive.org – for its books, music, videos and the WayBack machine.

I have also been on Cathy Schrock's mailing list for some time and before that made frequent visits to her earlier online presence (now at http://school.discoveryeducation.com/schrockguide/)

One of the main reasons I have for writing this book is inspiration from Cory Doctorow. You'll find lots of his writings are in my suggested readings at the end of each chapter. Lots more of his work is not included, but you should find the time to read it all.

Another reason is that I would like the students of my course to have a free textbook. Two commercial texts that are similar that I am aware of are Computer Confluence and Gift of Fire, both good books and filled with content that at this point in my writing, I can only aspire to.

You can get a digital copy of this book online at cedmonds.net and I have plans to continue refining and editing it. Probably the best place to pick up the latest version is there. Feel free to use the contact link at the site to make suggestions or for general contact via email.

I. The Mechanics of Computers

1. The History of Computers

2. Hardware and Software

3. Networks

Why Social Issues?

There isn't much these days that doesn't involve the use of some form of Information Technology: shop at your supermarket, and you will notice that the cash register is a POS (Point of Sale) computer with an Ethernet connection to the store's automated inventory and accounting systems. When it is time to register your child for school, you will have to do it online. Airlines have moved exclusively to e-tickets, telephone assistance is a computer controlled, automated system, city traffic is controlled via a network of traffic cameras, and most of the legal paper-work a citizen is faced with will require you to provide a national ID number that is part of a huge government database. Even in the less technologically-advanced developing world, the rapid proliferation of the use of cellular phones means that more and more people are a part of and consequently affected by the Information Technology revolution. In short, the world as we know it would just about come to a standstill without effectively operating Information Communications and Technology (ICT) systems.

With each passing year, the components that make up a computer system are getting smaller, faster and more capable. At the same time, these devices are being embedded in more and more of our appliances: a modern automobile includes more computer technology than the Apollo astronauts had when they went to the moon. There are computerized chips in many of our kitchen appliances, our home entertainment systems and our wrist-watches.

I-pod Nano
http://en.wikipedia.org/wiki/IPod_Nano

While there are still sections of the world population that do not have regular, daily contact with this technology, the lack of interaction with IT has become a dividing factor: those who access the "system" are in a better position to get their work done or to progress than those who do not or cannot. Families who have access to and regularly use these technologies have a great advantage over those who have never used a computer or have no access to the Internet, for example. What kind of employment opportunities are available to someone who has no computer experience? At the same time that there are undeniable benefits from making use of the available technology, there are many areas where technology affects our lives that can and should be scrutinized: what kind of a world is it where it is virtually impossible to just live your life "off the grid"? What kind of world has it become where the Big Brother governments and corporations are able to track your every move and individual privacy is being eroded by the needs of efficient IT systems, state control or security?

An office computer
http://en.wikipedia.org/wiki/Desktop_computer

As educated, responsible, thinking citizens of the world, it behooves each of us to understand the way these technologies operate so that we can evaluate and make informed decisions about how we want these technologies to affect our lives, what freedoms we are willing to give up in the name of better and more efficient information systems so that we are able to critically examine the claims of our government or the large corporations that provide our basic services that "technology will improve" our lives. As is true with most things, there are pros and cons, and often the decision is not a simple, clear-cut one. It is here that a comprehensive understanding of the issues that surround our use of technology will help us make informed decisions. When your friend argues that we are losing our freedoms because of the invasion of technology into our lives, or when your government asks you to vote to decide on the extent that you are willing to have technology control your life, a well-founded understanding of the way technology operates will help you make the right choices.

There are several ways to go about examining the issues related to IT. Critical to any discussion of the issues is a solid understanding of the technology itself: how did the world come to the current state of affairs, how does the technology actually work, what parts of our lives are affected, and what are the major issues being discussed today? As technology develops, some of these factors change. Take, for example, the growth of the Internet and the changes that its growth has made to our lives: things that we could not do twenty years ago are now a common part of many people's lives. In the future, there are sure to be many more similar shifts in our patterns that are brought about by the increasing use of IT. So, a study of the social issues in IT requires a level of historical perspective, a solid knowledge of the terms, features and function of the technology and a critical look at the areas and ways in which we use IT systems.

The Road to the Modern Computer

In its simplest definition, the computer is a tool for computing. As such, it is possible to trace its

Hash marks

roots back to the earliest form of counting and calculating. In this light, one of the earliest developments could be considered to be the nearly universal system of hash marks. One of the more common systems is based on the number of digits on a human hand, where four vertical lines are crossed with the fifth line to indicate a completed "set". The human hand, thus, was a tool that we carry with us 24/7 – a bit like the way some of carry PDAs or cell phones that have calculators included?

Another early advancement in computation was the invention of the abacus. Although history does not record who invented the abacus, it is fairly clear that the abacus we know, with sliding beads on rods (ca 2500 BCE), is a development of a more basic
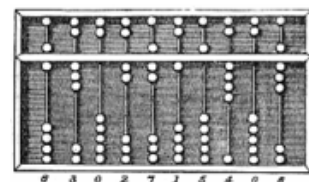
An abacus
http://en.wikipedia.org/wiki/Abacus

counting machine. It is important to note that this historical development marks a progression from hash marks or similar markings as a method that improves our ability to count to the use a tool for calculating. An adept user of the abacus is able to perform more than just addition and subtraction, and the resulting sums can be rather large numbers: the abacus is still used today in places partly because it is a simple but effective device.

It is worth considering the extent to which these early systems make use of one of the basic principles of modern computers: the binary system. With hash marks, the mark either exists - or it doesn't (it is a 1 or a 0). In an abacus, the bead is either in its resting position or it has been moved.

There were various other early calculating devices developed through the Middle Ages, including the astrolabe, a mechanical device for calculating the position of the stars and planets in use in ancient Greece, and similar devices invented by Muslim scientists such as Biruni.

Another often cited step forward in the progression to the modern computer is John Napier's invention of the logarithmic table (ca 1617 CE) and a system known as Napier's Bones. Napier realized that calculations with more complex numbers often resulted in rather simple errors that could be avoided by the use of "look up" tables. While this invention is not the invention of a device, it is the systematization of a process as well as a major step forward in man's ability to perform rapid computations. Within a few years, other inventors had built on Napier's work and were creating various tools that made use of his log tables. Several inventors came up with different designs and calculating devices that were mechanical in nature. One such invention was the slide rule, invented by William Oughtred around 1625 and actually still used for calculations when the USA first went to the moon!

Napier's devices
http://en.wikipedia.org/wiki/Napier%27s_bones
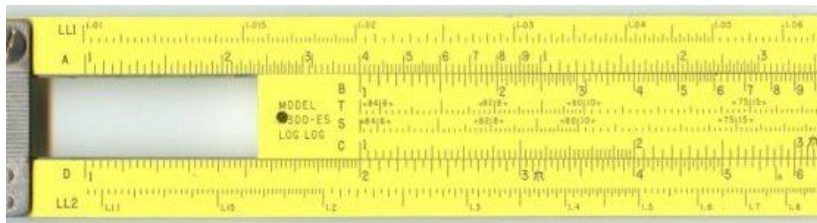
A hand held slide rule
http://en.wikipedia.org/wiki/Slide_rule

Like the abacus, most people today would consider the slide rule an antiquated museum piece. However, we might consider if it worth learning or at least preserving the knowledge of how to operate these simple but effective computational tools against a future day when we find ourselves without amenities we now take for granted.

The Frenchman Blaise Pascal (whose name was later given to the computer programming language invented by Nicklaus Wirth in the 1970s) invented a mechanical calculator known as the Pascaline around the middle of the 17th century, not too long after the invention of log tables and the slide rule. His device was able to add and subtract numbers by turning the dials, and in some ways is the precursor of the mechanical calculators that were in use for accounting up until the middle of the 20th century.

A Pascaline
http://en.wikipedia.org/wiki/Pascaline

Towards the end of the 17th century, Gottfried Wilhelm von Liebnitz came up with the design for a more complex mechanical calculating device that was also able to divide and multiply; however, his ideas were not actually brought to life until almost 100 years later. Most likely, the technical capabilities of the times were not up to the precise machining of the parts to make his device work (and this is not the first or last case of someone's ideas not being translated into reality because of the production capabilities of the times.)

In the 1800s, a Frenchman named Joseph-Marie Jacquard developed a mechanized weaving loom that used punch cards similar to those that were used many years later in early computers. Here, holes punched in paper or cardboard act as a "guide" for the device that "reads" the cards and in this case, control the pattern that the weaving machine is creating. Once again, there is a parallel to the binary system here: a hole in the card indicates a "1" whereas the lack of a hole would equate to a "0". Aside from the similarities to the punch cards used in later computers, this is the same basic principle that is used in player pianos and music boxes as well.

Jacquard loom and cards
http://en.wikipedia.org/wiki/Jacquard_loom

Detail of machine parts in Babbage's device
http://en.wikipedia.org/wiki/Difference engine

In England, in the first half of the 19th century, Charles Babbage (frequently referred to as "the father of modern computing"), invented two mechanical machines for advanced calculation. The first of them, the Difference Engine was a machine that was intended to calculate values of polynomial functions. The machine had approximately 25,000 parts, weighed 13 tons and was only finally constructed using his plans in 1991! The primary reason given for his not being able to actually build it himself was that the manufacturing abilities of that time were not capable of the precise cuttings and machining required for such a complex piece

of equipment. Charles Babbage went on to come up with another device that he worked on until his death called the Analytic Engine. The Analytic Engine was similar to the Difference Engine, but it used punch cards. A lot of support for Charles Babbage's projects came from the daughter of the poet Lord Byron: a lady known as Ada Lovelace (and whose name was given to the programming language Ada).

The electric telegraph, developed throughout the 18th and 19th centuries and finally made practical by Samuel Morse in 1837, while still not a computer as we would recognize one today, could also be said to have had influences on the development of the computer. Sometimes called "the Victorian Internet", in particular, there are several ways in which this device foreshadows computing devices: the dots and dashes that make up the Morse alphabet are a form of binary information, the system made use of long distance transmission of information over wires and the voltage that passed down the line is the same voltage that is still used today in network cards installed in modern computers (+ or - 5 V)

Yet another step forward toward the creation of the modern computer involves a man named Hollerith. At the end of the 19th century, Herman Hollerith was working in the US census office. The data from the census of 1880 had taken nearly 10 years to calculate, and with the growth of population in the ensuing 10 years, it was clear that the calculations from the 1890 census would not be completed before it was time for the 1900 census. Hollerith set about designing and then using a mixed electro-mechanical device that would automatically calculate the data from the 1890 census. His Census Tabulating Machine also used a system based on punched cards. In this case, where there were holes on the cards, an electrical circuit was completed and a series of counters were incremented, thereby performing the calculation/addition. The 1890 census data calculations were completed in only 3 months. As a note of curiosity, Hollerith went on to later found IBM.

A mechanical adding machine
http://en.wikipedia.org/wiki/Adding_machine

The primary device that was used for calculations during the period known as the First Generation of computers was the adding machine (computers – if you can call them that – were used for mathematical computations). This machine was a hand cranked, gear-based device that was in use almost until the era of the personal computer. Major companies like IBM made their initial fortunes selling these office assistants to companies large and small: anyone who needed to do large quantities of math did their calculations with these adding machines.

From the late 1930s to the 1950s, there were major developments that transformed computing from a primarily mechanical to a primarily electronic system. As has often been the case, much of the funding and impetus for these advancements were powered by the needs of the military: a better and more accurate way to calculate the trajectories for long range weapons, the need to create super-secure data transmissions or codes and the need for faster information in the heat of war.

Again, in much the same way that Samuel Morse is given credit for the telegraph, even though he was not the original inventor and even though his device was built on such other technological developments as Alessandro Volta's discoveries in electricity, the invention of the electronic digital computer needs to also be seen as the collaborative work of many people.

An English mathematician named Alan Turing wrote a paper (1936) in which he theorized that a machine operating in a binary format would be capable of solving any conceivable mathematical problem if it were presented in the form of an algorithm. His proposed machine is known as the Universal Machine. Turing was also working at the code and ciphering school in England, and helped design a machine called the "bombe" that was the precursor to the Colossus computer that eventually cracked the secret German "Enigma" code in use during the Second World War.

In the United States at about the same time, a mathematician named John von Neumann took Turing's ideas about the Universal Machine and refined them to explicitly state that a "stored-program" computer would need an architecture that included the same basic components that even today are used in building computers: memory, control unit, logic unit, input and output (see diagram) Much of the computation that had been done by machines up to this point in time was task-specific: the computer would be programmed manually
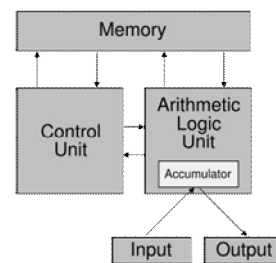
von Neumann design
http://en.wikipedia.org/wiki/Von_Neuman
n_architecture

A vacuum tube
http://en.wikipedia.org/wiki/Vacuum_tube

(generally by re-wiring the cables and circuits inside the computer). The stored-program computer, on the other hand would be capable of reading the binary information that defined the program, not just the binary data that was to be calculated, and essentially "reconfiguring its own wiring" without the need for humans to physically re-wire the device for each new program or calculation. Once again, it would be unfair to state that this was entirely von Neumann's work, but it is his name that is associated with the basic design of the modern computer (known as the von Neumann architecture)

Also in 1936 in Germany, the same year that Alan Turing had published his paper about the theoretical Turing Machine, Konrad Zuse invented a mechanical device that had many of the features of a modern calculator, including a "control unit" and memory.

And in 1939, John Atanasoff and Clifford Berry invented an electronically powered digital computer that used the binary system that had been proposed some years earlier by Alan Turing. Their computer, called the Atanasoff-Berry computer, was able to store its data in vacuum tubes.

In the 1940s, spurred on by the needs of the military, the Harvard Mark I and the ENIAC computers were developed in the United States. In England, the Bletchley Park Colossus computer was developed and it was this machine that eventually helped "crack" the German military's top secret Enigma code that was being generated by a complex mechanical device.

In 1945 Vannevar Bush wrote and article in the Atlantic Monthly magazine called "As We May Think". It was a seminal idea of a theoretical device that presaged the coming computer revolution in many ways. He proposed a desk-type machine that would store and display on a screen all the information a person could collect and included a system for linking the information for easy access and retrieval.

The historical summary of the first computers above, by nature of its brevity, leaves out many other computers that were developed during the period between the arrival of electricity and the "modern" computer. For a more detailed list that includes most of these computers, refer to Wikipedia's article on the history of computers at
http://en.wikipedia.org/wiki/History_of_computers

Along with the developments in the electronic circuitry were developments in storage. While the data for the Jacquard loom was stored on a series of connected cards that were run through the "processor", the use of stored data was limited by technological ability. Experiments with stored data included the use of reels of paper tape with punched holes. One edge of the tape had a series of evenly punched holes that fit the sprockets of a wheel that turned and advanced the tape. Other holes arranged in 5, 6 or 7 rows held the data. In the 1950s,

Paper data tape in use – 1960s
http://en.wikipedia.org/wiki/Punched_tape

technological advances allowed the use of magnetic tape in place of paper, for example in the UNIVAC. This is the iconic image of the large computer with spinning reels of tape that could be written to or read from.

In general, you could summarize these early computers as being huge (the size of large rooms), unreliable (with so many vacuum tubes, there was always some element burning out), incredibly expensive and time consuming to build and very definitely only available to the top geeks of their countries.

At about this time, parallel developments in technology helped computing move to its next stage. In fact, computers that were built using vacuum tube technology are commonly known as "first generation" computers. The technology generation that followed the use of the rather unreliable vacuum tubes in computers brought with it not only more reliability, but also a reduction in size: it was the use of transistors and diodes.

Transistors
http://en.wikipedia.org/wiki/Transistor

The US patent for the transistor was granted to Bell Labs, although their product was built on the work of earlier scientists working as far back as the 1920s. In essence, the transistor and the vacuum tube both performed the same electronic task: acting as a switch that would allow electrical current be switched : current on or current off (think binary). The transistor was a great improvement over the vacuum tube not just because of its size and improved reliability, but also because it could be produced with a highly automated manufacturing process, because it used less voltage (the earlier computers used so much power that there are apocryphal stories of entire cities losing power as these huge computers were operated), because transistors operate at cooler temperatures, are less sensitive to shock and have extremely long operating lives.

The effects of the adoption of transistors in computers meant that they were much more reliable, smaller in size, less expensive to build and as a result, more and more of them began to appear. They were still not something you bought for your house, but the common users/buyers were now no longer just the government or the military, but businesses and universities. They were, however, still very much only for geeks, but there were more and more people who knew how to run them, fix them and play with them. For the public/consumer, the most visible benefit of the transistor revolution was the availability of the inexpensive battery operated transistor radio - finally, a radio that you could carry in your pocket!

Further technological developments in the late 1950s led Jack Kirby of Texas Instruments to invent the Integrated Circuit. This development is known as the basis for the third generation of computers. While the transistor was a great improvement over the vacuum tube, connecting many transistors and diodes (a simple computing device would need thousands of these parts) to each other involved lots of wiring. In addition, even short distances between these thousands of transistors added delays to the speed of the devices - the electrical signals would have to travel along the wires from point to point. Kirby's IC packed large numbers of the miniaturized transistors onto a single chip. The individual transistors were much smaller than stand alone transistors, the distances between the

Integrated circuit
http://en.wikipedia.org/wiki/Integrated_circuit

individual transistors was nearly microscopic, the voltage requirements were even less than that of discrete transistors and the manufacturing process was improved and cheaper. These chips also allowed for a new kind of assembly of electronic devices, where a prepared chip could rather

easily be screwed into position, ready to operate. The manufacturing process was improved over time, allowing the transistors to be layered like an apartment building (see 3D schematic image) , and today, it is possible to fit more than 1 million transistors in 1 mm^2 (compare this with the size of a single stand alone transistor).

However, in spite of the technological progress, the personal computer still had not been developed. Instead, the most common consumer result of the Integrated Circuits was the arrival of the affordable electronic calculator and the digital watch as manufacturing processes and costs improved in the late 1960s.

In 1971, several people working at Intel refined the Integrated Circuit so that all or almost all of the function of a central processing unit (CPU) could be built into a single chip instead of having a system built out of multiple specific purpose integrated circuits. This development is known as the fourth generation of computers. The first 4-bit microprocessors were basically a calculator on a single chip. The Intel 4004, produced in 1971 was challenged for patent rights by Texas Instruments and eventually the two companies worked out cross-licensing agreements. In 1972, Intel released the 8008, the first 8-bit processor. Other companies such as Motorola and Zilog built on this work, producing the Motorola 6800 and the Zilog Z80, which in turn began the home computing revolution in the early 1980s. Moore's Law comes into play at this point in time, as Gordon Moore (who is the co-founder of Intel) predicted that the number of transistors that could be placed on an integrated circuit would double every two years (later refined to every 18 months). Soon, Intel and other manufacturers were producing 16-bit processors (Intel's 16-bit 8086 is the start of the x86 family of microprocessors that were the standard for the PCs of the "Win-tel" near monopoly in the 1980s
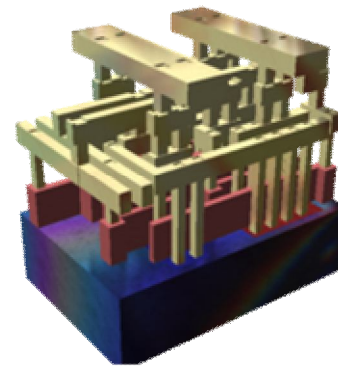
3D schematic of a chip
http://en.wikipedia.org/wiki/Integrated_circuit

and 90s. In the late 1970s, Motorola came up with the 68000, the chipset that was used in the early Apple Macintosh, the Commodore Amiga and the Atari ST, which although Motorola called it a 16 bit processor, had the architecture of a 32-bit system. Intel's own designs had progressed through the 80386, 80486 and the Pentium (penta = 5, for 80586), and the 32-bit design maintained its market dominance until the turn of the century (ca 2000 CE), when the trend moved towards 64-bit systems.

On the one hand, there was this rapid growth in development of the capabilities of the electronics along the lines of Moore's Law. At the same time, there were parallel developments in the spread of the devices as costs came down (the 8-bit Sinclair ZX81 sold for about $100 in 1981) and people started buying them for home use. Whereas the first digital computers, aside from being too expensive, were not at all "friendly", the home computers that began multiplying in the 1980s were designed for

A command line interface
http://en.wikipedia.org/wiki/Command_line_interface

home use and had interfaces that a most anyone could work with. From a user's viewpoint, perhaps the most critical of these developments was the invention and adoption of the GUI, first introduced commercially by the Apple Macintosh and later made popular in the Windows operating systems. The GUI took computing from a "command line" based interface (where the user typed in commands and the computer frequently output results in a text format) to a system commanded by a mouse and resulting output appearing in graphical format often inside multiple windows.

From the 1970s on, technology developments are so many and so fast – essentially a parallel of Moore's Law for computers in general. Peripheral devices of all sorts were developed. Software for all kids of needs was written. Each of these is worthy of further research, and some will be covered in later chapters as we look at how computers actually work, the parts that make up computers and some of the uses they are being put to today. And of course, the Internet was invented and in many ways changed the world. But without the work of the pioneers referred to above, the era of modern computing would not have come about.

And as for the future, aside from the continuing miniaturization of the components (such that today, a computer CPU will contain 200 million or more transistors), or the use of multi core processors to help boost capacity, there are other developments that continue to speed up processing power. One such development is in the area of quantum computing. Another is the exploration of living, biological computers. New materials that work better than the standard silicon used in the traditional chip, such as germanium-helium, or advances in nanotechnology that will allow placement of transistors even closer together in microscopic proximity or the development of "Flash" technologies or the "memristor" could all play a part in deciding the direction of 21st century computing. Where the future will lead is anyone's guess. Whatever the outcome, it is sure to be faster, smaller, cheaper and more widely embedded in our lives (and maybe our bodies).

Biography: Grace Hopper and the "Bug"

At a time in history when a career in the military was much more of a male job than even today, and when work as a "computer" (that was the name for people who worked with computers) was a man's occupation, Grace Murray Hopper was employed by the United States Navy. She was one of the first programmers of the Harvard Mark I computer, a computer that was considered to be the first universal calculator and was used heavily by the US military.

Grace Hopper got her undergraduate degree from Vassar College and completed her graduate studies at Yale in mathematics and physics in 1930. She got a PhD in mathematics in 1934.

Grace Hopper
http://en.wikipedia.org/wiki/Grace_Hopper

Her first marriage was to Vincent Hopper, who was head of the English department at NYU.

In the late 1940s, she worked for the Eckert-Mauchly Corporation, which was developing the UNIVAC computer. While she was doing this work, she developed the first compiler program, a major innovation in computing. (A compiler is a program that "compiles" the code that a programmer writes so that it can run directly, without needing to be interpreted, on a computer's operating system.) When she later returned to work for the Navy, she was involved in working on the validation software for the COBOL programming language, which was derived in large part from her original work on a programming language called ARITH-MATIC. It was her idea that programming could be done in a form that was much closer to English than to the native "machine code" that computers at that time normally used.

In 1966, she retired from the Navy with the rank of Commander. However, she asked for and was given active duty in the Navy again in 1967, a position that she kept off and on (she retired again and was assigned once more in the 1970s) until she retired as the oldest officer in the United States Navy in 1986. She was later assigned the rank of Captain. From then until her death in 1992, she worked as a consultant for DEC (Digital Equipment Corporation).

Among other special attributes, she was nicknamed "Amazing Grace", and one of a very few Navy ships named for a woman was named for her (the USS Hopper).

Perhaps the most famous (but somewhat dubious) anecdote about Grace Hopper is that of the coining of the term "computer bug". The story is that one day the Mark I computer developed a problem. Upon inspection of the insides of the machine, a moth was found to be blocking one of the relay switches. The story is that she said that to repair the problem they had to "debug" the system and she has been credited with the invention of this common term.

The "bug" annotated
http://en.wikipedia.org/wiki/Grace_Hopper

A Selected Timeline of Computing Devices

As you review/study the timeline below, keep in mind the fact that history is somewhat subjective: for example, Babbage may have designed his machine in the 1800s but it wasn't actually finished until 1991 and so some historians list the date as 1822 and others as 1824. More important to your understanding than precise dates is the general flow of events: Babbage could not have arrived at such an invention without the previous work of others before him (In the words of Isaac Newton "If I have seen further it is by standing on the shoulders of giants.") That said, here is a general outline of events leading to the modern computer:

Date 🖾	Event
c. 2400 BC	The abacus - the first known calculator, was probably invented by the Babylonians as an aid to simple arithmetic around this date. This laid the foundations for positional notation and later computing developments.
c. 87 BC	The Antikythera mechanism: A clockwork, analog computer designed and built in Rhodes. The mechanism contained a differential gear and was capable of tracking the relative positions of all then-known heavenly bodies. It is considered to be the first analog computer.
820	Persian mathematician, Muḥammad ibn Mūsā al-Ḵwārizmī, described the rudiments of modern algebra whose name is derived from his book *Al-Kitāb al-muḫtaṣar fī ḥisāb al-ǧabr wa-l-muqābala*. The word *algorithm* is derived from al-Khwarizmi's Latinized name *Algoritmi*.
1206	Arab engineer, Al-Jazari, invented numerous automata and made numerous other technological innovations. One of these is a design for a programmable humanoid-shaped mannequin: this seems to have been the first serious, scientific (as opposed to magical) plan for a robot.[14] He also invented the "castle clock", an astronomical clock which is considered to be the earliest programmable analog computer.[15] It displayed the zodiac, the solar and lunar orbits, a crescent moon-shaped pointer travelling across a gateway causing automatic doors to open every hour,[16][17] and five robotic musicians who play music when struck by levers operated by a camshaft attached to a water wheel. The length of day and night could be re-programmed every day in order to account for the changing lengths of day and night throughout the year.[15]
c. 1400	Kerala school of astronomy and mathematics in South India invented the floating point number system.
1492	Leonardo da Vinci produced drawings of a device consisting of interlocking cog wheels which can be interpreted as a mechanical calculator capable of addition and subtraction. A working model inspired by this plan was built in 1968 but it remains controversial whether Leonardo really had a calculator in mind [1]. Da Vinci also made plans for a mechanical man: an early design for a robot.
1614	Scotsman John Napier reinvented a form of logarithms and an ingenious system of movable rods (referred to as Napier's Rods or Napier's bones). These were based on logarithms and allowed the operator to multiply, divide and calculate square and cube roots by moving the rods around and placing them in specially constructed boards.
1622	William Oughtred developed slide rules based on John Napier's natural logarithms.
1623	Wilhelm Schickard of Tübingen, Württemberg (now in Germany), built the first discrete automatic calculator, and thus essentially began the computer era. His device was called the "Calculating Clock". It was capable of adding and subtracting up to 6 digit numbers, and warned of an overflow by ringing a bell. Operations were carried out by wheels, and a complete revolution of the units

wheel incremented the tens wheel, a concept widely used later, as for instance in odometers and in counters on cassette decks. Schickard had been a friend of astronomer Johannes Kepler since they met in the winter of 1617. Kepler is said to have used Schickard's machine for his astronomical studies. The machine and plans were lost and forgotten in the war that was going on, then rediscovered in 1935, only to be lost in another war, and then finally rediscovered in 1956 by the same man (Franz Hammer)! The machine was reconstructed in 1960, and found workable.

1642   French mathematician Blaise Pascal built a mechanical adding machine (the "Pascaline"). Despite being more limited than Schickard's 'Calculating Clock' of 1623, Pascal's machine became far more well known. He built about fifty, but was only able to sell perhaps a dozen of his machines in various forms, coping with up to 8 digits.

1671   German mathematician, Gottfried Leibniz designed a machine which multiplied, the 'Stepped Reckoner'. It could multiply numbers of up to 5 and 12 digits to give a 16 digit result. The machine was lost in an attic until rediscovered in 1879. Leibniz's most important contribution to computing, however, was his refinement of the binary number system which is used in all modern machines. He was also one of the inventors of calculus.

Date ⊠	Place ⊠	Event
1801	🇫🇷	Joseph-Marie Jacquard developed an automatic loom controlled by punched cards.
1822	🇬🇧	Charles Babbage designed his first mechanical computer, the first prototype of the decimal difference engine for tabulating polynomials.
1832	🇬🇧	Babbage and Joseph Clement produced a prototype segment of his difference engine, which operated on 6-digit numbers and second-order differences (i.e., it could tabulate quadratic polynomials). The complete engine, which would have been room-sized, was planned to operate both on sixth-order differences with numbers of about 20 digits, and on third-order differences with numbers of 30 digits. Each addition would have been done in two phases, the second one taking care of any carries generated in the first. The output digits were to be punched into a soft metal plate, from which a printing plate might have been made. But there were various difficulties, and no more than this prototype piece was ever finished.
1834	🇬🇧	Babbage conceives, and begins to design, his decimal 'Analytical Engine'. A program for it was to be stored on read-only memory, in the form of punch cards. Babbage continued to work on the design for years, though after about 1840 design changes seem to have been minor. The machine would have operated on 40-digit numbers; the 'mill' (CPU) would have had 2 main accumulators and some auxiliary ones for specific purposes, while the 'store' (memory) would have held a thousand 50-digit numbers. There would have been several punch card readers, for both programs and data; the cards were

to be chained and the motion of each chain reversible. The machine would have performed conditional jumps. There would also have been a form of [microcoding](): the meaning of [instructions]() were to depend on the positioning of metal studs in a slotted barrel, called the "control barrel". The machine envisioned would have been capable of an addition in 3 seconds and a multiplication or division in 2-4 minutes. It was to be powered by a [steam engine](). In the end, no more than a few parts were actually built.

Date	Place	Event
[1848]()	🇬🇧	British Mathematician [George Boole]() developed binary algebra ([Boolean algebra]()) which has been widely used in binary computer design and operation, beginning about a century later. See [1939]().
[1886]()	🇺🇸	[Herman Hollerith]() developed the first version of his tabulating system in the Baltimore Department of Health.
[1889]()	🇺🇸	[Dorr Felt]() invented the first printing desk calculator.
[1890]()	🇺🇸	The 1880 US census had taken 7 years to complete since all processing had been done by hand from journal sheets. The increasing population suggested that by the 1890 census, data processing would take longer than the 10 years before the next census —so a competition was held to find a better method. It was won by a Census Department employee, [Herman Hollerith](), who went on to found the [Tabulating Machine Company](), later to become [IBM](). He used Babbage's idea of using the punched cards from the textile industry for the data storage. His machines used mechanical [relays]() (and [solenoids]()) to increment mechanical counters. This method was used in the 1890 census and the completed result (62,622,250 people) released in just 6 weeks! This approach allowed much more in-depth analysis of the data and so, despite being more efficient, the 1890 census cost about double (actually 198%) that of the 1880 census. The inspiration for this invention was Hollerith's observation of railroad conductors during a trip in the western US; they encoded a crude description of the passenger (tall, bald, male) in the way they punched the ticket.

Date 🔃	Place 🔃	Event
[1906]()	🇬🇧	Henry Babbage, Charles's son, with the help of the firm of R. W. Munro, completed the 'mill' from his father's Analytical Engine, to show that it would have worked. It does. The complete machine was not produced.
[1906]()	🇺🇸	[Vacuum Tube]() (or [Thermionic valve]()) invented by [Lee De Forest]() in [U.S.A.]().
[1936]()	🇬🇧	[Alan Turing]() of [Cambridge University](), England, published a paper on 'computable numbers'[25] which reformulates [Kurt Gödel]()'s results (see related work by [Alonzo Church]()). His paper addressed the famous '[Entscheidungsproblem]()' whose solution was sought in the paper by reasoning (as a mathematical device) about a simple and theoretical, computer known today as a [Turing machine](). In many ways, this device was more convenient than Gödel's arithmetics-based universal formal system.
[1937]()	🇺🇸	[George Stibitz]() of the Bell Telephone Laboratories (Bell Labs), New York City, constructed a demonstration 1-bit binary adder using relays. This was one of the first binary computers, although at this stage it was only a

demonstration machine; improvements continued leading to the 'complex number calculator' of January 1940.

1937		Claude E. Shannon published a paper on the implementation of symbolic logic using relays as his MIT Master's thesis.
1938		Konrad Zuse of Berlin, completed the 'Z1', the first mechanical binary programmable computer. It was based on Boolean Algebra and had most of the basic ingredients of modern machines, using the binary system and today's standard separation of storage and control. Zuse's 1936 patent application (Z23139/GMD Nr. 005/021) also suggested a 'von Neumann' architecture (re-invented about 1945) with program and data modifiable in storage. Originally the machine was called the 'V1' but retroactively renamed after the war, to avoid confusion with the V1 buzz-bomb. It worked with floating point numbers (7-bit exponent, 16-bit mantissa, and sign bit). The memory used sliding metal parts to store 16 such numbers, and worked well; but the arithmetic unit was less successful, occasionally suffering from certain mechanical engineering problems. The program was read from holes punched in discarded 35 mm movie film. Data values could have been entered from a numeric keyboard, and outputs were displayed on electric lamps. The machine was not a general purpose computer (ie, Turing complete) because it lacked loop capabilities.
1939 Nov		John Vincent Atanasoff and graduate student Clifford Berry of Iowa State College (now the Iowa State University), Ames, Iowa, completed a prototype 16-bit adder. This was the first machine to calculate using vacuum tubes.
1939		Konrad Zuse completed the 'Z2' (originally 'V2'), which combined the Z1's existing mechanical memory unit with a new arithmetic unit using relay logic. Like the Z1, the Z2 lacked loop capabilities. The project was interrupted for a year when Zuse was drafted, but continued after he was released.

Date	Place	Event
1940 Jan		At Bell Labs, Samuel Williams and George Stibitz complete a calculator which can operate on complex numbers, and give it the imaginative name of the 'Complex Number Calculator'; it is later known as the 'Model I Relay Calculator'. It uses telephone switching parts for logic: 450 relays and 10 crossbar switches. Numbers are represented in 'plus 3 BCD'; that is, for each decimal digit, 0 is represented by binary 0011, 1 by 0100, and so on up to 1100 for 9; this scheme requires fewer relays than straight BCD. Rather than requiring users to come to the machine to use it, the calculator is provided with three remote keyboards, at various places in the building, in the form of teletypes. Only one can be used at a time, and the output is automatically displayed on the same one. On 9 September 1940, a teletype is set up at a Dartmouth College in Hanover, New Hampshire, with a connection to New York, and those attending the conference can use the machine remotely.
1942		Atanasoff and Berry complete a special-purpose calculator for solving

Summer		systems of simultaneous linear equations, later called the 'ABC' ('Atanasoff–Berry Computer'). This has 60 50-bit words of memory in the form of capacitors (with refresh circuits —the first regenerative memory) mounted on two revolving drums. The clock speed is 60 Hz, and an addition takes 1 second. For secondary memory it uses punch cards, moved around by the user. The holes are not actually punched in the cards, but burned. The punch card system's error rate is never reduced beyond 0.001%, and this isn't really good enough. Atanasoff will leave Iowa State after the U.S. enters the war, and this will end his work on digital computing machines.
1943 Apr	🇬🇧	Max Newman, Wynn-Williams and their team at the secret Government Code and Cypher School ('Station X'), Bletchley Park, Bletchley, England, complete the 'Heath Robinson'. This is a specialized counting machine used for cipher-breaking, not a general-purpose calculator or computer but some sort of logic device, using a combination of electronics and relay logic. It reads data optically at 2000 characters per second from 2 closed loops of paper tape, each typically about 1000 characters long. It was significant since it was the fore-runner of Colossus. Newman knew Turing from Cambridge (Turing was a student of Newman's), and had been the first person to see a draft of Turing's 1936 paper.[25] Heath Robinson is the name of a British cartoonist known for drawings of comical machines, like the American Rube Goldberg. Two later machines in the series will be named after London stores with 'Robinson' in their names.
1943 Dec	🇬🇧	The Colossus was built, by Dr Thomas Flowers at The Post Office Research Laboratories in London, to crack the German Lorenz (SZ42) cipher. It contained 2400 vacuum tubes for logic and applied a programmable logical function to a stream of input characters, read from punched tape at a rate of 5000 characters a second. Colossus was used at Bletchley Park during World War II —as a successor to the unreliable Heath Robinson machines. Although 10 were eventually built, most were destroyed immediately after they had finished their work to maintain the secrecy of the work.
1944 Aug 7	🇺🇸	The IBM ASCC (Automatic Sequence Controlled Calculator) is turned over to Harvard University, which calls it the Harvard Mark I It was designed by Howard Aiken and his team, financed and built by IBM —it became the second program controlled machine (after Konrad Zuse's). The whole machine was 51 feet (16 m) long, weighed 5 (short) tons (4.5 tonnes), and incorporated 750,000 parts. It used 3304 electromechanical relays as on-off switches, had 72 accumulators (each with its own arithmetic unit), as well as a mechanical register with a capacity of 23 digits plus sign. The arithmetic was fixed-point and decimal, with a plug-board setting determining the number of decimal places. Input-output facilities include card readers, a card punch, paper tape readers, and typewriters. There were 60 sets of rotary switches, each of which could be used as a constant register —sort of mechanical read-only memory. The program was read from one paper tape; data could be read from the other tapes, or the card readers, or from the constant registers. Conditional jumps were not available. However, in later years, the machine was modified to support multiple paper tape

		readers for the program, with the transfer from one to another being conditional, rather like a conditional subroutine call. Another addition allowed the provision of plug-board wired subroutines callable from the tape. Used to create ballistics tables for the US Navy.
1945	🇺🇸	Vannevar Bush develops the theory of the memex, a hypertext device linked to a library of books and films.
1945	🇺🇸	John von Neumann drafts a report analyzing the previously built EDVAC (Electronic Discrete Variable Automatic Computer). His comments, entitled 'First Draft of a Report on the EDVAC', are the first detailed description of the design of a stored-program computer, giving rise to the term von Neumann architecture. It directly or indirectly influenced nearly all subsequent projects, especially EDSAC. The design team included John W. Mauchly and J. Presper Eckert.
1946 Feb 14	🇺🇸	ENIAC (Electronic Numerical Integrator and Computer) : One of the first totally electronic, valve driven, digital, program-controlled computers was unveiled although it was shut down on 9 November 1946 for a refurbishment and a memory upgrade, and was transferred to Aberdeen Proving Ground, Maryland in 1947. Development had started in 1943 at the Ballistic Research Laboratory, USA, by John W. Mauchly and J. Presper Eckert. It weighed 30 tonnes and contained 18,000 electronic valves, consuming around 160 kW of electrical power. It could do 50,000 basic calculations a second. It was used for calculating ballistic trajectories and testing theories behind the hydrogen bomb.
1947 Dec 16	🇺🇸	Invention of the Transistor at Bell Laboratories, USA, by William B. Shockley, John Bardeen and Walter Brattain.
1947	🇺🇸	Howard Aiken completes the Harvard Mark II (see Harvard Mark I).
1948	🇺🇸	IBM introduces the '604', the first machine to feature Field Replaceable Units (FRUs), which cuts downtime as entire pluggable units can simply be replaced instead of troubleshot.
1949 May 6	🇬🇧	This is considered the birthday of modern computing. Maurice Wilkes and a team at Cambridge University executed the first stored program on the EDSAC computer, which used paper tape input-output. Based on ideas from John von Neumann about stored program computers, the EDSAC was the first complete, fully functional von Neumann architecture computer.
1949 Oct	🇬🇧	The Manchester Mark 1 final specification is completed; this machine notably being the first computer to use the equivalent of base/index registers, a feature not entering common computer architecture until the second generation around 1955.
1949	🇺🇸	" Computers in the future may weigh no more than 1.5 tons. "

—Popular Mechanics, forecasting the relentless march of science.

http://en.wikipedia.org/wiki/Timeline_of_computing_2400_BC- 1949

Reading: [As We May Think by Vannevar Bush](#)

Links for further reference

The Museum of Computer History - http://www.computerhistory.org/

DigiBarn's Museum of Computer History - http://www.digibarn.com/

The computer used in the Apollo moon missions - http://authors.library.caltech.edu/5456/1/hrst.mit.edu/hrs/apollo/public/visualintro.htm

Stanford University's online computer museum - http://infolab.stanford.edu/pub/voy/museum/phototour.html
The Antique Attic from IBM - http://www-03.ibm.com/ibm/history/exhibits/attic/attic_intro.html

A Brief History of Computing - http://www.jeremymeyers.com/comp

HitMill's large list of computer history links - http://www.hitmill.com/computers/computerhx1.html

About dot com's links to computer history - http://inventors.about.com/lr/history_of_computers/58264/1/

PBS's Triumph of the Nerds pages - http://www.pbs.org/nerds/

For you to consider and further research

Who were John Presper Eckert and John Mauchly? Why are they famous in the history of computing? What anecdotes about their work are of interest?

What else was John von Neumann involved in besides the design theory of computers? What is the link between his main areas of work?

In what year did the PC revolution really take off? What were the factors that contributed to its popularity?

When did the first battery powered laptop appear for sale? What was its capacity? Its specs?

When did PCs become affordable? What is the price that defines affordability?

Compare the qualities and abilities of paper tape, magnetic tape and solid state memory in terms of reliability, speed and durability.

What other early mechanical calculating devices would you include that are not mentioned in this section? (For example, other Arabic/Muslim scientific contributions that you think affected the development of the computer?)

What other chip manufacturing companies have you heard of that are not mentioned (but should be)?

Considering the short time PCs have been around, what will the future bring?

Why have computers taken over our lives? Can we return to a world without PCs?

After chips are embedded in our appliances, will they embedded in our bodies?

How do you envision computers will look 100 years from now?

Selected Terms

4-bit processor
Atanasoff-Berry Computer
binary system
Colossus Computer
CPU
De-bug
Embed
ENIAC
Enigma Machine
Ethernet
e-ticket
First Generation (Second …)
GUI interface
Harvard Mark I
hash mark
ICT
Integrated Circuit
lookup table

mechanical calculator
Memristor
Multi-core
Nanotechnology
player piano
POS
punch card
side rule
Stored-program computer
Tabulating Machine
Transistor
UNIVAC
Vacuum tube
Vannevar Bush
Victorian Internet
Von Neumann architecture
Win-tel

How Does a Computer Work?

Combined with the lower prices for the raw parts used to build a personal computer, the advent of the GUI made computers a lot more accessible. The people who operated the earliest computers, and even those early adopters who first learned to compute on the primitive DOS-based machines had to understand much about the way a computer works. These early computer users literally had to re-configure their computers every time they wanted the computer to perform a new kind of calculation or program. Similarly, users of early systems were required to understand a lot of the basic commands that made a computer work. The remnants of these days are remotely accessible from the "cmd" command at the Windows "Run" menu choice.

The Wikipedia definition of a computer is "a device that manipulates data according to a list of instructions". Another, perhaps more graphical definition of a computer breaks the device down into its main parts. While there are architectural variations, the basic design of a computer can be broken down first into two main categories: hardware (the solid parts) and software (the instructions). Note that there is a certain amount of overlap here: some of the actual hardware has instructions built into it. It is hardwired so that the

Macintosh GUI

computer can perform some basic operations even before any data is loaded or entered, for example when you first "boot" or turn on a computer. The basic components that make a computer work can be summarized as hardware, software and data, and this is true whether you are talking about a handheld device, a desktop model, a high-end workstation for video processing, a server or a super computer in a university research lab.
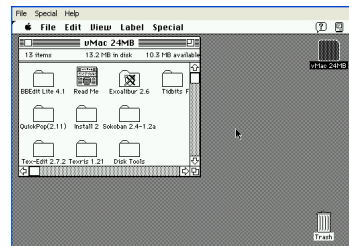
A general purpose computer needs to be able to accept input, it needs to be able to process the data, it needs to be able to output the resulting information and it needs to be able to store the information. Based on this, another definition of a computer would describe it as a device that processes data based on an architecture that includes 4 basic parts: input, data storage, output and processing/control elements. This design has been the model for virtually all computers since the 1940s, when John von Neumann came up with the basic idea.
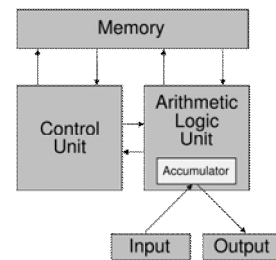
Von Neumann architecture

Hardware

The hardware that makes up a computer system can be internal (inside the computer case, such as the motherboard, memory and CPU) or external "peripherals"(such as the monitor, the mouse or the keyboard). Each of the hardware devices are generally categorized as being a part of one of the basic "von Neumann" system parts: processing system, memory system, I/O system (for Input/Output), and storage system.

Inside most modern computers is a large card (or board) that has lots of etched circuits (some of them wide "pathways" called buses) on it as well as slots for additional cards in addition to several Integrated Circuits soldered to it. This large card is known as the motherboard, and because there are many competing standards, different motherboards are able to work with different sets of chips. (You cannot use a motherboard designed for the early x86 family of processors with today's CPUs.) Inside the case, there are also additional devices inside their own casings or boxes (for example you will probably find a separate power supply, a separate casing section for the drives, special casings for fans to cool the system, and so on.)

Power supply inside case

A Personal Computer (PC) includes an electrical system that begins with a power supply which accepts household electrical voltage (220 or 110, for example) and converts it to the lower voltages that are used by the various internal devices. A typical power supply has several bundles of cables that extend towards the motherboard and the internal devices to provide them with the power they need to operate. This internal voltage tends to be in the range of 5 – 12 volts. One main set of cables plugs directly into the motherboard, and the other sets of cables mostly provide power to the various devices like CD/DVD drives, which need power to turn their internal motors.
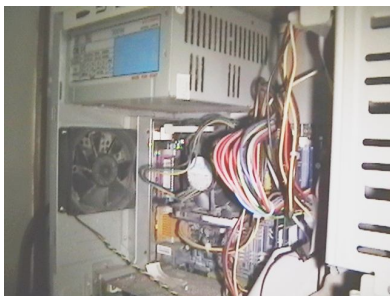
Inside the case

Typically, on the outside front of a computer case, there will be power switch (and maybe a "warm" reset switch as well – today's computers unfortunately still "hang" or freeze (aka the Blue Screen of Death – BSOD for Windows systems) often enough that this "feature" is almost standard!). There may also be places for you to plug in various external devices that are regularly used but commonly removed when the system is turned off (for example, headphones and USB devices). On the back side of the computer case, there are a series of other plugs (generally known as "ports" – if you know French, you might relate to the use of the word for "door") that allow the user to connect various external/peripheral devices that are not frequently unplugged(for example, the keyboard).

INPUT DEVICES

For the most part, input devices are external hardware parts – box-enclosed additions that sit on your desk outside but near your computer. The primary input devices today remain the keyboard and the mouse. Keyboards come in a variety of shapes and designs (consider how users of a non-Latin alphabet input their symbols!). In general, a keyboard includes several discrete areas: the alphanumeric section (A-Z and 1-0),

Closeup of a keyboard

the numeric keypad (the special numbers-only section generally to the right side), a row of "Function keys" (F1, F2 …), the cursor keys (arrow/direction keys) and various additional control keys (CAPS LOCK, Delete …) Keyboard-type commands or text-type directions can be input using other devices besides the keyboard: some systems allow user text input from a

pen-based system which may recognize handwriting, or perhaps voice recognition software via microphone input which recognizes voice commands.

The standard mouse is a device that detects motion along the desk surface and translates it into directions for the graphical user interface – the GUI. In addition to detecting direction, the mouse also accepts input via 1 or more buttons which the user clicks/presses to signal selection of a choice. The standard mouse of the 1990s detected motion via a "ball" that turned wheels inside the mouse (up, down, left or right) and accepted click input via a right and a left button that could detect single, double or triple clicks from the user's fingers. The classic Macintosh variation had only one button, and some Windows mice had 3 buttons and possibly some side-positioned switches to constrain the mouse movements, where the third button offered control of special features, that specialized programs might need. Today's mice have moved away from the rolling ball system (why?) to an optical system that has fewer moving parts and offers more accurate, more precise control.

A mouse

Other input devices that may be attached to a PC include a scanner (generally a "flatbed" scanner, but there are handheld scanning devices) for capturing and inputting images, graphics tablets that allow the user to move a pen across a surface that registers the motion and pressure of the pen to command the computer, a microphone (that would allow the user to control the computer via voice commands), and other task specific, specialized devices to input data (bar code readers are common input peripherals in supermarkets, for example, but not in people's homes, and there are special input devices for disabled people that detect and convert to input the blinking of an eye).

OUTPUT DEVICES

The two most common output devices are screens/monitors and printers. In the field of "real-time" output, recent trends in technology have made a move away from the "classic" CRT (cathode ray tube) monitors of the 20th century towards variations on an LCD (liquid crystal display) screen. Among the major benefits of the newer LCD-type screens is lower power consumption (and therefore less heat dissipation), and less possibility of radiation (the CRT bombards the user with possibly dangerous electrons shot directly at the user's face from a "gun" at the back of the monitor). The general trend towards a continuing drop in costs has meant that projection screens are also now fairly commonly attached to home/business desktop computer systems. As technology changes and new methods are discovered, LCD projection systems are being replaced with newer, better quality, more reliable systems such as DLP (digital light processing), which uses computer controlled microscopic mirrors, and LCD monitors are being replaced by plasma and OLED (organic light-emitting diode) screens. As with many other computer parts, if you are looking to purchase a new system, you will want to research cost versus benefit and quality because there are many choices now available.

Printers have evolved over the years so that the most common type of printer from the 1980s is now only commonly used in places like banks. The dot matrix printer, once the most common type of printer, operates with a series of 8 or more pins that strike the printing surface (either directly onto (heat) sensitized paper or to an ink-coated ribbon) and produces

its images via a series of dots. The two most common printing technologies in use today are the ink-jet and laser printers. Prior to dot matrix technology, most printing was done on devices with fixed typefaces such as daisy wheel printers and line printers.

Ink jet printers "squirt" very small drops of ink onto the printing surface to produce the output. Laser printers coat the printing surface with toners (powder dyes) and then bake them onto the paper or other printed media. A variation of these printing output devices that is more commonly found in industrial applications is the plotter: a large format printer that may use pens or ink to produce large, poster-sized images. Yet another variation on the standard printer is the photographic printer that is sometimes attached directly to digital cameras and often works with heat sensitive papers and dyes (thermal printers).

Dot matrix printer output
http://en.wikipedia.org/wiki/Dot-matrix_printer
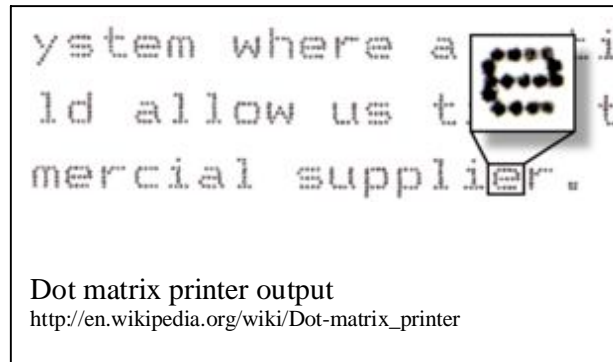
The quality of the printed output (called the resolution – a term also used to measure screen quality) is measured in dots per inch (dpi). Although it is possible to print graphical images on a dot matrix printer, if you consider the in-built principle of spaced dots, you can imagine what the quality of the output might be like (pretty poor). Regardless of what type of printing device you use, it is very difficult to match printer output colors with screen colors – or to match either of these with "true" color. An average laser printer offers a resolution of 600 dpi, and at this level of detail, it is hard to see that the characters are in fact made up of dots. Whereas monitors typically work with a red-green-blue system (RGB) to generate colors, color printers commonly use cyan, magenta, yellow and black inks (CMYK) to produce output. (Research idea: what is the resolution of "classic" book printing?)

One family of devices can act as both an input and an output device. Modems and network cards attach to the I/O system of a personal computer to provide incoming and outgoing data transfer, generally connecting to the telephone system or POTS (Plain old Telephone System). Typically, their function has been to convert the analog noises of the telephone system to the digital requirements of the computer's internal system, but more recent telephone system advances have partially done away with the need to convert the data to an analog format for transmission along the phone lines

A network ethernet card

(How does ADSL work?). Additionally, touch screen monitors (used at bank ATMs and PDAs are also "combo" devices. (Can you think of any other devices that are both input and output?).
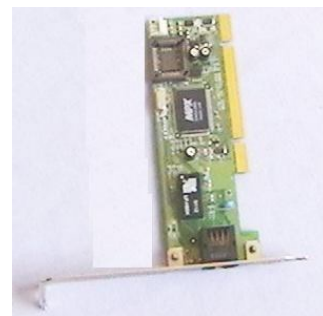
STORAGE

The category of storage devices includes hard disk drives (HDD), floppy disks (no longer common because of their limited capacity for storage), CD and DVD drives and various

external devices that often connect to the USB (Universal Serial Bus) ports of the computer, such as Flash drives.

Of these, the HDD, floppy and CD or DVD drives are generally housed inside the case. Each of them has its own metal casing, a sort of box that protects the internal hardware of the drive. For floppy disk drives and CD/DVD drives, the "front" side of the device box is accessible through a slot in the front side of the computer case; this allows the user to insert the media (floppy diskette or CD) without having to open up the computer case. Once they have been installed inside the case, HDDs do not need to be accessed, so they do not have a visible slot on the outside of the computer. Most computer cases have a "rack" that holds these drives. The drives are attached to shelves in the rack with small screws (to keep them from sliding around because a user will be pushing the disks into them during use). At the back edge of these drives there are several different cable connection points. An HDD or a floppy disk drive will have a series of pins fitted to a cable standard like IDE, SCSI or SATA for connecting the data cable and another place for attaching the power cable. A CD/DVD drive will additionally have a third place for connecting the sound output from the drive to the computer's main sound system on the motherboard.

Front panel of a "tower"case

HDDs and floppy disks use magnetic properties to save the data. Using a magnet on a "head", they can polarize (north/south) the metals on their surfaces and the polarized metals can be read as 0s or 1s depending on their polarized orientation.

CDs and DVD are optical devices that burn "pits" and "lands" into their surface, and when the laser beam in the device shines on them, will reflect back to an "eye" that detects whether it is reading 1 or not reflect back because it is reading a 0.

USB storage, in the form of removable USB Flash drives or USB connected external Flash HDDs offers portability of the data, so users can take their data with them and plug the device into and access data at another computer.

Side panel of a Macintosh laptop

Finally, magnetic tape is another medium that can be used to store data. Many of the earliest personal computers used cassette tapes to store and retrieve data (note that this process covers both input and output) and even today, large amounts of corporate data are regularly archived on tape. All of these storage options are considered "non volatile" storage media: the data that is saved on them will remain saved even when the electrical power has been turned off. And each of them has its benefits and drawbacks. Some are removable, some are cheaper, some are better for long-term archiving purposes, some are faster, and each has different capacities.

With storage decisions, users need to consider several factors: speed of data access (how fast does it read and write?), cost per byte of storage (how much does it cost to archive 1 MB of data on a DVD versus the cost on a tape), permanence (will you be able to get your data back

in 10 years if you save it on a device that is no longer being sold? Will the metal oxide materials survive 10 years of storage?), speed (tape is great for large amounts of data but because it is sequential, you must wind the tape to the point where your data is, whereas a CD or HDD can be accessed directly). Is the cheapest actually the most cost effective solution in the long term?

Within the category of storage, some people may note that memory is also a form of storage. In fact, memory is considered "primary" storage, while the above media a called "secondary" storage.

MEMORY

Today's computers utilize two main categories of computer memory: RAM (Random Access Memory) and ROM (Read Only Memory). RAM is generally considered volatile: if no electrical power is available, the data saved in memory will be erased. Hence, it does not offer a viable form of long-term storage.
The most common use of ROM is in the BIOS (Basic Input/Output System), a chip that provides the computer with the basic instructions it needs to "boot" (start up). Some of the information that is kept in the BIOS chip is hardwired (built in at the time of manufacture) and some of it can be changed and saved according to a user's options. However, a small "watch-type" battery inside the case provides electrical power to the BIOS at all times, even when the computer is turned off. BIOS chips are a common method for adding computing power to household/everyday appliances: applications where a set of unchanging instructions are appropriate.

RAM is what people generally think of when they talk about memory. RAM is available as chips soldered onto a thin, narrow card that fits into special memory slots on the motherboard. In generally, the more memory a computer has, the better it is able to store temporary data needed to work. Early x86 computer system had 4MB (Megabytes) of RAM. Today's XP and Vista systems need at least 1000MB (or 1GB) of RAM to work effectively.

One way to understand RAM is to compare it with a large postal box system: lots of empty boxes that can hold different kinds of information in "addressable" locations. When a computer is powered up, the information that the computer system needs "now" is transferred into these memory locations. For example, the RAM may hold your temporary data while you are working on writing a document (and that is why you could lose your file if the power goes off or if the computer crashes while you are working:
the data for your file is temporarily stored in RAM.) A computer system that does not have sufficient RAM for the tasks it is trying to perform (for example if you are simultaneously running several different programs or working on a very large project that required lots of memory) will use the HDD as a temporary memory location, "swapping" the data that cannot fit into RAM back and forth from the HDD to RAM. When a computer's power is turned off, the data in RAM is lost

Memory chips

(but the computer may be able to locate and retrieve parts of the data/file that were temporarily stored on the HDD).
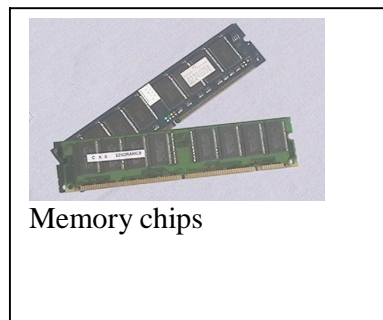
PROCESSOR

The processing components of a computer system are basically the CPU (central processing unit) and the ALU (Arithmetic Logic Unit). Developments in computer architecture over the years have added new tweaks to this basic configuration in an attempt to improve speed and efficiency, but the principle hasn't really changed.
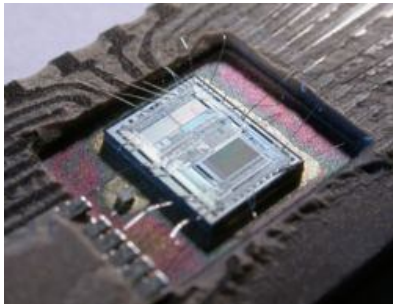
The CPU processes instructions as fast as its clock allows. A modern CPU may have a clock speed of 2 GHz (Gigahertz), for example. Every second, the CPU is able to process 2 giga (~2 billion) instructions. The CPU operates on a cycle known as the "fetch-decode-execute" cycle in which the CPU asks for the next instruction (mostly likely in one of the RAM locations), decodes what this instruction data means (is it an action? is it a number?), and then passes it along to the logic unit to be executed (or acted on). The CPU has a very, very limited amount of memory (called registers) in it – enough, for example, to hold 2 numbers that need to be compared (or added) The ALU works together with the CPU to evaluate the decoded data that is stored in the registers and then, when it has performed its operation, will pass that data on for saving in memory so that it can perform the next logical evaluation. In addition, the processing hardware includes a "control unit" that helps keep track of "who is doing what and what to do next".

An Intel CPU
http://en.wikipedia.org/wiki/CPU

For example, a simple addition operation could be handled this way:
1. The CPU fetches the next piece of data from a RAM address.
2. This piece of data is an instruction: in this case the CPU decodes the instruction as "add two numbers".
3. The CPU tells the ALU that it is going to add the next two pieces of data, which are numbers.
4. The CPU cycle fetches the first of the two numbers from the next memory address and passes it to one of the registers.
5. The CPU fetches the next of the two numbers and places it in the other register.
6. The CPU instructs the ALU to evaluate the values in the two registers and then "write out"/save the result to a memory location address.

At a more electronic level, the numbers, for example, are a binary series of 0s and 1s. A group of miniature transistors will be turned off or on (1 for on, 0 for off) to "hold" the value of the number. A group of 8 of these "bits" (called a byte) is required to hold one such number or character.

```
      *    * * *
  1 1 0 1 1 1 0
 −    1 0 1 1 1
 ----------------
 = 1 0 1 0 1 1 1
```

Binary data
http://en.wikipedia.org/wiki/Binary_numeral_system

In the search for faster and more powerful computing, one recent trend to keep up with the demands of the market has been to increase the number of CPUs (Think: 2 heads are better than 1). Super computers have used this technique (massively parallel processing) for many years, but it is now becoming more common for PCs to include "dual" or "quad" cores: 2 or 4 CPUs working in unison can provide more "number crunching" power than a single processor.

OTHER HARDWARE

The case of a computer also houses a family of devices known as expansion cards. A computer's motherboard has a number of slots built into it that allow users to add to (or expand) the standard hardware. These cards typically have one side with metal connectors that match an industry standard, and a back plate or panel that allows connection of external cables: a special sound card would need external connection capabilitiers for microphones (input) and speakers(output). Over the years, various industrial standards for the metal motherboard connectors have evolved to provide faster transport of the data coming to and going from these devices through various buses (wire pathways). Some of the better-known standards are IDE (for HDDs), PCI (for NICs), AGP (for graphics).
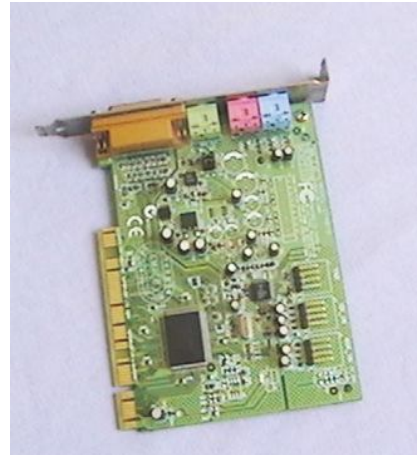
A sound card

Among the kinds of devices that may be connected are graphics (or video) cards that offer improved graphics features such as better and faster rendering of images sent to the monitor (for example, a serious games player may want top quality graphics or another user may want to watch broadcast TV on the computer). A graphics card will have its own graphics processor (called a GPU) and additional memory built into the card so that the process of drawing the pictures for the screen does not take away from the power of the main CPU.

Similarly, some users will install high quality sound cards. Like graphics, most motherboards today have built-in sound capabilities, but a user who wants to use the computer for professional sound recording may need a dedicated sound card, again with its own processor and memory. The back/external panel of this card will be visible from the back of the computer case and will allow the user to plug in external devices like headphones, speakers or to connect to a professional sound system. (Note that sounds cards allow for both input and output.)

Other cards that may be installed in some computers include NICs (network interface cards) that allow connection to an Ethernet network, modems or wireless cards for connecting to the Internet, and TV cards for receiving TV broadcast signals directly to the computer.

CLASSIFYING COMPUTERS

Computers are often classified according to their size or the tasks they are intended to serve. At the top in terms of size, power and cost are the huge, powerful computers that are designed for large tasks such as theoretical physics or astronomy, such as a Cray computer. Like the early computers of the 1950s, they are not produced in large quantities and can cost millions of dollars. These computers are called supercomputers. A bit smaller than these "monster" computers, but still capable of super tasks are the mainframe computers, which even today took a lot like the computers of the 1950s. These are the computers that typically handle the

computations for large business operations such as Fortune 100 companies, universities and governments. With developments in the Internet and networking in general, some of the functions of the mainframe computers are being handled by servers. Servers are often grouped in "farms", where large numbers of these computers combine their power to serve many users, often accessing them from distant corners of the world in a form of computing that has come to be known as "cloud" computing. Smaller computers that are more powerful than the typical desktop computer are classified as workstation computers, and might, for example, be used for high end tasks such as film processing and editing. The computer that most of us recognize – the office or home computer is generally known as a personal computer (PC). A variation on the desktop PC is the "dumbed-down" version called a "thin client" that has minimal hardware and requires a connection to a network server which provides much of the necessary service. And finally, there are smaller devices that are classified as hand-held devices.

Much of this categorization is beginning to breakdown. There are still supercomputers and desktop PCs, but new types are being invented as well. One such example is the area of wearable devices: not yet powerful enough to run intensive applications, but at the same time, not really in any of the above categories. Similarly, the line between a hand held computer and a portable phone is breaking down: "smart phones" like the iPhone, for example, are essentially handheld computers.

EXPERIMENTAL COMPUTERS

As more and more devices are equipped with computer chips, the line between what is called a computer and what is "only" an intelligent appliance is becoming blurred. Much of the experimentation involving computing power is in this area: cars rely more and more on processing power to handle complex system interactions such as mixed fuel systems, the home TV system is now partially integrated with additional computer controlled devices such as TiVo, a system which allows users to record TV shows to a had disk.

Another trend in the developing area of computers is the field of working beyond the "von Neumann" architecture. The von Neumann design of computers that has been in use since computers were invented has been criticized for its inherent "bottleneck" design. The process of moving bits in and out of a central processor appears to have its limits, and some researchers are looking for alternative systems and designs that could break through these barriers.

One such design idea involves the use of living organisms. The idea is that a living system offers opportunities that could lead to breakthroughs in size and speed.
Another area of research is known as quantum computing, which operates on the theory that unlike a binary system where the data is either a 1 or a 0, there are data states and gains to be made from systems that allow for data that is neither 1 nor 0, but instead, could be many states in between.
Yet another options being explored is the combination of smaller devices that cooperate, and through cooperation can achieve processing power beyond a single monolithic system.
Finally, the drop in price of flash technology has meant that

A Palm PDA

computers that do not rely on traditional hard drives (using large flash memory in its place) has meant that computers that boot quicker, consume less power and take up less space are becoming popular alternatives, particularly in devices called netbooks – small sized laptops such as the OneLaptop Per Child program's XO computer.

Software

Software is the instructions that make a computer's hardware perform its tasks. Without software, a computer would "idle", doing nothing because it wouldn't know what to do. Computers are basically dumb and need to be instructed to do things.

The first generation of computers was built in a way that allowed it to run only a single program. In order to get it to run a different program, to do a different type of computation, it had to be re-wired or re-built. Only later were computers designed so that they could run "stored" programs simply by reading a new set of directions.

As noted above, there is a limited amount of software (sometimes called code) that is written into the hardware components of a computer, as for example, the startup directions that are built into the BIOS chip. Software, after all, is a long string of 0s and 1s, and although most software is saved on disks, it is possible to save software on chips as well. (If you ever had a Gameboy ®, you may have realized that the games were saved onto chip cards).

Software can be thought of as a solution to a problem: an algorithm for how to do something. As Alan Turing postulated early in the 20th century, a computer can solve any problem that can be broken down into a series of explicit directions.

Consider this classic example: you need to put a lamp post in your garden. If you break the job down into its various components, you will see that you can detail the sequential steps fairly clearly so that you could describe the work that needs to be done to someone else.

1. First, get a shovel.
2. Then select the location where you are going to place the lamp post.
3. Next, take the shovel and push it into the earth.
4. Remove the dirt that you loosened with the shovel from the hole.
5. Go to step 3.

The key to a good algorithm is both efficiency and accuracy. Remember: computers are dumb – they do not have "common sense". Although the above "digging" algorithm is mostly correct, for a computer, these directions would present a problem. A human would understand when to stop. A computer following these directions would dig a hole right to the other side of the world because the algorithm doesn't say when to stop repeating. (Incidentally, the digging example above is one part of what the Mars Phoenix robotic computer was programmed to do.)

Software can be classified in several broad categories: Operating system software, utilities, and applications. Software needs to be written for a specific operating system and for specific hardware: programs written for a Macintosh system
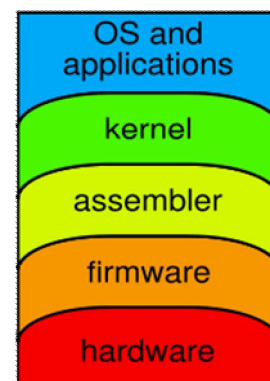
Software abstraction layers
http://en.wikipedia.org/wiki/Abstraction_layer

are not compatible with a Windows system, for example. Further, software that requires special hardware may not work on a computer without that hardware, or it will run erratically or poorly without the necessary hardware.

At the lowest level, software is a string of binary digits. Each processor also has its own set of operational commands. Generally, backwards compatibility is possible, but an older computer and processor may not be able to understand instructions that were written for a newer set of chips.

Whatever programming language is used to write the instructions, in the end, these instructions need to be converted to a language the computer can directly understand. Programming languages have evolved since the days when programmers directly switched the cables by hand (a low level form of programming known as machine language) to higher level languages that are easier for humans to work with and which often resemble English. However, programs written in the higher level languages (like BASIC or C++) need to be translated, compiled or assembled into a form that the processor can work with. (See the table above for a graphical representation of how software operates on hardware.)

When a computer first boots, one of the first programs that needs to get up and running before a user can do much is called the Operating System (OS). The most common OSes today are various versions of Windows, the Macintosh OS or Linux. These operating systems handle the low level functions that may control the hardware so that the user doesn't need to be concerned with how to tell the computer to perform its basic tasks. For example, the computer needs to be continuously "listening" to the keyboard or the mouse so that it can react if the user presses a key. Or the OS may handle the actual sending of the stream of data characters that needs to be printed to the printer port. Typically all of the common OSes offer a GUI interface to the user that hides the inner workings of the system and makes the user's job easier.

Obviously, however, most people do not write their own programs – even if it has become much easier to do. Instead, the average computer user purchases or downloads the software he needs to do certain tasks.

The programs that a user runs are called applications. This category of software includes programs for writing documents, drawing pictures, making movies, listening to music, doing mathematics and surfing on the Internet.

A GUI from Linux desktop
http://en.wikipedia.org/wiki/GNOME

Software applications may be commercially sold and require a license (some can cost thousands of dollars) or they may be trial versions that work for a limited time (often called shareware), or they may be free programs (freeware, open source or public domain). (The same is true of OSes: some are free and some are commercial.) Typically, commercial software is sold or licensed and the terms of use are controlled by an EULA (End User Licence Agreement) which spells out in (incomprehensible) legalese what rights the person who purchased the software is granted – or

not – and to what extent the company producing the software can be held responsible for the quality of the software. Much user frustration stems from the fact that theEULA for commercially sold software is essentially non-negotiable: you either agree and use it as is or you don't use it at all.

In a historical perspective, there have been ways in which people have felt that some software has been so good that it has made a difference in the public's acceptance or perception of their need for computers. For example, the general public saw no need to own a computer in the 1960s: there wasn't much that the average person could do with one if they had one. The kind of program that convinces large numbers of people to adopt a new technology is called a "killer app".

Combined with the availability of reasonably priced computer systems in the 1970s, accounting software made it clear to many businesses that using a computer with a spreadsheet application could make a (profitable) difference to the success of a business. The program that is credited with changing the public opinion was called VisiCalc. Two other programs that might be said to have influenced the public favorably towards owning a computer were the GUI, first from Macintosh and later Windows OS (in spite of its many problems in early versions!) and Netscape (the first Internet browser, which actually had close to a %90 market share until Microsoft decided to improve and emphasize its own application, called Internet Explorer.)

Yet another category of software is known as utility programs. The distinction between utility programs and applications or OS software is a little confused. A utility program is usually a fairly small program that is intended to take care of a single task and often enhances the OS. Some utility programs may be included with the OS and others may be added/installed when the user sees a need. Examples of this kind of program could include programs to optimize space on a hard disk (a defragmenting utility, for example) or a file conversion program (to take a movie file in the WMV format and convert it to the AVI format, for example). You may be able to see that these programs are not so much designed for the user to actually create material as in a word processing program, but rather to make small necessary adjustments that simplify the users tasks.

There has been a movement related to software distribution for some time that appears to be gaining in popularity. Initially (and still in some uses), an individual's computer would connect to the local network server and run the application over the network: the worker's PC had virtually no software installed on it. Aside from the benefits of cheaper PCs (because they didn't need all the parts of a normal desktop PC), this configuration is much easier for an IT department to manage. The IT department is able to keep tight control over the software in use, and hence the number of licenses they must pay for. In addition, this method also helps keep users from damaging the systems when the try to install their own programs. Today, partially because most computers are connected to the Internet, a variation of this idea (being called "cloud computing" because the Internet is often referred to as a cloud) offers users free or licensed access to application programs that are hosted on a remoted computer such as an Internet server. You may not realize it, but this is what services such as hotmail or Gmail have been offering for years. Now, that same configuration is available for other applications as well, such as in Google Apps.

The Software Giant

In 1975, when William H. Gates III was a
student at Harvard University, the first personal
computers had just started selling to the public.
Bill Gates and his friend Steve Ballmer made an
agreement with MITS, one of the companies
producing personal computers, to write software
for their computers. In 1981, Microsoft struck a
deal with IBM to develop an operating system,
DOS (for disk operating system), that
eventually became the standard OS for pre-GUI
personal computers everywhere. By the end of
the 1980s, Microsoft was marketing its early
versions of both Microsoft Office and
Windows.

http://en.wikipedia.org/wiki/Microsoft_Office

Among the noticeable changes that have
happened over the years has been the growth of the average size of a program. This trend is
commonly known as software bloat. Microsoft's first popular version of Windows, called
Windows 3.1, was marketed/sold in 1990 in a package that consisted of about 10 floppy disks
(1.4MB x 10 = ~20 MB total size). Windows 2000 and XP were distributed on CDs (~ 700
MB in size). Today, Microsoft's Vista OS is sold on a DVD.

Part of the reason for the bloat is that software in general is much more capable than it used to
be. If you take the example of Microsoft Word, an application that is called a word processor,
you can get an idea of the extended capability of today's software. Word allows you to do
much more than simply write a text: you can use the drawing tool bar to drawing pictures.
You can do spreadsheet-type calculations in the tables in Word. You can even use the macro
editor in Word to write computer programs in Visual Basic. All very handy, but it is worth
considering if you really need all this in a word processing program.

The Vista version of the Microsoft Office "suite" of programs also fills a DVD. Although
there are different versions of the suite that include more or fewer programs, the most
commonly known configuration includes Word (for word processing), Excel (for
spreadsheets), PowerPoint (for presentations), Publisher (for desktop publishing) and Access
(for databases). Armed with these applications, you should be able to run an entire office on a
group of networked computers.

The Software Development Cycle

It is awfully easy to criticize a large company like Microsoft for the quality (or lack) of their
software. Security holes that allow hackers to exploit weaknesses in the programs, delays of a
year or more in getting new versions of programs onto the shelves of stores, oversized
(bloated) files sizes and more are some of consumers' complaints. Before you start talking
about how bad the software is, you might consider the other perspectives related to software
development.

Putting a program on the market can be a daunting task. On the one hand, there is the open source movement – free software where the underlying code is made available to the entire world. Some of the open source movement is a reaction to the overpricing of commercial software like Windows. Another part of the open source community is dedicated in principle to the idea that software whose code is "hackable" is inherently better because other people can freely examine, criticize and help fix any problems that occur.

While there are a limited number of programmers who work to develop a program on their own, collaboration among several people (or groups of people) is the norm. At the least, good software development requires the use of "beta" testers – people with no direct interest or detailed knowledge of the program, who test the program for functionality, user-friendliness and robustness: does it do what it promises to do, is it relatively easy to navigate and operate, and does it work under unusual circumstances?

A program on the scale of Word (or Windows) is extremely "tentacled": it has functional links/interaction with many other programming elements. Consider for example the relatively mundane task of adding support to your program for a mouse. Not all mice are equal: the number of buttons a user's mouse has may cause unforeseen problems if the user has the mouse configured for left-hand use, the underlying software that makes a mouse work may not be written so that it includes the latest "patches". Lines of code may be using a call to a routine that is based on the default speed of the processor, which can change over time (a FOR-NEXT loop, a basic element of programming, runs as fast as the processor's internal clock, so programs that were written for earlier processors will run faster than they used to – with unintended consequences.)

The entire process of software design begins with the idea: for example, "we need a program that allows the user to create a printed document."

Before anyone sits down to start writing the lines of code to make this happen, a more specific definition of the requirements of the program is necessary: is it OS specific (Windows only), will it run on a network/internet, will it use already developed (and likely proprietary) software from third parties? What will the specifics of each menu section include, what is the color scheme, what are the specifics of this kind of program?

Modern software development usually involves writing blocks of computer code that perform a specific function: the basic idea behind computer programming is to break a larger task down into smaller "blocks": typing a letter onto a blank screen involves checking to see if the user has pressed a key (a low level system feature), reading the code generated by the user's keypress, transferring the alphanumeric equivalent of the keypress-generated code onto a pre-defined area/window of the screen at the correct position (is the cursor at the end of a line or somewhere in the middle of previously typed text..), displaying it in the correct format (Arial 12 bold, centered in the second of five colums…)

The problems are further exacerbated by the needs of a large variety of users: MS Word aims to provide for the needs of the simple "flat" text writer with few if any formatting needs, up to the professional page layout artist who expects to be able to adjust the kerning on individual letters to "tweak" the final output. Even "standard" software like Word has so many features and many of them are rarely used by the average user.

In brief, the software development cycle entails the following "standard/accepted" steps:

Software Development Cycle

Analyze Needs → Design Program → Develop Program → Test Program → Maintain Program
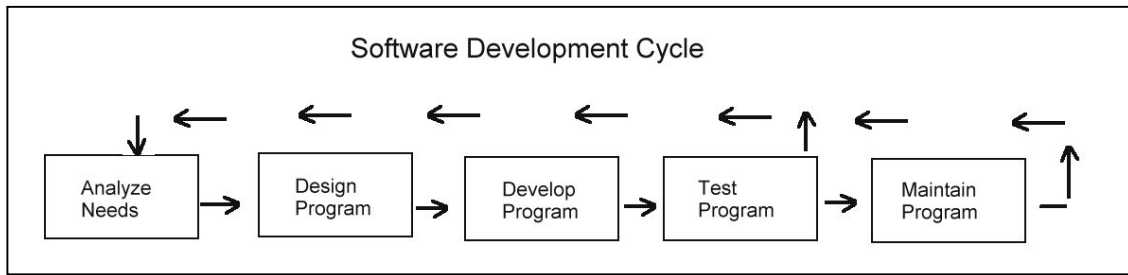
The initial step, analyzing the needs, requires that the programmer(s) consider what the program is intended to do. What will users expect or need? Consider the example of a word processing application: will it simply allow users to enter text or will it also allow users to include graphics (Word or Notepad?). Will it allow for "non-standard" language input?

Each step of the above cycle has its own areas of expertise: planners, programmers, testers … And they all need to work together as a team: deadlines, agreement, often adapting their ideas as new issues become apparent. Considering the stages and number of people involved, it is easy to see how "bloat" can occur.

Often, the people who put together a program ask for input from outsiders – sometimes in the form of "beta testers", non-programmers who will simply use the program and give suggestions on how it can be improved. People who have spent long hours developing a program can easily overlook simple issues that "regular" people will see.

Even after a program has been placed into the market, there is often a need to go back to the program once more and make changes for a new version, or perhaps to provide updates or patches because of critical mistakes. If the program is being sold, it will likely need to be maintained: patches, fixes new versions and new features will be added over the years.

The Open Source Movement

Software whose code is secret cannot benefit from the input of many people. This is the theory behind the Open Source software community. The first and most famous example of this movement is the Linux operating system, developed first by Linus Torvald. Open Source software is almost always free and open to changes by the public – anyone is welcome to look at the software code and make changes. If the changes are worthwhile, they are adopted and included in later versions or updates to the original software. Today, there are thousands of software titles available for free: you can find open source programs for almost every need, so that you do not need to spend any money for software. Although much of the focus is on software that runs on the Linux OS platform, there is a lot of open source software available for Windows and Macintosh OSes as well. For example, Adobe sells its Photoshop application for hundreds of dollars per copy; an Open Source/free program called GIMP does essentially the same job and is constantly being improved by people dedicated to the job.

Open Office
http://en.wikipedia.org/wiki/OpenOffice.org

Another example of a successful open course software project is the Open Office suite of programs that is offered as an alternative to the commercial Microsoft Office suite.

Even in areas that normally have very special needs (and hence a limited market potential – often a reason why software companies charge large sums) open source software can be found. One such area is in film editing software. On the one hand are the large companies that hope to earn huge sums from a lucrative market (How much does it cost to produce a film and how much of this cost is for the software?) The film Big Buck Bunny, produced in 2007, rivals the quality of professional similar films, but it was part of a project to prove that Open Source is a viable option in the market for creating animated films like those that Hollywood produces, for free: if you have the time.

So: a computer is essentially two parts – the hardware and the software. For each of these, there are many, many options. Some cost a lot; some are free. Although the general rule of "you get what you pay for" is true in most markets, this statement is not necessarily true for computers: especially when it comes to software.

There are computing devices that can fit in your pocket and computing devices that still fill a large room. Some cost just a few dollars, others are so expensive that only a few can afford them. Regardless of what the decisions you make about speed, size, operating system and applications, you can be sure that the computer you buy today is going to be a museum piece in just a few years!

Reading: How Computers Work (doc) by Roger Young (with permission)
Programming From the Ground Up (pdf) by Jonathan Bartlett

Additional Resources

Personal Computer Hardware Assembly (doc) by S.C. LAM
Computers (General) at Wikipedia
Personal Computers at Wikipedia
IBM, Apple, Dell, Compaq computers
PC Magazine
Harvard University Introduction to Computers Course
OpenSource software

For you to consider and further research

How do the Chinese or Arabic speakers "key" their text with a keyboard?

List some other input devices not mentioned above. Where are they used and for what purposes?

What are the cost comparisons among the various types of printing technologies? Why is it that banks still use dot matrix printers? And why is it that ink jet printers sell very cheaply and the ink used in them sells for almost as much as the printer itself?

In 2008, the Peach Open Movie Project produced an animated film called Big Buck Bunny and released it under a Creative Commons License: free to use, free even to change if you keep the original

credits. One of the goals of this project was to prove that it is possible to create professional quality materials using free software. Why would anyone do something like this for free?

How did Internet Explorer manage to overtake and "kill" Netscape?

Are all versions of Linux free? Where did Linux come from? (And where do you think it is going?)

Is it "fair" that a program like Photoshop costs more than $500 per copy? Is there any time when such a high price for a popular program is justifiable?

Even today, after many, many updates and revisions, there are sections of code in Microsoft's software that have "bugs" that can cause problems for people who buy the programs. What should Microsoft's level of legal responsibility be for these "manufacturing errors"?

What kind of market coordination is necessary when you have several companies manufacturing the hardware parts that go into a computer and equally as many companies writing software that operates these devices? Are there any benefits to a company like Microsoft (or Intel) having a near monopoly?

How many different versions of Windows have been "launched" since 1975?

Even citizens of a small country in Africa use Microsoft products. Critics complain about the effects of a product like Coca Cola on the social fabric of a developing country. What about the effects of Microsoft products? Is software more influential in causing social change than a soft drink?

Is it correct for a large global company to sell its software at a reduced price in countries where the average earnings are much lower than in the US?

Malware is the current term for "evil" software such as viruses. How would you categorize this kind of software? (Is it a utility?)

What about a user's data file – for example a .jpg picture that a user took with a digital camera? Is this software? Is an Excel file ever an application or is it simply a data file? What kind of software should it be classified as?

Compare the various types of storage devices in terms of their features: speed, capacity vs cost. Which would you use to backup the files from an office with 100 people using computers?

Cases: there are 3 basic types of casing: tower, pizza box and hand held. How would you design the case of the future?

Cooling: the main noise source of today's PCs is the fan. How would you fix this issue? What methods are creative inventors using?

Some experts say quantum computing is the future. How does it work? What will be next?

Computers based on 0s and 1s are now almost 100 years old. What might replace this system?

Open source software and Creative Commons (or pirated code) is fairly prevalent. What will the future bring for sales of (expensive) commercial software? For creativity?

Selected list of terms
Here are some of the terms used in this section (as well as a few that were not used but that you might run across in your studies):

80386/ x86/i86
ASCII
ADSL
Assembly
ATM
Binary
BIOS, POST, CMOS, ROM
Bit
Boot
Bus
Byte
Cable
Clock Cycle, Fetch-Execute-Decode Cycle
Cloud Computing
Core/Dual
Cpu, ALU, Register
DPI
Etch
Ethernet
Hang/Freese/BSOD
Hex
High Level Language
I/O Device
IDE, PCI, AGP/SATA
Layers Of Abstraction
Machine Code
Mainframe, Workstation, PC
MB, TB, MHz, GHz
Memory Types/Heirarchy
Moore's Law
Motherboard, Circuit Board, Expansion Card
OLPC XO-1
Open Source
OS
Plug/Jack
Port
RAM/ROM
RGB/CMYK
Refresh Rate & Dot Pitch, USB USB
Slot
Smart Phone
Storage Device
TiVo

Unicode
Utility Program
Von Neuman Bottle Neck
Word Size

In the half century or so that people have been linking computers to each other, many changes have come about. Perhaps the most important of them is the freedom from wires: consider the world before portable phones – and then consider the trend towards Internet access from anywhere. Even with phones that allow access to data from anywhere, we are still far from truly connected to the data we often want and need. Fast, universal access to unlimited data will change our lives.

Networking Computers

A stand-alone computer – one which does not communicate with other computers – can be a powerful tool for problem solving, crunching numbers, research and entertainment. But the true power of the computer comes when it is able to communicate and coordinate its tasks with other computers. The early computers of the 1940s had to be fed their data by re-wiring the circuits: each new piece of information and each new task had to be reprogrammed by manually reconfiguring the computer. Towards the end of that decade, advances in computing allowed for stored program computing: the computer could be fed both data and instructions that it could process without the need for time consuming re-wiring. However, in order to get the computer to perform, the user had to physically be on the scene. Any information that the computer produced was limited to its own output – the printout, the storage or the monitor of that single computer: input and output was local.

Directing the output (or the input) from one computer to another is, like sending the data to the screen or the printer or the storage, an I/O operation and requires a channel (or port) that enables the computer to communicate with the external device. This "channel" was initially in the form of a wire: a cable connecting the computer body/case to a printer, modem or other external device.

The output from earlycomputers could be stored – on cards, on tape, on paper printouts and then be carried to another computer that was capable of reading or making sense of the information – a technique that later came to be known as "sneaker net" (from the fact that someone wearing "sneakers" could run or walk the data to another computer). The limitations of this kind of data sharing are fairly obvious: it could take days to physically move the data from New York to Los Angeles. What was needed was a way to electronically transfer the data between remote locations.

Already in place as a medium for sending information were copper wires. Copper wires were used to send telegraph signals as well as telephone signals over long distances. What was needed was an interface that could connect the computer to the copper wires.

Two main technologies developed to handle this need. In fact, news services in the United States began using a simple device for their teletype machines, first in the 1920s and then more seriously in the 1940s; however, the teletype doesn't really qualify as a computer. By the 1950s, the US military had begun linking their computers using dedicated communications lines (not the public phone cable system). The device that the military was attaching to its computers was a device called a "digital sub-set". In the US, in 1958, AT&T, the company that had a virtual monopoly on the

Early US Robotics modem
http://en.wikipedia.org/wiki/Modem

telephone system, introduced a commercial device for its customers. The device was able to send and receive signals at a rate of 2400 baud. That rate equated to 2400 electrical pulses per second (roughly 2K bits/sec – recall that a byte has 8 bits). This device was a half-duplex device, which meant that it could only either send or receive, but not both at the same time (like a walkie-talkie, where one user needs to say "Over" to signal the other user that it is OK to talk now.)

In 1962, AT&T introduced a full-duplex device that was capable of 300 baud speeds of communication on normal phone lines. By the end of the 1960s, the market had begun to grow, and there were acoustic coupling devices available for commercial use. These devices allowed users to place the telephone handset in a "holder" that was connected to the computer's I/O system. Throughout the 1970s, advances were made that increased the throughput speeds from 300 baud to 1200.

An acoustic coupling device
http://en.wikipedia.org/wiki/Modem

Further developments had made modems both affordable and practical devices for hobby users by the 1980s. It was at this time that home users discovered the joys of sharing data not just through direct communication between two users, but through a shared computer, and the Bulletin Board System (BBS) began to grow. With a BBS system, a user was able to dial the phone number for a modem that was attached to a remote computer and "login" to the remote system. A computer hosting the BBS program might have more than one modem attached, and so it could simultaneously host more than one remote user.

The Age of BBSes

Throughout the 1980s, BBSes ruled the field of shared computer communications. The Internet was not yet publicly available. BBSes required a user to dial the phone number of the BBS system and then login using a terminal program. Although later advances allowed for some limited use of graphics, the interface was primarily text-based. Once a user had connected and logged in to the system, there was a menu of options that could be chosen. Commonly, a user could upload or download files from or to a storage area, and the storage area could be protected or divided so that different users would have different levels of

An example of ASCII art –
Character symbols create the image
en.wikipedia.org/wiki/ASCII_art

access. Users could also post or read messages to "forums" as well as sending private message to and from personal mailboxes. Some BBS systems also hosted online games (again, primarily in text format). Some BBSes made use of advanced ASCII techniques to provide elementary graphics and color – in the form of text known as ASCII art.
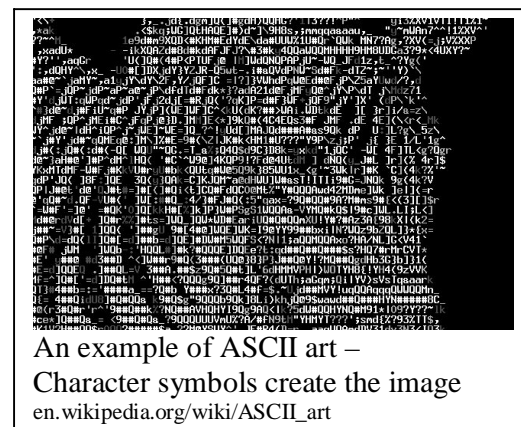
There were BBSes dedicated to certain hobbies, so that users with common interests might share their materials. Although it was possible to connect to any system if you knew the phone number and were able to create a user account, most BBS connections were local: otherwise, you would be paying long distance phone rates – a rather costly way to

communicate. Most BBSes did not charge users to become members, but they still had to pay the phone company for the time they were using the phone system.

With the arrival of the Internet, the popularity of the BBS systems quickly faded. Many of the functions of the BBS systems were available on the Internet: uploading and downloading files, mail, forums etc. During the time when Internet access was not so common, some BBS systems installed gateways that would allow users to login to a BBS and use that connection to access the Internet. Several large BBS-type companies like AOL and Compuserve managed to maintain their closed systems with various forms of inter-connection to the Internet for many years after the arrival of the Internet. Among the benefits of the closed community was the ability for the users to be able to locate material because the BBS had organized it for them. For the BBS companies, rather than try to deal with the relative anarchy of the Internet, it was easier to deal with, manage and control a closed set of users – in addition to guaranteeing a source of revenue through monthly membership fees.

A modem (modulator/demodulator) is a device that is able to convert digital data to analog sound signals or tones that the telephone cables can transfer. A (remote) modem on the other end picks up these sounds and reconverts them to digital format for the other computer to process. The 0 of the digital system is a tone generated at 1070 Hz and the 1 is a tone at 1270 Hz. Fax machines that became popular in the 1980s are essentially dedicated image conversion devices with modems, and in fact, almost all computer modems can also work as fax devices. Throughout the 1980s, various companies, including US Robotics, worked to increase the speeds that data could be sent, eventually working up to 56K by the late 1990s. At this speed, all sorts of "tricks" are used, including data compression or even pairing two modems together to effectively double the speed. With the advent of digital phone lines, the use of the traditional modem has been replaced by ADSL modems and WiFi wireless connections.

The second most common way to connect to or more computers is through the use of a dedicated network. A computer on a network doesn't use a modem for its data transfer, but rather uses a network interface card (NIC). As part of the development of ARPANET, special computers were used to connect other computers to each other – an elementary kind of router. In 1973, Robert Metcalf invented a technology called Ethernet, which initially competed with other network technologies such as "token ring" but has since become the de facto world standard. As part of the development of the ARPANET, other scientists including a man named JRC Licklider came up with an additional technology known as TCP/IP – a set of rules for how networked computers should communicate. Metcalf went on to found a company called 3Com, and in the early

A 3Com NIC
http://en.wikipedia.org/wiki/3Com

1980s began to market an I/O device that allowed people to connect their computers to Ethernet networks. In the 1980s, (this was before Microsoft was offering commercial solutions in network technologies), there were a number of different standards for the cards, for the cables and for the way the devices interoperated. A company called Novell managed to bring them all together into a system that allowed various parts to work well (called NetWare). (Only after this did Microsoft begin to make inroads in the network area.)

Although there are various ways to set up and operate a network, the basic principle involves attaching cables to a NIC installed in each computer, and then joining these cables at common points so that they can send messages to each other. Each computer is called a node on the network. A local area network (LAN) is the kind of network you would find in an office in a building. Sometimes, these offices will have other branches in other cities, for example, and so they will be joined with a wide area network (WAN). The Internet itself can be seen as a kind of WAN and is often called a network of networks.

Various network toplogies
http://en.wikipedia.org/wiki/Network_topology
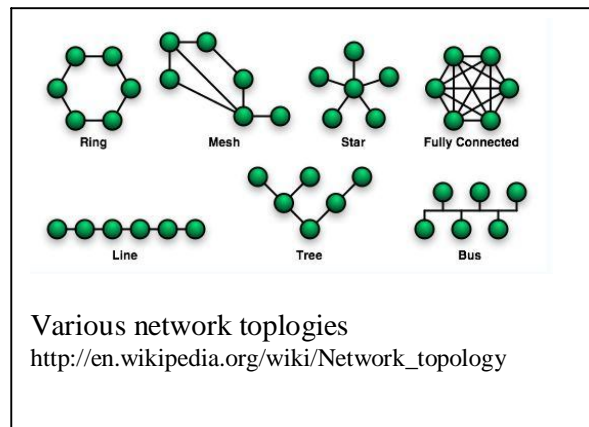
Computers on a network do not have to be the same kind: you can have Windows, Macintosh and Linux computers all wired together. You do have to have them all speaking the same language: a protocol, or a set of rules for exchanging data. There are different structures for networks, but most small networks are designed on a peer-to-peer design. This allows all computers on the network to be both clients and servers: both able to request and provide service to the others. Most OSes today include all the software that is needed to accomplish these networking tasks without the need for a dedicated Network Operating System. There are also several ways to physically connect the computers in a LAN, and often the design is a hybrid of the types. Since the 1990s, similar to advances in modem technologies, various technical developments have improved the speed at which data is able to travel around a network. In the mid-1990s, the typical speed of a LAN was 10Mbps; today it is as high as 10000 (10 Gigabit Ethernet). Most networks will use a combination of physical cabling to connect the various parts of the network. Commonly, twisted pair cables of the CAT5 type will be used to connect a local PC to a central device like a switch. Switches in various parts of the building may be connected to yet another central location using fiber optic cables. Today, you are likely to find wireless access points throughout the network which allow users with WiFi communication cards to roam around the building and still connect to the network without the need for cables. Connecting a company to the outside world can be done via similar cabling options or by wireless technologies that may include satellite links or microwave towers (like cellular phone systems).

Networks have been adopted by most organizations for the simple reason that there are many benefits. Networks make it easier for people to share equipment, and as a result, they reduce the costs of computing: a single printer can serve multiple machines instead of having to attach a printer to each computer, for example. Many institutions operate networks that are open only to their own users. If this kind of network uses internet protocols (TCP/IP and/or HTTP) for an internal web server and similar services, then it

A wireless access point device

is an "intranet". An extranet is a part of an intranet that is accessible to users with the necessary credentials from outside the physical location of the intranet.

Networks allow people to share information and programs. This increases productivity and again reduces the costs of operating the computers. Some networks will have servers (dedicated machines that are generally not equipped with monitors and keyboards and are not intended to be "sat at") that are used to store either common programs or common files and data. By definition, networks allows users to work together in ways that would not be possible without interconnections. One class of software called groupware is specifically designed to facilitate collaboration among members of a group, for example simultaneously adding and making changes to a single file, creating and organizing schedules and meeting times or managing joint projects.

The "network of networks" celebrated its 20th anniversary in 2008. In 1988, the US government approved linking NSFNET, the National Science Foundation's network (by this time, several universities were using ARPANET's TCP/IP protocol among themselves) to commercial systems. In 1989, several of the previously closed systems like Compuserve opened gateways to the NSFNET system and the first Internet Service Providers (ISPs) began offering commercial service via dialup telephone lines. In 1991, Tim Berners-Lee of CERN publicized his invention of the World Wide Web project. Beginning with this development, most historians of the system agree that the Internet grew by %100 every year through the 1990s. As of 2008, it is estimated that 1.5 billion people use the Internet.
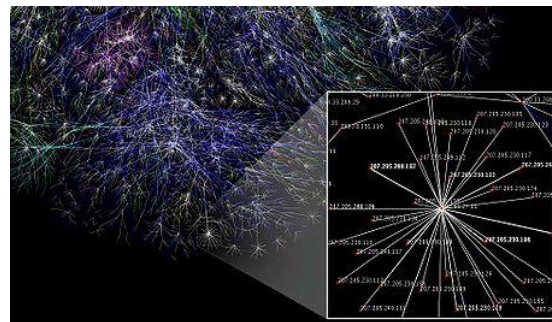
A map of part of the Internet
http://en.wikipedia.org/wiki/File:Internet_map_1024.jpg

The reasons for its success are obvious. Although English dominates the Internet as the most requested language with about %30 of the clicks, close to %40 of the worldwide users are in Asia (only about %15 are in North America.) The Internet is "on" 24/7. E-mail is still one of the main reasons people use the Internet. The WWW, the interlinked repository of documents, images and other media is a major commercial force in globalization: linking to a site like amazon.com, a customer in any corner of the world can shop for the same things that an American at home can. Excepting the use of government managed filters, a person in a small village in Africa can read the same news at cnn.com that you can. Students in remote sections of Australia regularly "go to school" using their Internet connections to virtual classrooms. The list of reference materials that a decade ago would have cost you good money to purchase and are now available online for free includes the New York Times (nytimes.com – a printed copy will still cost you close to $1.00), the Encyclopedia Britannica (britannica.com – the full printed set used to cost close to $1,000.00) and many, many more examples. In fact, you no longer need to attend a "bricks and mortar" university to get your degree: hardly any universities exist that do not offer online degree programs. Nor do many people have to commute to work: they connect to their offices via their Internet connections from home.

As more and more of our data goes online, there are issues worth considering about traditional notions of privacy: access to virtually unlimited data is great, but what if that data is harmful

or personal? Once the content has gone online, there really isn't any way for it to ever disappear: somewhere, someplace, someone has made a copy. Finding it may not be so simple – for all its success, monster repositories of links to data like Google do not encompass all the data that is online. It is estimated that in 2008, the visible web (that part that Google and others "know" about) contains about 170 terabytes of information. The "Deep" or Invisible Web is estimated to contain almost 100,000 terabytes of data – these are pages that are online but "hidden" behind instructions to the Google-bots not to index the pages or are pages that are behind proprietary systems that may require users to login and are thus blocked from public view.

The trend towards more wireless networking has meant that a person can get access to the virtually unlimited information potential of the Internet almost anywhere. Another of the trends has been towards the merging of computers and smaller, pocket-sized devices. Although there are limitations due to the size of the screen image, a web-enabled cell phone allows the user to "roam" and still check e-mail or query the net for data. In countries where the infrastructure has not been developed and miles of cable need to be laid down to bring the Internet to the people, wireless networking seems to make more sense – in essence, skipping the expensive steps that other countries like the US went through.

Reading
"When SysAdmins Ruled the World". Doctorow, Cory.

For further study and research:
Network schematics: http://en.wikipedia.org/wiki/Network_diagram
Main Wikipedia article about Networks: http://en.wikipedia.org/wiki/Computer_network

For you to consider:

What is the value of a traditional school education when all the information you is need is on the 'net?

Portable Internet is available on our cell phones. What's next? Always online chips embedded in our brains?

Always online devices mean you can always be connected. How do you deal with the demands of society that you should always be accessible?

How did Ethernet come to be the accepted network topography? What is the history of network development?

How do nodes on a network communicate? (What is a "token"?)

How do astronauts send email? What about spaceships orbiting distant planets?

Who controls the Internet? Who should?

How do content owners block "bots" from indexing their pages?

Selected Terms:

Acoustic coupling device
ADSL
ARPANET
ASCII
Baud
BBS
CAT5
Closed system
Digital sub-set
Ethernet
Feed data (to ~)
Forums
Gateway
Groupware
Hosting
Infrastructure
Invisible Net (Deep/Dark Net)
LAN

Modem
Netware
NIC
Node
NOS (Network Operating System)
NSFNET
Port (channel)
Protocol
Roam
Sneaker net
SOHO
Teletype
Throughput
Twisted pair
US Robotics
WAN
WiFi

II. Areas of Influence

4. Business and Finance

5. Privacy and Security

6. Government

7. Forensics

8. Robots and Artificial Intelligence

9. Arts, Entertainment and Leisure

10. Education

11. Online Communities

12. Mapping Data

Areas where ICT has an Impact

An earlier chapter dealing with software – in particular, the popular yet illegal methods of software acquisition - could lead naturally into the area of ethics, but that is a subject for later investigation in this book. Instead, we will next look at what is arguably the prime mover behind much of the software "on the market".

The programs virtually everyone uses (and even take for granted?) such as Word, Excel and PowerPoint, although they may be staples of the academic world this text is intended for, were actually developed with the business world in mind. (See a discussion and arguments against using PowerPoint in schools here, for example)

If you look at the weekly news magazines like Time, Newsweek or The Economist and examine their major sections, you will find specific sections dedicated to the various important areas of modern life.

Time magazine has regular sections devoted to Business and Technology, Health and Science, Entertainment, Politics, Science and Society. Newsweek frequently divides its news into Sports, Politics, Business and Technology, Culture, Health, The Arts and World Affairs. The Economist offers news reviews in the areas of Business, Finance, Science and Technology, Arts and various regions of the world (Asia, Europe…). Increasingly, ICT is an important aspect of the news.

http://www.vi411.org/
wp-content/uploads/2007/01/web.jpg

Some common threads are apparent from this basic examination: these magazines all seem to think that Science and Technology, Arts and Entertainment, Business and Government are important enough to cover each week. There are regular references to news developments and the impact of ICT in each of these areas. These are much the same areas as the "Areas of Impact" that are listed in the International Baccalaureate course that covers Information Technology in a Global Society and in the list of "Issues" on the following pages. Although there may be other parts of our lives that are affected or influenced by the pervasiveness of computer systems, these general categories can serve to provide a basis for discussion and give us an understanding of how ICT presents us with issues worthy of examination.

If we are armed with an solid understanding of how computers do what they do, we should be able to knowledgably discuss and evaluate the various pros and cons, the arguments against and in favor of developments in each of these areas and the potential effects of each on our lives. Certainly, the trend for more and more use of technology of this sort means that we will be seeing further debate about the benefits and the drawbacks to the further use of computers in our lives. In the end, it is up to us, as responsible members of our (democratic) societies to be informed enough to rationally consider what we think is best for our world.

In examining each of these areas as a part of our lives that is affected by technology, it will be helpful to keep in mind the various social and ethical issue that can potentially come into play. Some of the issues are more suited to specific areas; some of the issues may not apply to every specific news article. Few areas are never touched by every one of the issues.

The essential social and ethical issues that come into play are: reliability, integrity, security, privacy, authenticity, intellectual property, equality of access, control, globalization and cultural diversity, and policies and standards. In each of the different areas where ICT exerts its influence, an informed discussion should consider the stakeholders and how these issues are managed. In searching for solutions to the problems that arise from continued expansion of ICT use in these areas,, the impact on individuals, on different cultures and on society as a whole need to be examined. These impacts may be different at the local or at a global level. The informed discussion needs to consider who is responsible and accountable. It needs to look at the policies, rules and laws. It needs to look at the alternatives and the consequences of decisions that are made.

For example, in the area of Business and Finance, without assurances that the computing equipment and data are reliable, people are naturally unwilling to expose their financial future. People want to be sure that their money is secure when it is stored and transferred electronically. Consumers do not want their personal data exposed to fraudsters and cyber thieves. Businesses that are selling online goods need to be sure that, as it is with tangible materials, their virtual goods are also covered for property rights laws. The governments of the world need laws and policies to help them guide and control the finances of a virtual economy.

While each of the separate Areas may not be equally influenced by all of the issues, more often than not, these same themes resurface repeatedly. Briefly, these issues can be defined/described as follows:

Reliability
Does the hardware or software operate reliably? If we cannot rely on the system, the value is greatly reduced.

Integrity
People need to be sure that the data they input is the same data they later expect to retrieve. I the data is changed (by a hacker or a system error), its integrity has been compromised, and again, will suffer in terms of reliability.

Security
Protection of hardware, software and data from unauthorized access is a key component of security. If people cannot be assured that the system is secure, they will be unwilling to rely on it.

Privacy
People and cultures have different expectations of privacy, but world-wide, it is a key factor in defining personal rights. Societies decide for themselves what defines anonymity and to what extent the individual can expect parts of their lives to be private.

Authenticity
Identities need to be clearly verified and vouched for. Particularly in a virtual world, techniques that can assure someone's claims are critical to doing business: valid logins, digital signatures and such are the keys to proof of something's authenticity.

Intellectual Property

Many of the laws and assumptions that governed the pre-digital world have been found lacking in the new economy: Printing a book or making an original recording used to be expensive and time-consuming in an analog economy; hence, protecting the property rights of material creators was a lot simpler. Digital copies can now be made cheaply.

Equality of Access, Globalization and Cultural Diversity
Increasing globalization has meant that differences that used to separate the people of the world are eroding. Without the infrastructure in place in remote areas of the world, it is impossible to ensure that everyone has equal access.

Control
ICT can be seen as a tool for control: it can improve our sense of reliability of systems, but it can also be an imposition as governments use it for surveillance, for example.

Policies and Standards
Rules, laws and conventions are needed to ensure that systems can operate and cooperate. These rules help to ensure that many of the other issues also function: security is enhanced when there are policies/laws that define penalties for misuse.

Business and Finance

You may recall from the software section that the first "killer app" was a spreadsheet program called VisiCalc. This should not be a surprise: the first large computer company was called IBM (International *Business* Machines Corporation). Early computers were very much the realm of businesses, the government and universities, so it is somewhat natural that people realized early on the benefits of having a machine do your work for you. In today's business environment, particularly when you consider the effects of the Internet on business transactions, you can also see how closely tied business and finance are to computing. After all, businesses are generally in it for the money. The various fields within computing (manufacturing, software development, service provision …) are also each major areas of business today.

Although there are ways that the other areas of impact that we will look at are affected by business and finance (education may not be for profit, but it involves lots of money; sports, entertainment, science, and government also cannot operate without some link to business), the areas of ICT use in business are foremost in this section: ICT is a business.

The typical business has an office (or two) of some kind. At a minimum, in this office, documents are prepared, edited, reviewed and published. Financial records are updated on an ongoing basis – each new sale is recorded: daily, weekly, and monthly financial reports are prepared and yearly goals and plans are decided based on the various figures and calculations that result. Presentations are prepared and delivered: employees presenting to their bosses, bosses presenting them to their supervisory boards and so on. The widespread and more efficient leverage of their data through the use of ICT is often the key to their success.

If the list of uses above sounds familiar, that is probably because you are familiar with Microsoft Office. The name is no coincidence: the suite of applications that makes up the core of Microsoft Office (or Open Office, StarOffice or Corel's similar programs) is a collection of programs that were designed to help run a more efficient business: word processing, spreadsheet calculations, database management, presentations software, graphics, collaboration, and communication.

The Typical Office

It may be hard for someone who grew up with computers to fathom, but the power transfer to the office and office worker brought about by the widespread use of the computer has been immense. Although the computer industry's claim that "computers will give you more free time" is often called into question (computers don't necessarily create free time, but they do make lots of tasks easier), you should stop for a minute and remind yourself of what it must have been like to do these "Office" tasks without a computer.

Office cubicles
http://en.wikipedia.org/wiki/Cubicle
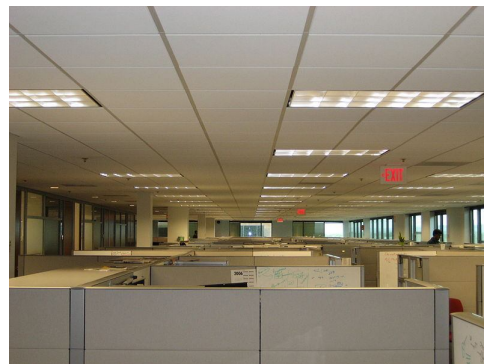
Preparing a yearly report in pre-computer times meant lots of typing on a typewriter. If there were any mistakes, the document had to be re-typed. When it came time to add in charts or graphics of any sort, it was time to call in a publishing house: special light tables, cutting knives, photographers and graphics artists would work together to produce a "mock-up" copy of the document for review by an editing team. Mistakes would be marked in the mockup copy and the publishing group would go back to work, re-typing, re-cutting, re-pasting the next version of the mockup copy. When final approval was given, the job would be passed along to the printing house, where they would take photographs of the individual pages (or worse, yet – prepare metal or rubber plates) which would be used to print the final copies. The entire process could take a very long time and cost a lot of money. Today anyone can do this – even at home; all you need is Word and a laser printer.

In the days before PowerPoint, the standard presentation was given as a talk either with a "flip board" (large format papers on a tripod stand that the presenting person would flip over to show the next page of information – often with the presenter drawing or writing key terms on the blank page.) With the arrival of OHPs (Overhead Projectors), presenters moved to use clear acetate sheets of critical charts (often photocopied, after the commercialization of the "Xerox" machine) that they could project at a size the audience could see. The current industry standard for presenting information

OHP in a classroom
http://en.wikipedia.org/wiki/Overhead_projector

to an audience, Microsoft PowerPoint dates back to an earlier application developed in the 1980s by a company called Forethought before Microsoft had become what it is today. Businesses were quick to recognize the "power" of its persuasive features.

Financial records used to be kept in large paper-based ledgers, oversized notebooks filled with handwritten numbers. Granted, during the early 20th century, mechanical calculators of the sort that IBM manufactured, were the norm. Finance people cranked the mechanical arms and hand-transferred the resulting sums to their spreadsheets. Today, of course, this has been replaced first by Excel-type programs and then further automated through the use of POS fueled database systems.

The typical office needs to keep records of its transactions – both for internal planning uses and as a legal requirement. If the needs of the business are fairly small, a simple spreadsheet such as Excel will be enough. If the business is larger or more geared towards online systems, a spreadsheet program is not going to suffice. In comparison with other software solutions, a spreadsheet is limited because a spreadsheet is designed for managing "flat" relationships: ie, it doesn't facilitate linking among and between data in several tables of data like a relational database (SQL, Access) does.

Even larger, better "integrated" companies are likely to be making use of ICT services: online sales, catalogues, and customer services (CRM, customer relation management) perhaps through an online "portal" or website; they may have representatives who do not work in the office (teleworkers) who need to access their information from remote locations, and they may have their own IT departments that manage all these complex operations (some businesses outsource these needs instead of keeping them in-house). Even more IT centered businesses may find they need IT personnel to write or adapt the software that is specific to their area of business.

As more and more businesses move their operations online, it becomes easier and more profitable to make extensive use of the potential of IT. Rather than keeping a large warehouse full of items that may or may not sell, if your manufacturing unit (or outsourced manufacturer) also works online, a business can keep costs to a minimum by following a "just in time" process, where your customer's order is sent to the manufacturer within a few seconds of his placing the order, and his personalized order is processed and shipped directly to him within a very short time, whether it is a personalized car or pair of shoes.

Today's typical online transaction involves a number of related technology innovations that have been made easier by developments in technology. Included in the complete process are several separate transaction that need to be integrated:
electronic fund transfers
supply chain management
online marketing
online transaction processing
inventory management and
electronic data interchange.

Both data and fund transfers have their roots in the pre-Internet era, when banks and businesses began to exchange electronic information, and then spread with the growth and acceptance of credit cards in the 1980s. With the adoption and growth of the Internet in the 1990s, it became more common and finally practical for companies to establish first a presence (a website or portal) and then an entire online business operation based on a virtual store front. Amazon and eBay, for example, were established in 1995. Today, more than $200 billion worth of commerce is conducted over the Internet.

One of the innovations that helped secure the popularity as well as the confidence of many people conducting online business was the invention of protocols (software and hardware rules) that encrypt the financial data as it moves across the Internet. SSL (Secure Sockets Layer) and then TSL (Transaction Sockets Layer), like most other applications, have undergone various updates to make them more secure. The first version, in 1993, worked together with the then popular Netscape browser but it had several security flaws. The version in use by 1999 was endorsed by leading credit card companies including Visa, Mastercard and American Express. The process involves establishing a stateful connection (most web browsing is stateless, ie: no permanent connection between the browser and the server is maintained) and exchanging encrypted data, first verifying each party is who they say they are through the use of

SECURE HTTPS CONNECTION?

I AM CERTIFIED AS XYZ.COM

OK. CONTINUE

LET'S USE 128 BIT RSA

MY 128 BIT RSA ENCRYPTED PASSWORD IS ...

Digital signature in operation

digital signatures verified by a certificate authority, and then setting up a unique (one-time) transaction based on a randomly generated mutually shared key that is used to decipher the data. For many early years, the international standard was a 40 bit key because the US government blocked exportation of software with a high level of security. Today, the standard in use is 128 bit keys. The protocol makes it difficult (but not impossible) for anyone to steal or break into a transaction in progress. Even if someone does get a hold of the encrypted file, it is estimated that "cracking" a 128 bit encrypted transaction would take a long time (128 bits is 2^{128}). The transaction would be long finished by the time someone cracked the key. Because there is a limited potential to "crack" this technology, one technique under development is quantum encryption, which is currently considered to be unbreakable.

E-Commerce

As the world has moved towards a global economy, e-commerce and e-business have become much more important components of any company. Behind a company's ability to do business on line is the need for an integrated financial operation. A well-organized banking environment allows finance to move from a local operation (the home town bank) to a global B2B (business to business) that at the same time gives a lot of flexibility and power to the individual. One result of an improved banking system is the ability of companies to grow beyond their traditional local markets. For example, when you visit an online store-front, you have very little ability to discern how many people are actually employed at the business, and in some ways, it isn't the number of people employed that matters, but rather, how well the company is able to leverage its position and strengths. What matters is whether the business can satisfy the customer.

E-commerce refers to buying and selling over the Internet. Several main components of a business are potentially strongly affected by e-commerce. They are the production process, where stocks and similar raw materials are transferred among suppliers, as well as the actual control of the production, the consumer process, which includes the marketing and then processing of the goods and payment, and the internal management process, where training, information sharing and communication within a company can improve profits and productivity through the use of ICT.

ICT BUSINESSES			
	INFRASTRUCTURE	INTERMEDIARIES	COMMERCE
ECONOMY LAYER			
	ENABLING HARDWARE SOFTWARE AND EQUIPMENT	INTERNET SOFTWARE, DESIGN AND CONSULTING	COMPANIES THAT SELL ONLINE PRODUCTS
TYPES OF COMPANIES			
	ISPs, SERVER CABLE MANUFACTURERS, SECURITY SOFTWARE MAKERS	ADVERTISERS, CONTENT PROVIDERS, AGENTS	CORPORATIONS SELLING SERVICES ONLINE,
EXAMPLES	CISCO, AOL, AT&T	YAHOO, GOOGLE, EXPEDIA	AMAZON, DELL, HERTZ

(table above based on information at http://www.Internetindicators.com)

The multi-dimensional scope of this kind of an operation becomes more apparent when you break the operations down into the various components that are needed to make this work. At the infrastructure layers, you have the companies that provide the hardware (servers, routers, cables) and the companies that provide the internet access (telecoms). At the Applications infrastructure layer, you have the companies that make the web development tools and consulting services (Adobe makes Dreamweaver and Flash software that is used all over the web; Microsoft makes the server software that helps SQL run).At the next layer, there are the intermediaries, companies like the credit card processing services, the online search engines and advertisers and logistics/shipping companies who make it possible for the customer and the retailer to find and trust each other and then transfer the goods and payments. And finally, at the commerce layer, you have the companies that deal directly with the consumer, such as Amazon.com.

In the early 1980s, before the Internet went public, but at a time when early adopters had personal computers, closed networks were the popular way to get online. One version of this kind of online community was the BBS (Bulletin Board System). Two of the largest of these communities actually survived into the Internet era in one form or another while continuing to charge their users monthly fees: AOL (American Online) and Compuserve, each eventually integrating their closed communities with the larger internet. One of the advantages of this kind of a closed community was the ability to more closely monitor activity (all users were registered account holders), and this also meant that financial services could be fairly reliably controlled. These services were successful until it became apparent that the fact that they were "closed communities" meant that they were limited: resources outside them (ie: the Internet itself) were not available to their users.

One of the first banks to test the possibilities of online services was Citibank, in 1985. Fees were expensive, modem speed was 1.2K (today's home ADSL speed is at least 1024K) and the interface was text only; as a result, was not very attractive to a majority of customers. Although Electric Fund Transfers (EFT) and Electronic Data Interchange were technically possible in the

http://en.wikipedia.org/wiki/EBay

the at this

1970s, these services were not available to the home user. Services for the home user had to wait until credit cards, Automated Teller Machines (ATMs) and telephone banking in the 1980s and then it took another decade before online banking became fairly common. The arrival of home banking coincides with the development, first, of SSL, and the arrival of online merchants like Amazon, Dell Computers and eBay in 1995.

The major attractions (for some people) of online banking is 24 hour access, the ease of doing transactions, and the ability to integrate online data with other software applications like Quicken ® or TurboTax ®. In the US, about 40% of banks offer online services, and many bank customers still prefer to use a real

ACCOUNT NUMBER: 2892276532					
DATE	NUMBER	DESCRIPTION	IN	OUT	BALANCE
					7000.00
12.06.2009	22321889	VISA PAYMENT #6726453479		249.98	6750.02
15.06.2009	22332089	CHECK #19746		55.00	6695.02
15.06.2009	230040562	CHECK #19747		500.00	6195.02
19.06.2009	242406570	AUTOMATIC PAYMENT		936.88	5258.14
21.06.2009	262654356	VISA REFUND	232.88		5491.02
23.06.2009	4987354420	RETIREMENT AUTO		738.42	4752.60
24.06.2009	498845671	INVEST PORTFOLIO		1109.66	3642.94
27.06.2009	244897634	PHONE TRANSFER		350.25	3292.69
29.06.2009	250001243	CHECK #19749		210.79	3081.90
20.06.2009	2500045231	MONTHLY SURCHARGE		11.95	3069.95

Online Bank Statement

"bricks and mortar" bank rather than a virtual bank. Although banks have made enormous progress in their attempts to provide a secure operating environment for their online clients, many people feel the risks are still too great – and all-too-regular news coverage of banks' problems in managing this have not made their task easy. (As Willie Sutton, the infamous bank robber of the 1930s said, "I rob banks because that's where the money is.")

Banks' use of computer technology is much more than simply online services. Some of the most advanced algorithms in software are used by banks, for example, to vet credit card purchases – looking for unusual and unlikely spending patterns in an effort to block fraudulent purchase before they even happen.

Working in concert with advances in finance online, the growth of the customer base in the same time frame has been another reason for the rapid growth of online shopping. In 1993, there weren't more than a few hundred websites online. By 1996, that number was around 100,000. It is estimated that that number had grown to more than 160 million by 2008. One current estimate of the number of people who have internet access is 1.5 billion and a worldwide growth average of 300% since 2000. Considering that the estimated world population is about 7 billion, that is a large number of potential customers. Not surprisingly, the volume of online sales has increased every year since the "invasion" of the Internet.

A typical online transaction can be viewed in the following graphic:

A typical online transaction
Image credit: cedmonds@robcol.k12.tr © 2008
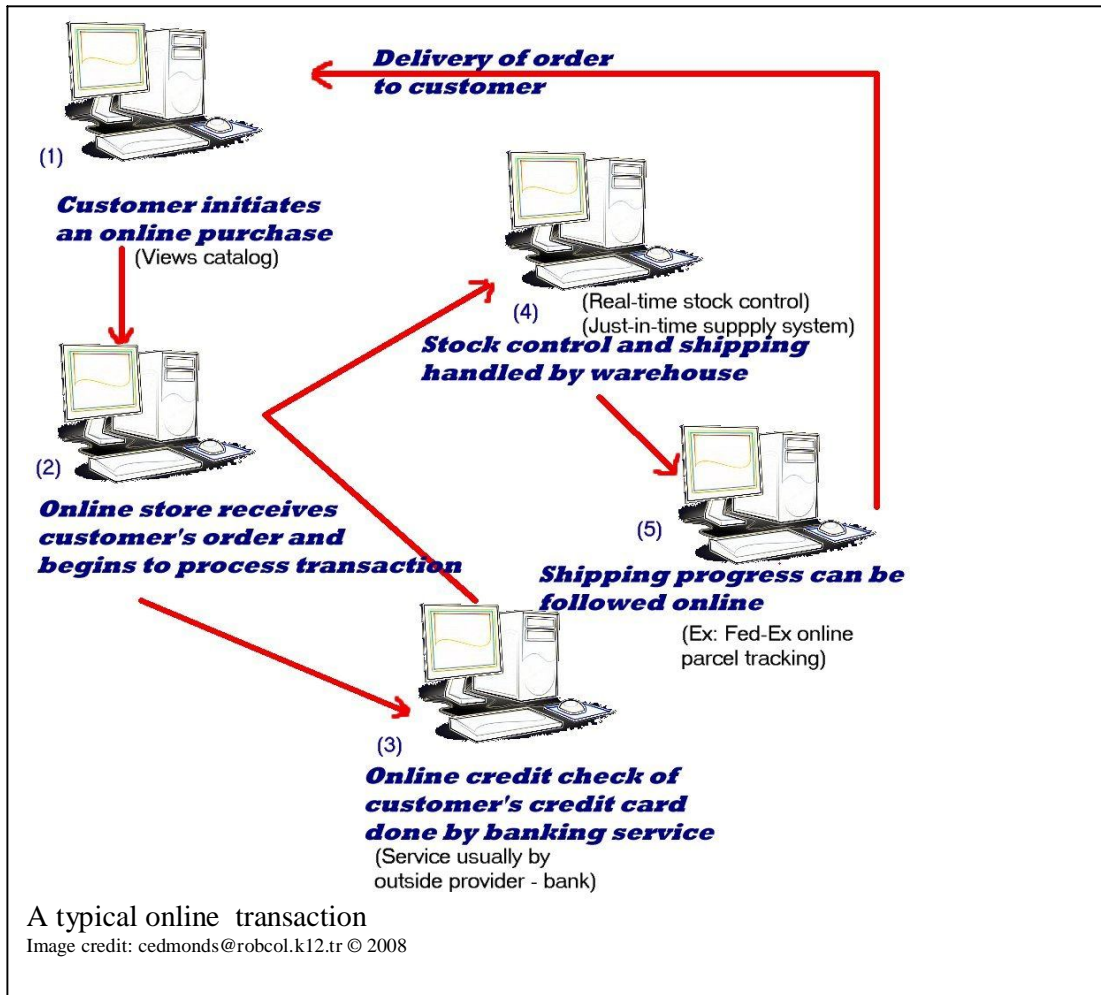
In several places in the above transaction, accurate, readily available data is key to the success of the transaction. For example, the online catalog needs to show correct prices, color and size choices; the credit card service needs timely information about the card holder's current balance (and some kind of intelligence about the card holder's "style" to help identify possible fraud), the warehouse needs to accurate stocking records as well as needing some of the information about the customer so as to finalize the order, and finally, the shipping department also needs a copy go the customer's address in addition to their own internal data about the shipment.

Behind all of these lies the power of the database. A database is an organized collection of stored information. A database application is a program that makes it much easier to manage large amounts of related information. In a customer database, there would likely be several different "files". One file might contain all the information about shirts that the store sells. For each shirt, there would be a single "record" that contained information about that specific shirt type: available sizes and colors, price, type of cloth etc. Each of these specifics (the price) for one item is called a "field". Some fields hold textual information, some hold numeric data,

others hold computed data. Each item in the database is given a "key" to identify it and this key allows users to create relational links among the items and still keep them organized. Because of all these inter-relationships, a database system is often called a Relational Database Management System (RDBMS) as opposed to the similar concept in a spreadsheet (which is called a "flat" file).

Different workers using the database will have varying levels of access to the data and varying ways that they can view or work with the data they can see. The stock clerk would see only that information which was necessary for him to complete his part of the transaction: he wouldn't need to see the customer's credit card information, and he probably would not have permissions to make any changes to the data. A store manager, on the other hand, would need to be able to access the kind of information that would allow her to make informed decisions about monthly sales trends for all departments in the store, and then perhaps be able to make pricing changes.
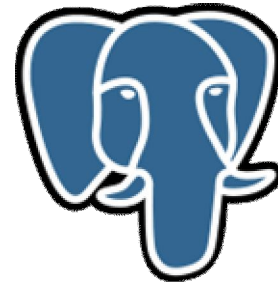
PostgreSQL is a free RDBMS
http://en.wikipedia.org/wiki/PostgreSQL

Because a database may hold an immense amount of data, the key to finding the information you need lies in performing a directed search rather than just browsing through all the records, whether they are relevant to your needs or not. The most common format for this search is called a query, and the most widely used language for building the query is SQL (Structured Query Language). Microsoft's application for managing a database is called Access, and there are many other solutions a company can choose from, but almost all of them support SQL.

A Historical Perspective on the Use of Computers in the Office

In the 1960s, when large companies began to use computers to facilitate their work, these computers tended to be huge mainframe computers operated by special technically skilled employees, often located in a special section of the office building (the basement, for example.) Use of the computer was centralized and limited to a special few.

With the arrival of cheaper, less powerful networked desktop computers in the 1980s, offices began to move towards distributed (or integrated) computing, where a group of computers could be connected to create a "workgroup" that shared related tasks. The era of true networking on an enterprise scale did not arrive until the 1990s: Microsoft's first commonly used version of Windows that facilitated this kind of office network in a primitive format was called Windows 3.11 and came out in the early 1990s. Initially, management did not see a great need to be a part of this network: it was considered that computers were for the workers. However, it wasn't long before company bosses saw the need for MIS (Management Information Systems) that would give them better real-time information about how the business was going. In time, these systems also evolved to include Decision Support Systems that were intelligent enough to help managers make decisions based on the data they had gathered.

President Bush in a videoconference
http://en.wikipedia.org/wiki/Videoconferencing

One of the promising trends to come out of the use of computers for work has been the possibility of teleworking. In a day and age where the costs of driving long distances to work, or maintaining a large parking area for all employees'

cars are an important consideration, some companies have been looking at the option of having employees work from remote locations, including their homes. Obviously, some occupations are better suited to this style of work (for example, the salesman who is always on the road would be a good candidate for this work model), but as the technology improves, companies are finding that computers can help keep costs down, keep more employees happy by saving them a daily commute and provide them with more time with their families in the process. Many companies are also discovering that teleconferences are becoming a viable alternative to the time and cost of sending people long distances for meetings that can be done through a computer.

The use of the term "the office" above shouldn't limit your imagination of the processes described to the standard business model or standard office of earlier generations. The examples of an online store using computers also apply to almost any operation in today's information economy.

In describing the traditional office above, one example of the power of computers was in the preparation of printed material. In fact, the computer has revolutionized the entire printing industry. Newspapers do all their layout, editing and related pre-printing work on computers. Modern book publishers do the same. The personal computer has meant that today, anyone can put together a book. At first, this may not seem so impressive, but you might consider how limited the number of people who had books was even in the 1800s. The proliferation of blogs in recent years should also been seen as part of this trend: anyone with a computer can be an author.

The IT Department

As noted above, in the 1960s, the IT department was often relegated to the basement of a business. The people who operated these machines were no longer called "computers" (that term applied to computer operators of the previous generation.) The various positions that were available were mostly technical in nature: typically, a staff of highly trained technicians and a Director of the Computer Center.

By the 1990s, with the rise in importance of the computing services, the IT Department was becoming a more prominent, more visible division of the corporation. As desktop computers were now on every worker's desk, there was a need for a "help desk" facility, where specialized employees could trouble shoot workers' problems. It had become apparent that without constant, effective computer support, an entire business could come to a stand-still and so the person in charge of the entire IT operation had to be a critical member of the management of the business. In addition to the CEO (Chief Executive Officer) of a large company, the head IT person was elevated to a position of major importance and sometimes given the title of CIO (Chief Information Officer).

A server rack
http://en.wikipedia.org/wiki/19-inch_rack

Depending on the size of the operation, today a large company might also employ IT or IS (Information Systems) people in the following areas:

Managers	**Programmers**
Purchasing Agents	**User Assistance Architects**
Computer Scientists	**Database Specialists**
Security Managers	**Technical Writers**
Systems Analysts	**System or Network Managers**
Trainers	**Hardware Maintenance Technicians**

Again, depending on the area of business that the company is involved in, there are IT careers in these broad categories: (source: IEEE – computer.org)

- Artificial Intelligence -- Develop computers that simulate human learning and reasoning ability.
- Computer Design and Engineering -- Design new computer circuits, microchips, and other electronic components.
- Computer Architecture -- Design new computer instruction sets, and combine electronic or optical components to provide powerful but cost-effective computing.
- Information Technology -- Develop and manage information systems that support a business or organization.
- Software Engineering -- Develop methods for the production of software systems on time, within budget, and with few or no defects.
- Computer Theory -- Investigate the fundamental theories of how computers solve problems, and apply the results to other areas of computer science.
- Operating Systems and Networks -- Develop the basic software computers use to supervise themselves or to communicate with other computers.
- Software Applications -- Apply computing and technology to solving problems outside the computer field - in education or medicine, for example.

Reading:
> The Evolution of Online Banking by Daniel Singer (Journal of Internet Business)

Reference and Additional Resources
Read "The Future of Free" by Chris Anderson
Visit some US banks (Bank of America, Capital One, JP Morgan …).
Visit the US government financial institutions (Dept of the Treasury, the Federal Reserve …)
Visit some stock exchanges (NYSE, IMKBhttp://www.imkb.gov.tr/ …)
Learn about computer careers at IEEE (computer.org)
Learn how to become an Amazon affiliate/associate

Further Research & things to consider:

Business can no longer operate without tech support. Who really controls business systems? Is it the software companies?

If business controls so much data, what happens to the little man? Are we pawns of these companies?

What is the future of money in your pocket? Most people carry cards, but before long, we may not even need cards: what about RFID cash embedded in our arms?

What kids of ICT careers would you find in the banking sector?

How does PayPal work?

How easy is it to add credit card processing to a website you yourself build?

What are micro-payments?

Related Terms

AOL	Fraud
B2B	just-in-time
BBS	MIS
Certificate authority	outsourcing
CIO	Quicken
Compuserve	real time
database	relational
Decision Support System	SQL
Digital signature	SSL
e-commerce	Stateful connection
Encryption	teleworking
Flat file	transaction

Privacy, Security and Ethics

Online privacy and security has become one of the issues that defines our lives in the digital era. Our personal privacy is under threat from our governments (in the interest of protecting us from terrorists), our ability to navigate the web freely is under threat from hackers and fraudsters who "phish" for our passwords and account details, and the OSes and apps we use are so full of bugs that need almost daily updates that we – as mere users – are at the whims of others if we want to conduct any kind of "real" business, because conducting business today more often than not means going online.

Our personal computers store our communications in the form of archived email messages, financial records, many of our photographs and various other personal, private files. For many people, the data stored on their computers is extremely personal and much of it is private and sensitive and needs to be kept secure. Regardless of whether we work as a student, teacher, businessman, writer or stay-home-father, computers hold our records.

Security camera watching us

Perhaps the most important development of our lives going digital is the amount of information about us that is accessible online – much of it data that we ourselves have provided freely. If you haven't already done so, you should definitely do a "vanity" check in Google using your name as the search term (be sure to include your name inside quotation marks: "John Doe", so that the search engine retrieves only those items that include your name and not all items that include "john" and "doe".) Most any company who plans to hire someone will be certain to do the same, and although it may not reveal everything, it does have a tendency to at least bring out some kind of a picture of who you are. More and more companies will also search for information in social networking sites like Facebook. It has become "de rigueur" to check out a blind date this way before you finalize your first night out: even if you find nothing, there is some value in knowing that the person is not notorious.

Who Collects Your Data?
In many countries, you will need some kind of identifier to conclude government related transactions. Want to know if you can get bank credit? You'll need to provide your government issued ID number. Want to learn if the 2nd hand car you plan to buy is stolen? You'll need to provide the data provider with some personal information. (How many online accounts and passwords do you need to keep track of?)

Facebook collects your data
http://en.wikipedia.org/wiki/Facebook

At first glance, much of this data appears harmless. To get access to the full text of

many online publications, you need to have an account with them. Their access policy requires you to provide them with your email address and a password you specified during the registration process. Beneath this seemingly innocuous login data is a form that requires you to provide them with certain other personal information. What do they do with this data? Where do they store it and what guarantees do they give you regarding their safeguarding of this data? Do you actually read any of these policies before you click on the "Continue/Accept" button?

The issue of online personal data becomes even more intrusive with many other online services. In fact, most well-known publications are models of probity: they have almost no record of data loss and the data they collect is unobtrusive. Or is it? Studies have shown that "researchers" armed with little more than your gender (male/female) and postal zip code, can often enough poke around on the web to use this data to make further search matches that can positively identify you, your home address, and from there, further personal data about you that could lead to in-depth data that could compromise your security and privacy.

All too frequently, we read in the news about large scale data loss, sometimes affecting hundreds of thousands of people at a single time. To someone who has not had to try to clear up a case of identity theft, the problem may seem minor. We may defend providing personal information online by asking "so what if they learn some of my personal information?" After all, so many online services require at least your name, email address and country, and we freely provide it, many times without even bothering to read the company's privacy policy. We tend to feel that if we want the company's services, we have no choice, and so we provide this "limited" data in exchange.

Just what can a thief do with your name and address? Is there any reason to fear identity theft? You may have heard that it is more dangerous to give your credit card to a waiter in a restaurant than it is to use it on the internet. While this may be statistically true, do not let this fact obscure the reality that there are still plenty of cases where people have their information compromised online.

Privacy

Privacy means that every individual has the right to decide how far society can "intrude" into his or her life. Although it is not so easy to define specifically, privacy is considered to be one of the basic human rights. Most countries include some definition of these rights in their constitutions, even if there are varying degrees in practice among different countries. Privacy generally includes an individual's right to expect that his "home is his

VeriSign,Thawte and others guarantee your digital security
http://en.wikipedia.org/wiki/VeriSign

castle", that the home is a private place that you can be invited into but cannot enter without permission. Privacy also generally means that your conversations and thoughts are protected from intrusion without permission. More and more, today, privacy also means that you have a right to be able to control what information/data about you that you are willing to give to others. Privacy includes three main concepts: secrecy, anonymity and solitude. It is the right to be left alone.

The main areas of privacy are related and very much informed by technology although privacy is generally seen as a property of a person. They are:
- Information privacy (includes: credit information, government records, data protection)
- Bodily privacy (includes: genetic data, body searches)
- Territorial privacy (includes: public and workplace surveillance, ID checks)
- Privacy of Communication (includes: email, phones)

A number of laws have been passed in many countries that aim to control the right to digital privacy. Although the USA was a leader in the growth of the Internet, the first digital privacy laws were established in Europe (Germany 1970 and Sweden 1973); only in 1974 did the US pass its first digital data protection law. (What laws exist in your country?)

A growing trend in too many countries is to limit the availability of some online information (often in the name of national security, but in the process dealing a blow to our right to privacy) by employing nationwide content filtering tools. Although a number of websites have adopted their own self regulated system of content filtering by either registering their content with an authority such as ICRA (Internet Content Rating Association - for example, content may be voluntarily labeled as adult or gambling), there is no worldwide standard or requirement, and so some countries feel compelled to take their own action. Although China is often noted as one of the worst "offenders", there are many others that do it too. And its it not only at a national level: many businesses block access to certain content, partly because it can be seen as a misuse of the company resources, but also because of fear of legal action in the event of an employee doing something unethical or illegal online with company sponsored online access. Content filtering is also used in a number of households: parents who fear their children may access inappropriate material can and do install filters on their home systems. These filters may even include a key stroke monitoring application in addition to the filter. This way, a parent or employer can keep even tighter control over another person's surfing habits. While it may be arguable that within the family, definitions of privacy need to be altered from societal norms, this is still an invasion of privacy.

Content filtering protects users
http://en.wikipedia.org/wiki/Content_filter

Keystroke monitors are not only used by parents to control their children's Internet access, but they are also a tool hackers can use to steal data as the user types. A simple keystroke monitoring program can be disguised as an email attachment or even inserted into a web page so that the user is unaware that his privacy has been compromised. The downloaded application then secretly sends the captured keystrokes over the Internet to the hacker, who may be looking to gather bank account data or other critical passwords.

What can/should the average user do to try to protect himself from these threats? Aside from keeping your anti-virus program up to date (daily checking for updates), users are advised to install firewall software and malware detection programs such as anti-spybots that search

Spybot Search & Destroy protects user
http://en.wikipedia.org/wiki/Spybot_-_Search_%26_Destroy

the user's computer for evil software that may have gotten past the other defenses. A conscientious user might also make use of software to manage cookies. Although most experts will point out that cookies are more beneficial than harmful, in part because cookies are only meant to be read by the websites that issue them, there are potential dangers in some uses of cookies. Still, cookies do contain personal data about the user and these cookies are transmitted back and forth across the Internet. Similarly, you may want to periodically check and delete parts of your browser's history file: browsing applications will normally keep a list of the most recent (and favorite) locations that you visited on the Internet, and access to this file is something that you might want to keep private. (Keep in mind that deleting your copy of these files doesn't mean there are no records: your ISP is more than likely to have its own copies, and service providers are generally required by law to archive this data in case legal authorities request it.)

For sensitive data, users can opt to encrypt their data. You can encrypt data that is stored locally on your computer so that anyone who tries to access it must know the correct "key" to make sense of the information. The basic idea is to use a randomly generated sequence of numbers and letters – the more the better (128 bit security means 128 random characters).

You can also use the same basic technique to encrypt any data you send over the Internet. This method will help ensure that your data remains private, even if someone manages to get physical access to the file. One of the more famous issues related to encryption is the story of Pretty Good Privacy (PGP). Developed by Phil Zimmerman in the early 1990s, PGP was freely distributable and

GPG – Free Software version of PGP
http://en.wikipedia.org/wiki/GNU_Privacy_Guard

some people felt it undermined the government's ability to access data. The law prohibited its distribution outside the US (the same law also caused Microsoft to have to market different versions of Internet explorer: one for US use and another for use outside the US), and Zimmerman got into legal "trouble". Awkwardly for the government, the trouble only served to make PGP more famous – and better.

Another technique that some people use is to surf anonymously. Any time you use the Internet, it is possible for a number of intermediaries to learn a bit about you. At the very least, every online transaction requires a known IP address; this is basically your "return address" and without giving this information, you would not be able to get any responses to your online requests. Although an IP address in itself is not necessarily enough to identify you personally, in combination with other information that your ISP has (your computer system must login to get online services), it is possible to use this data to identify you or your local system (your home, for example). When you use an anonymizer, you connect to a remote computer that then handles your requests for you, relaying the data it gets on your behalf

The Onion Router anonymizes surfing
http://en.wikipedia.org/wiki/Tor_(anonymity_network)

back to you. To your ISP, this makes it appear that you are connected to an "innocent" address while the "innocent" address handles your surfing, in essence hiding your actions. This technique has actually had quite a bit of US government support in the form of The Onion Router (TOR), a project that was set up to help people in repressive regimes gain access to sites their governments do not allow.

Using a free web-based mail account is yet another method you can use to try to maintain some sense of privacy. These free mail systems allow you to hide your personal information better than a work, school or ISP based mail system, partly because they tend not to require too much accurate personal information when you create the account.

As more and more companies move onto the web, they (rightfully, from their perspective) want to maximize their profits. Companies that you provide with your email address will want to send you information about special sales and similar events. Many companies will also offer discount cards if you will give them some limited information about yourself when you sign up. What many naïve consumers do not realize is that every time you make use of the companies' discount card, you are providing the companies with more and more information about your personal habits. Companies are thus able to amass huge amounts of data (known as an e-profile) about thousands of customers and will use this data "to provide better service". This is essentially what large companies like department stores are doing when they provide you with a discount/loyalty card: in exchange for providing them with information about your shopping habits, they will give you a discount. You are in effect selling them data about your personal habits for a (limited) discount on their goods.

In the wake of increasing terror activity, many governments have realized that surveillance cameras provide the security forces with a cost-effective means of observing and controlling public areas. Although there have been many challenges to this use, individuals' privacy is taking a back-seat to the need for effective monitoring and recording of public places. It is here that the need to balance privacy and security is facing some of its toughest tests these days.

Security
Security means being free from danger or injury/harm – whether it is physical or emotional. If something is secure, you are sure that nothing can happen to it, that it is not vulnerable. In terms of ICT, this tends to mean that information and resources (software and hardware) are protected from any kind of damage; they are confidential and the integrity has not been compromised. ICT security is often associated with these three concepts which are also closely related to the concepts of privacy (sometimes referred to as CIA):
Confidentiality: only persons with proper authority have access
Integrity: information does not get altered without authority
Availability: information is only worthwhile if you can access it to use it when you need it

Also included in some definitions are:
Authentication: verifies that a person is who he claims to be
Non-repudiation: a guarantee that if you make an agreement, you are responsible
In short, a secure system is one that you can trust with sensitive data: the data you put there today will be available without alteration tomorrow and only authorized persons can access it.

The old adage "an ounce of prevention is worth a pound of cure" is nowhere more true than in the area of computer security. Particularly as a direct result of the growth of e-commerce, the section of computing devoted to security has become one of the most important (and profitable) sectors of the industry. Loss or damage to data as a result of unauthorized access continues to grow at an alarming rate. Companies that make use of the Internet have found

that they need to employ network security experts who in turn will employ all sorts of software and hardware technologies to try to secure/protect their data.

For equipment that is made available to the public, there is some limited danger of vandalism to the equipment itself as opposed to vandalism of the data – consider that a 24 hour ATM will often be secured with a camera in addition to the built in software that aims to protect the data. However, in comparison with the actual data itself, this is a much smaller problem.

As noted above, for a system to have value, the data must be accessible: data is of no value if you can't get to it. In order to secure data, the most common method is to require a user to

ATM keypad with encryption
http://en.wikipedia.org/wiki/Automated_teller_machine

authenticate himself, to prove that he does in fact have permissions to access the system. In its simplest and most common form, this is done by the combination of a user account name and an associated password. Because of the danger of someone guessing a password (account names are generally much easier to guess since they are often "logically" based on real names), most computer systems will require that a password be of at least a minimum length. Research into hacking has shown that a password that combines letters (preferably mixed capital and small) and symbols and that is not less than 6 characters in length offers reasonable security.

While it is common practice to require a password to login to our personal computers – even at home – this method and level of security only offers limited protection for someone who is physically able to access your computer. Even then, the level of protection is feeble; easily available tools and techniques for bypassing this protection are available all over the internet. And it is only recently that people have begun to take a more serious approach to protecting their data from online, remote access. Here, again, there are many ways to get "into" someone's computer and many of them are almost impossible to detect without a pretty good understanding of computers and a fair amount of vigilance. Even with regularly updated anti-virus software, plus a firewall, plus malware monitoring programs, you can still be giving away your personal information and not know your privacy and security defenses have been breached.

Alternate security access controls may involve the use of a "possessed object", again often combined with a password. This is the system that is used by bank ATM systems: you have a card (the object) and an associated Personal Identification Number (PIN) that allows you access to your bank account. As technology improves, another method that is gaining in acceptance is the use of biometric controls. Cameras that are able to scan or read a user's iris, fingerprint touch pads that also detect if the finger is "alive" by looking for a pulse and/or temperature, and voice recognition are all being used as authentication devices that allow access to computer systems as well as limiting physical access to areas that need to be secured.

As noted above, although any and all transactions on a network will leave a trail (in the form of an IP number or more), this data is generally also not so easy to access (nor should it be!).

Computer systems (servers, for example, but also home computers) will keep a record of transactions known as a log. The information contained in these logs can often help – after the fact – to locate and help detect an intrusion or an attempted intrusion. Modern advanced network security devices will employ algorithms that attempt to intelligently analyze network traffic, and are able to identify attempts to break in and take their own evasive action.

A company that is doing business on the internet not only needs to protect its data, but also needs to provide the public with a way to verify that the company is in fact who they say they are. Particularly in a day and age where unethical hackers try to redirect users to look-alike websites in an attempt to mislead unwary users, the use of digital signatures and digital certificates is one other tool that companies will employ in the interest of security. A digital certificate is a guarantee, backed up by a trusted authority (CA or certificate authority such as Verisign or Thawte), that the website or company can be trusted when they say who they are. Combined with a data encryption method known as Secure Sockets Layers (SSL), a digital certificate is enough to assure most customers today that they can safely do business.

IE icon that shows you are at a secure site

Back to the adage about cure and prevention, another area of data security that cannot be taken too lightly is the need to back up your information. One part of a secure system involves ensuring that the system stays online at all times, and this is done through the use of uninterruptible power supplies – essentially a battery system that will keep a computer system running for a short period of time if the electricity fails. Combined with disk redundancy systems like RAID (= Redundant Array of Independent Disks) which will save critical data simultaneously on several hard drives and thereby ensure that there is a backup copy, UPSes will help secure your data. However, there is no substitute for a physical copy of the data that can be stored in another location (for example in an off-site bank vault). In order to do this, of course, you need to make and move a copy of the data and you need to do it regularly. Often, the medium of tape is used to store a daily backup of files, both because it is relatively cheap (but slow) and because tape can handle large amounts of information as well.

Although backup copies of critical data files are an important tool for protection from data loss due to hacking, deliberate crime is not the only danger. Unfortunately, poorly written software can also be a security issue. Bugs in a program can cause data leaks as well. (Microsoft has an unfortunate notoriety in this area). In addition to leaking or allowing access to data, poorly written software can also cause a system to crash and thus loose critical data.

It seems that the major security threats that are common these days just keep getting worse as the security systems themselves improve – a game of cat and mouse.. The use of social engineering, whereby an unethical computer operator will try to "trick" users into giving away personal data has become one of the more common methods used to circumvent security systems. Computer users who are either less informed or careless can be fooled into thinking that they have been sent a link to a business they trust (their bank, their e-bay account…). The sent link will look like it is authentic, the site you are directed to will also appear to be authentic – but in fact it is a trap known as phishing (or spear phishing when it targets specific data or people).

Experts figure that (as of 2008), there are so many personal computers that have been compromised (and are actually running remotely controlled malware), that this has become a threat on a national level. Remote hackers are able to anonymously command their armies of

"zombie" computers to perform actions simultaneously. This technique can be used to launch what is known as a Distributed Denial of Service (DDoS) attack that effectively can shut down a specific target computer (server, generally) or even a larger group of computers. The method is basically to use the millions of zombie computers to send so many requests to the target system that the target cannot cope with them all and so ends up blocked (denied) or out of action.

Behind so many of these exploits are small programs that users unknowingly install on their systems (more often home systems are not as well protected as corporate systems). The generic name for this type of program is virus, but there are several major families of this kind of malware – and 000s of them exist (are "in the wild").

One common type is called a Trojan. As its name suggests, like the Trojan horse of Greek history, this is software that appears to be one thing but is in fact something else. For example, a free download you get off the Internet may claim to be a utility to protect you when in fact it is designed to harm your system. Potentially and commonly, Trojan horse program are seen as being destructive.

A worm is malware that is designed to "crawl" around a network and thus transports itself. In general, a worm is not usually harmful to data itself or hardware: it makes copies of itself and tries to navigate around networks. Although some people will include Trojans, worms and even adware programs as viruses, this is not technically correct. A virus must actually be "taken" from an infected computer to a clean computer – sometimes traveling via email or the Internet, sometimes being carried on an infected removable media such as a disk.
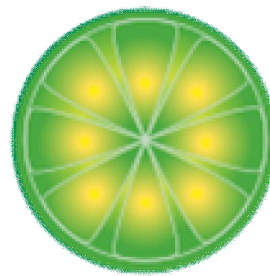
Some versions of Lime Wire were bundled with Lime Shop, which monitored your purchases
http://en.wikipedia.org/wiki/Limewire

Ethics
Ethics are moral principles. Ethics are a guide to decisions about right and wrong. The areas of ethics involves standards. Although there are strong links to religion (in that religion tries to tell us how to live our lives), because our societies include people of different beliefs, the definitions of what is ethical need to go beyond religious boundaries. Ethics involves concepts of justice as well: right and wrong and how we deal with each, and so the field of ethics is also linked to legal systems. The field of ethics is a branch of philosophy, but with the advent of computers and the way they affect us all, the specialized area of computer ethics has developed, and is still developing just as computing itself is also developing. Recalling that one of the major uses of the earliest computers was for military and government uses and that computers were in large part developed by educators, it does not seem surprising that very early on (in the 1940s), people began questioning the rights and wrongs of using computers: was it ethical to use computers to create the atomic bomb or to store the government's files on its citizens?

The Association for Computing Machinery is an association for computing professionals, and although these people are specialists in this area, their guidelines for members

(http://www.acm.org/about/code-of-ethics) can serve as a model for all computer users. Their members agree to:

Contribute to society and human well-being – their systems will minimize the negative effects of computer systems, will be used in socially responsible ways and make others aware of the potentially harmful effects of their systems

Avoid harm to others – this may include harm as a result of loss of systems or data or it may include harm to the environment from computer systems

Be honest and trustworthy – not to make false claims about himself or his systems, its limitations or problems

Be fair and take action not to discriminate – ensure that inequalities that may arise (haves and have-nots, powerful companies and the government) do not discriminate against anyone, that everyone has equal rights

Honor property rights including copyright and patents – even when there is no legal or licensed limitation, recognize that it is not ethical to duplicate or copy

ACM logo
http://en.wikipedia.org/wiki/
Association_for_Computing_Machinery

Give proper credit for intellectual property – even if there is no copyright, it is unethical to take personal credit for someone else's work

Respect the privacy of others – protect your data, allow only authorized access and correct errors

Honor confidentiality – information is private and unless specifically stated otherwise, is not to be shared.

Their list of ethical expectations goes beyond this, including a number of more profession-related guidelines, but the above will cover most people's use of computers.

Most people just want to use their computers to get their work done. There is a group of users whose interest in computers and computer users goes beyond everyday use that would fit the standards of the Association for Computing Machinery. For fun or for profit, these people break the above rules of ethical computer use.

The original hackers (ca 1970s) were people who mostly just wanted to learn everything they could about computers: their own computers and often any other computers they could get access to. The primary motivation was to learn as much as possible. Even into the early era of connectivity (BBSes and time share systems), the hacker ethos in general was not focused on disrespect or theft; there was a code of honor. Rather than using their skills to cheat the average user or to steal from the large "evil" corporations, their goals were to make a name for themselves, perhaps to show the large corporations that there were problems with their systems, perhaps to educate themselves.

The commercialization of the Internet and the growth in the number of computer users online opened up all sorts of other avenues for the curious. Not only were there many more targets to (try to) access, but the amount and type of data contained in these systems was different from the data that the early hackers had gained access to. In addition, online forums and websites made it much easier for a novice to learn the tricks of the hacking trade. This new generation of hackers who might download someone else's hacking program from the Internet, read a little guide on how to hack and then go to work, have earned the somewhat derogatory sobriquet of "script kiddies" – for their average age and the tools they use.

Although hacking generally has a negative connotation, not all hacking is unethical. Hackers have been grouped and classified as white, gray and black hat hackers, with white being "good" or ethical – people whose hacking might conform to the ethical standards. For example, it is fairly common practice for a large company to employ someone who is expert in the area of systems exploits (able to explore both hardware and software mistakes or flaws) to test their corporate systems: better to have a hacker on your payroll to test it for you than to have an outsider do it secretly.

Hacking sometimes still takes the form of "playing" around, for example, someone might (try to) gain access to a "friend's" computer either as a joke or a kind of school kid revenge. Although not less unethical or illegal, the damage caused by this kind of hacking is more on a personal, small scale.

More advanced and less scrupulous hackers are in the business to make money. Their goal may be to gain access to large unprotected funds ranging from an individual's bank account to large sums in corporate accounts or banks. Others are interested in making just a few cents from any one "hack" : small scale theft that adds up when there are millions of victims.

A different group of hackers with a different mindset is also involved in unethical computer use. These users are not involved in directly trying to gain access or hacking their way into a system. Rather, they rationalize that stealing from an often unknown large company is either acceptable or "not such a big thing" and certainly not something that can be considered a crime. Into this group go both the user who purchases blackmarket/illegal copies of software (or downloads the same). They may also do a little Internet "research" to get illegal registration information for the same illegal software. The same conditions are what is involved in the large scale sharing of digital music and movies/TV that the recording industry (for example the RIAA) is working to stop, and they call it "piracy" rather than theft.

Peer-to-peer networking is not necessarily a bad thing. There are a number of websites that make their materials (legal) available via P2P networks, partly because it is an efficient method for distributing digital files: rather than requiring all users to access a central server that then has to deal with all those users' requests, a P2P network spreads the work load around and every one benefits: it is faster and therefore less expensive. However, peer-to-peer use has come to be (incorrectly) equated with digital theft.

Aside from the RIAA, there are other groups of people working to fight the unethical theft of digital data. Obviously banks are highly involved in the area of ethical use of computers. Not only do banks need to be sure that their systems are safe from unauthorized access from outside, but they need to be equally sensitive inside their own walls. Much corporate theft of data actually comes from inside the companies, and the government and banks are no exception. It may be an angry employee or an employee who sees an opportunity that is too good to turn down. Further, because employees at large companies and banks have access to potentially valuable information about customers/clients (such as the credit records or bank account information), these companies have established their own codes of conduct for employees that spell out just what they may or may not do with their access to this digital data. Since illegal access is a crime, it is clear that the police and similar outfits

BSA Logo
http://en.wikipedia.org/wiki/File:BSA_logo.png

must be involved. An alliance of businesses – both computing related and other companies

who want to be seen as ethical – have joined forces behind a group called the Business Software Alliance (BSA) which now has offices all around the world and works to educate and stop unethical access to data, primarily illegal copies of software. Schools have played a role in educating students about the downsides to illegal file sharing: in the 1980s, it was common to see posters in school computer labs that advertised "Don't Copy That Floppy". Today, schools continue to take an active role in educating students about illegal downloading: many schools require students to pass courses that include units about Intellectual Property (IP) rights and laws, realizing that it is both so easy to steal other people's intellectual and artistic work right off the Internet and because of the prevalence of file sharing and a mindset that sees nothing wrong with it among younger computer users.

Reading:
The Hacker Crackdown by Bruce Sterling http://www.gutenberg.org/etext/101
Content – Cory Doctorow (pdf)

Resources:
Democracy Now! Has lots of related materials and their weekly news casts can be downloaded (creative commons licensed). Visit democracynow.org

The Electronic Frontier Foundation at eff.org – if they can't protect your rights, probably no one can.

Snopes (snopes.cpm) – a great place to go to check out hoaxes

A reliable source of information about viruses: us.mcafee.com/virusInfo

Questions to Consider
Should there be a greater penalty for someone who distributes illegal digital data than for someone who "simply" takes a copy of this same data? (Should the penalty for a website owner who is distributing "warez" be greater than the penalty for someone who downloads the warez?)

Research one instance of P2P file sharing that is legal. In your example, who is distributing what and why?

How good is a program's encryption (for example Internet Explorer?) One way to make a guess (since you probably cant evaluate the quality of the actual algorithm) is to look at the strength of the "key". How many bits are in the IE key? What difference is security does an increase in the number of bits make?

The loss of personal freedoms in the face of necessary databases in a major concern, especially when the data is so often compromised and so vulnerable. What is the solution?

As more and more systems get integrated (Bank ATMs are linked to large databases, medical records are accessible online both for doctors and patients), the value and the potential for abuse grows. Should we put a halt to this trend?

Most of our online actions are traceable – but in general they aren't actively tracked. Should they be? It might help reduce some kinds of crime.

If your data were compromised, where would you go for help?

What laws exist in your country that are designed to protect you (and your data)? Which laws exist to protect businesses?

What is the current cost of 1000 phished accounts? Of 1000 zombies?

Are there any reasonable (legal) uses for botnets?

Related Terms:
Anonymity
Biometric control
Botnet
Breach
BSA
Certificate Authority
Compromise
Content filtering
Cookie
DDoS
Encrypt
Firewall
ICRA
Identity theft
In-the-wild
Intrusive
IP rights
Key stroke monitor
Malware
Permission
PGP
PIN
Possessed object
Privacy policy
Safeguard
Script kiddie
Spybot
SSL
Surveillance
Trojan
Vulnerable
White-hat hacker
Worm
Zombie

ICT in Politics and Government

From the earliest uses of computing devices, governments have been among the major forces behind the use of technology. Herman Hollerith's 1890 Census Tabulating machine used by the US Census Bureau and the Harvard Mark II computer used by the US Navy in 1947 are two prominent examples of the government's interest in the power of these devices. When electronic digital computers began to be produced in larger numbers, one of the main customers for these huge machines were government-related offices.
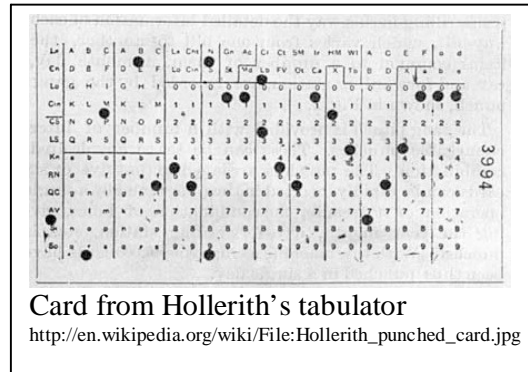
Card from Hollerith's tabulator
http://en.wikipedia.org/wiki/File:Hollerith_punched_card.jpg

Among the reasons for the government's heavy involvement were the great cost (who else could afford the early computers?), the huge amount of data that the government regularly needs to deal with, and the various military potentials of super-human calculation (building and launching rockets that can get to the moon).

In today's world, government plays a number of roles as regards ICT:
- the government needs to play a regulatory role, establishing laws and policies for the use of the technology;
- it needs to invest in future technologies, and so must commission various projects to advance its scientists, technology, military and general infrastructure;
- and it needs to act as a model for others, making the best possible use of technology for its own purposes.

Of course, the government's purposes may not always be in line with those of its citizens, and it is here that a number of non-governmental organizations (NGOs) play an important role, particularly in the area of protecting citizen rights. Especially in the area of privacy, the government may see a need for knowing all about its citizens – both to protect them and to provide for them, but the limits of personal privacy also need to be carefully considered when allowing the government to collect and use this kind of data.

In the United States, the term "government", following the established system of checks and balances whereby the different divisions of the government are in place to monitor each other, means that there are three separate "branches": the executive, the legislature, and the judicial. Each of them has its own areas of influence and each of them has specific duties and needs related to the use of ICT. Although governments around the world differ in structure, the US government's uses of computing technology often serve as models for other countries; being the democracy that it is, the US government's ICT use is well documented. See www.usa.gov as one place to get a sense of the extensive scope of the US government's online presence.

Although there are still large numbers of citizens in most countries who either do not have easy access to the Internet or who are not able to comfortably use these technologies (either for lack of skills and instruction or for reasons involving physical handicaps such as

blindness), there is no denying the fact that the power to communicate in both directions between citizen and government has great potential. When you can go online and download a necessary form instead of traveling all the way to "city hall" to pick it up, or when you can fill out a form online instead of having to mail it with the postal service, most citizens would prefer the former. For this reason, most governments have started to make more and more of their services available online, again, the information travels in both directions: the government can more easily inform its citizens as well as collect information from them.

It needs to be noted that while this chapter deals essentially with "legitimate" forms of government, it is by no means only the recognized political entities that are aware of and make use of the power of ICT. What began with pamphlets and radio broadcasts in the previous generation has moved online as terrorist and rebel groups have realized that for the very small cost of website registration, they, too, can have a voice online.

In particular, the jihad-related movement has seen that they can make relatively effective use of the Internet. Almost anyone who spends the time to dig for information can access various websites that host terror-related information, but this, again, is seen as being part of the price of freedom to discuss and share your thoughts. There are websites that host videos of terror attacks, techniques in how to build bombs, how to hide from or cheat law enforcement – and not all of these resources are "terrorist-sponsored". It is in this gray area that much of the discussion about who controls the Internet is focused: freedom of expression must have its limits, say some governments (and more and more these governments include the "democracies of the West".)

The Executive Branch
The Executive branch of the US government is essentially the President, Vice President and their advisory teams (for example, the cabinet); the President is also the commander-in-chief of the military, which is also included in the executive branch. It is that part of the system that is responsible for making sure that the laws are executed, for example through treaties with other countries. The executive branch also approves (or vetoes) laws passed by the legislative branch, and appoints the top justices (heads of the judicial branch) in the country. The President is also the chief of his(her) party.

Aside from the clear need to make personal use of the best in technology, the executive branch, through increasing use of e-government and related portals, collects and disseminates large amounts of information in various digital forms. From the White House web portal (whitehouse.gov), visitors can learn about the members of the executive team, the issues that the executive branch feels are most important (such as treaties or laws that are currently up for discussion), and link to various other sections of the government.

Logo from Barack Obama's web site
http://en.wikipedia.org/wiki/File:Obama_Biden_logo.svg

The 2008 Obama campaign is a good example of how government can make use of the Internet. The campaign stands out because Barack Obama was able to collect huge amounts of money, small amounts at a time from a very large number of supporters. The Obama

campaign was also able to make great use of its online facilities to organize its supporters: interested people were able to learn when and where there were opportunities to participate.

As a curious side note, there was a fair amount of discussion about whether Obama would be "allowed" to continue using the Blackberry he had been using before and during his campaign once he was elected President. Considering both the sensitive nature of his communication needs and the current in-built security weaknesses of ICT, it was deemed unsafe to let him continue "as is". In the end, a special setup with limited and highly secured communication links was agreed. This was a first: no previous President has felt the need for regular online email!!

In recent years, partly because of the potential freedoms that IT systems offer, there has been considerable investment in the use of electronic voting systems. Like many technologies in their early stages, these systems also have flaws that are causing many to question whether the risks are worth the benefits.

Along with the responsibility for the command of the military, the executive branch is also that section of the US government that manages the various law enforcement agencies including the police (some of this work is handled at a local or state level) and departments such as the CIA, FBI and the Department of Homeland Security. See the chapters about Privacy, Security, Ethics and Forensics for more information regarding police use of ICT.

The Legislative Branch

The Legislative branch of the US government is the Congress, which is composed of the House of Representatives and the Senate. The Senate advises the President and the House is responsible for introducing any laws that are intended to raise funds – between them and working with the Executive branch, it is their job to make the laws. Both chambers of Congress must consent before any proposal can become law. There are about 20 committees in each of the chambers (and more than 100 subcommittees!). The notion of congressional "oversight" is that the Congress should protect individual rights, prevent waste and fraud in the government, make the necessary laws, provide education for the people, create the lower judicial system, gather information needed to run the country and monitor the executive branch.

Like the Executive branch, the Legislative branch of the US government makes extensive use of various online portals (for example, www.senate.gov and www.house.gov) in addition to their own heavy use of ICT for their daily needs – almost all politicians have their own personal websites in addition to party websites (see www.rnc.org and www.democrats.org). As the major "law making" body of the land, the legislative branch is more deeply involved in computing: they legislate how the American people use computers.

As part of citizens' expectation of democracy, the laws of a country need to protect people's right of reasonable personal privacy. Part of the government's duty in a democracy is to protect these rights. When the government's perceived needs in the area of self defense conflict with these laws and basic human rights, friction can arise, as it has in the case of the

US government tapping into the records of its own citizens with the support of the phone companies in the efforts to combat terrorism.

Another example of how the government may get involved in the use of ICT is in the US' transition from analog to digital TV. The government first passed a law stating that there would be a new system put into effect in February of 2009: the law was passed after careful consideration in the Senate. The government further got involved by paying for and organizing a coupon-subsidized "set-top" box that citizens could use to cut the cost of the transition. In its role of guiding new uses of technology, the government rightly saw that a move to use of digital spectrum instead of analog broadcast would open up more and better uses of existing resources. Finally, when the government saw – at the last minute – that a large number of people were not going to complete their own transitions before the February deadline, the law was changed to allow for extra time.

The Judicial Branch

At the top of the Judicial branch is the Supreme Court. The Judicial branch also includes lower courts and works together with (but is separate from) even lower state and local courts. The Judicial branch decides who is right when there are disagreements, interprets the laws made by the legislature, and handles criminal and civil law cases. As such, the involvement of the Judicial branch in ICT (beyond its own portals – see www.supremecourtus.gov) is primarily in arbitrating if there are problems in implementing the laws passed by the other branches.

Particularly in the area of erosion of online freedoms, the Electronic Frontier Foundation (eff.org) fights numerous ongoing legal battles that work their way through the courts. From the EFF website:

Blending the expertise of lawyers, policy analysts, activists, and technologists, EFF achieves significant victories on behalf of consumers and the general public. EFF fights for freedom primarily in the courts, bringing and defending lawsuits even when that means taking on the US government or large corporations. By mobilizing more than 50,000 concerned citizens through our Action Center, EFF beats back bad legislation. In addition to advising policymakers, EFF educates the press and public. (http://www.eff.org/about)

US Senate Juduciary Committe wep page
http://judiciary.house.gov/

The Need for Regulation

Partly because the use of computers is a relatively new phenomenon and partly because it is developing in ways that cannot easily be predicted, much of the legislation related to computer use is happening after the fact. Among the duties of the Legislature is the need to make laws that govern the uses of information technologies. While the US government was

directly involved in the creation of the Internet, the rapid development and adoption of this technology occurred in ways that would have been difficult for anyone to predict accurately.

In order to promote the spread of the Internet, there needed to be protocols (rules) and a force behind these standards. There is some debate as to whether the intention of the people who created packet switching (whereby a user could connect to more than one remote computer from the same terminal and whereby the system would still perform if various central switches were incapacitated) really was to develop a system that could survive a Soviet attack, but in the end, the idea of survivability in the event of an attack was a critical part of the system. In fact, at the end of the 1970s and the start of the 1980s, there were several different standards and methods for exchanging and relaying digital data (including X.25, UUCP and others). These protocols were administered and developed under international standard related organizations.

Through the use of gateways and other devices, it was possible to link between the various different systems that were in operation. By the early 1980s, the system we know as TCP/IP had been agreed upon and adopted, in large part through the efforts and sponsorship of DARPA, a major US government sponsored research department. The original connections to ARPANET were government sponsored and so they were limited to universities and companies where the government had some control – there was no commercial aspect as this stage. In the early 1980s, several of these entities broke away from the main "net", and of course, it was not ARPA's job to run such a network: they were there to research and put the net into action. More and more educational institutions and companies joined the growing network.

In the early 1980s, first Norway and then Great Britain, and then places like the European Center for Nuclear Research (CERN) adopted the new TCP/IP standard. By the end of the 1980s, there were ISPs (Internet Service Provider companies) and the system had penetrated Asia as well as Africa. For many of the original (educational) users, the commercialization of the system presented a major problem. During this time, since ARPA was not designed to operate such as system, the US government established a number of entities to deal with the growing needs. A system of requests for comments (RFCs) whereby world experts could weigh in on the technical specifications was developed and legalized. A committee called the IANA (Internet Assigned Numbers Authority) took charge of some of the daily operations required to make the system work and in 1992, the NSF (National Science Foundation) created InterNIC to manage further operations as the system had grown so large.

Also developed was ICAAN, an international body responsible for Internet management, All of these committees and protocols had their support and roots somewhere in the US government.

In 1989, Tim Berners-Lee, working at CERN, developed a workable system of hypertext/hyperlinking that eventually led to the explosion and growth of the Internet as we know it. However, even today, there is much in the technical operations of the daily Internet that is rooted in the various branches of the US government. A 2005 meeting called the World Summit on the Information Society began to look into a more internationalized operation of the Internet. However, partly because one of the main tenants behind the Internet is free dissemination of information, there are many people who strongly believe that a heavy US

government hand (as the largest –best? – democracy in the world) is critical to keeping the Internet "free" of political interference.

Today, no small number of countries' governments (and debatably including the US!) use their political powers to control or otherwise place limitations on a totally free Internet (with some reason: the power of unlimited knowledge and access to information is well-known as a force that can cause at least as many problems as it can solve.) The case of Google actively filtering/censoring the Internet in cooperation with the Chinese government is one reason the US Congress has been investigating Google's business model overseas. A number of other countries implement some form of censorship and a group called Reporters without Borders (rsf.org) maintains data and rankings on the extent that governments - including the USA – limit online access to information.

Who owns/manages/runs the Internet?

Although the US has claimed a certain amount of ownership over the Internet both through its development of the Internet and its technological leadership, there are strong arguments against allowing the US to decide Internet policies that affect the entire world. In the early days of the Internet, this issue was not as important as it currently has become. Although the Internet is not owned or managed by the US government, there are many areas where the US government has been influential, starting with the mandate to establish the Internet in the 1960s.

ICANN logo
http://icann.org/

Officially, the Internet is managed by ICANN (Internet Association for Assigned Names and Numbers), a kind of NGO with International membership that is both academic and technical in focus. Their long-standing policy of RFCs (Request for Comment) has allowed (and continues to allow) anyone with the knowledge and desire to contribute to the policies and mechanics of the Internet. Although this system may not be perfect, the US and other Western governments are not ready to allow an International consensus to change the rules of how the Internet operates, despite serious pressure from United Nations bodies.

Various Important US legislature related to ICT

Laws which impact computers can come under several different categories. They may cover intellectual property issues such as copyright and licensing, they may cover the computing and communications industries such as bandwidth permissions and licensing, they include trade on the Internet in areas such as taxation of Internet sales and consumer protection and advertising, they may cover the use of computers as a government tool such as in online voting or citizen access to government, and the laws may cover censorship and freedom of expression. Some of the major laws that have been passed in the US and their associated issues include:

The Digital Millenium Copyright Act (DMCA) was passed by Congress in 1998 and signed into effect by President Bill Clinton. This law criminalizes the act of breaking the protections on copyrighted materials covered by DRM (Digital Rights Management). There has been a lot of criticism of this law (by among others, the Electronic Frontier Foundation – EFF) partly because it is said that interpretation of this law makes it too easy for authorities to claim that material is covered by this law and thereby forcing fearful users to delete digital material that may not actually be covered by the DRM laws. It is also claimed that this law makes it illegal to even research and analyze the cryptography that is used in DRM systems. One case where this has proved to be an outright hazard to citizens was SONY's XCP protection system in 2005 that silently installed when certain CDs were played on a computer. The XCP software actually installed a rootkit (software allowing potentially dangerous system level access) before warning the users via the EULA (End User License Agreement) so that users were not given the option to backout, and SONY was forced to discontinue the practice.

The Computer Security Law of 1987 was passed to help the government in dealing with its own uses of ICT. This law was updated in 2002 with a newer version called the Federal Information Security Management Act. The idea behind both versions of the law is to provide minimum standards and policies for government personnel that guide their uses of digital information. This law could be considered in light of the notoriously leaky/unsafe versions of Windows that were in use at the time (Windows NT was the first version that could be considered somewhat secure, and NT was only first released in 1993 – look again at the date of this law!) An apocryphal story about the computer security requirements of the most security conscious departments of government is that the only "secure" computer is one that is locked in a room with no access to the room and that the computer itself has no connectivity: essentially a computer that no one can use or access – clearly not very practical.

The Communications Decency Act of 1996 was part of the Telecommunications Act of 1996, and was an attempt by Congress to control media that included pornography on the Internet. TV and radio had already had limitations imposed by the Federal Communications Commission (FCC), and even thought the Internet was only a few years old at this time (1992-1996 = 4 years old), there were fears that there was too much indecent material available. This law made it illegal for anyone to send or make available to people under the age of 18 digital media that was "indecent or offensive to the current community". Free speech advocates objected to the use of the term "indecent" as opposed to the term "obscene" and the act was finally partially over-ruled in the Supreme Court in 1997 (the American Civil Liberties Union – ACLU – won its case, saying that the law limited the right to free speech). In 2003, Congress made changes to the wording of the law so that it would comply with the Supreme Court's decision of 1997, and there was a test case in 2005 which the Supreme Court upheld (= the updated law is currently in force).

The NET Act of 1997 (No Electronic Theft) is a law that made changes to copyright law in the US so that even people (criminals) who were distributing illegal copyrighted materials without profit could be punished. A famous case in 1994 of David LaMacchia at MIT who was distributing copyrighted material as a hobby ended up without his being fined or imprisoned. This law was passed to close this loophole and makes it possible to punish even people who do not gain money from distributing such works.

The CAN-SPAM Act of 2003 is a law signed into effect by President George Bush that aims to control the sending of commercial e-mail (and it includes references to similar uses for cellular phones as well.) The law defines what is and what isn't defined as spam, and makes it

illegal to send this kind of commercial e-mail unless it complies with three requirements: a clearly visible, working unsubscribe feature, accurate "from" and "subject" lines in the header of the email, and no false information in the header (that means it cannot be relayed to hide the real sender). Because the law still does not require the sender to get permission before sending, some people have called it the "YOU-CAN-SPAM" Act. Although there has been a noticeable reduction in the amount of spam since the law went into effect, it is believed that the main reason that you are seeing less spam these days is not so much because of the law but rather because of improvements in the technology that filters e-mail for security reasons.

The E-Government Act of 2002 is a law that states that the various departments of the US government must improve and promote citizen access to their government online. It is hoped that (among other goals) the passage of this law will make it easier for people to participate more in their government, to make it easier for the government to perform its duties, to provide better quality (and more) government related information, and to reduce the cost of government. It is a realization by the government that the future is largely digital and that the government needs to "get with the times".

BU SİTEYE ERİŞİM ENGELLENMİŞTİR

emesi,30/10/2008 tarih ve 2008/558 nolu kararı gereği bu siteye erişim TELEKOMÜNİKASYON İLETİŞİM

banned by "TELEKOMÜNİKASYON İLETİŞİM BAŞKANLIĞI" according to the order of: Ankara Çubuk Sulh Ceza Mahkemesi, 30

mesi,05.05.2008 tarih ve 2008/402 nolu kararı gereği bu siteye erişim TELEKOMÜNİKASYON İLETİŞİM B

is banned by "TELEKOMÜNİKASYON İLETİŞİM BAŞKANLIĞI" according to the order of: Ankara ı. Sulh Ceza Mahkemesi, 05.

Filtering the 'Net
Parts of the web, blocked by law in Turkey

The Patriot Act, which was passed in 2001 may not appear to be as directly related to the use or regulation of ICT as some other laws: the acronym stands for Providing Appropriate Tools Required to Intercept and Obstruct Terrorism. In many areas, this law updates previously existing laws – many of which do in fact deal with the use of computer technology. This law allows law enforcement agencies to search for information in a variety of "personal" records, and of course, today, most of these records are in some way digital files; hence, ICT plays a major role in this act. There has been quite a bit of controversy surrounding this law, among other sources, Michael Moore dealt with some of the issues in his film "Fahrenheit 9/11". Several of the non governmental "watchdog" agencies like the ACLU have tried to prove that there are sections of the law that erode the basic provisions in the Constitution for personal freedoms. More recently, directly related to ICT, the President required the telecommunications companies to provide secret and most likely illegal access to personal communications and information that would previously have been protected by the Constitution. Later, in 2008, Congress ruled that these "telcos" would not be legally responsible for having broken the laws regarding the protection of personal privacy at the request of the government. Interestingly, much of the related debate in Europe has been about data protection, whereas in the US, the debate has been more about privacy.

Many countries in the world have also put in place laws to limit or prohibit another area of online commerce that has turned out to be extremely profitable and successful: online gambling. Some countries do allow online gambling; however, in the United States, there is a confusion/inconsistency whereby government supported gambling operations (state lotteries, for example) are considered legal, but other commercial operations are not. Until 2005, Yahoo and Google prominently displayed ads for online gambling sites in their search result windows. One way that the US government has worked to limit its citizens from gambling online is to require banks not to transfer funds to known operations - even if they are outside the USA. Several Caribbean countries, where online betting is legal, have complained to the World Trade Organization (WTO) that laws like the US Wire Fraud Act (on which the blockage of funds is based) are illegal. Among the reasons and concerns for blocking online

gambling are the possibility that it can be a conduit for money laundering and that there is something morally wrong with gambling.

Lest all the above laws used as examples leave the impression that most of the laws put into effect recently have had a negative impact, it needs to be said that the use of ICT continues to grow, and so they overall impact of legislation and government controls must be seen as mostly positive. In spite of the major criticisms about the erosion of privacy and personal rights, commerce on and overall use of the Internet continues to grow, for example, replacing printed media as the major source of advertising recently. There have been laws passed in many countries that legalize the use of digital signatures; as a result, there are many legal applications that can be done online. And for all its ineffectiveness, laws like CAN-SPAM and the Patriot Act do give everyday users of ICT at least a framework that aims to help protect them.

Copyright, Copyleft and Creative Commons

One of the major legal areas the Internet has had an impact on is in issues related to copyright. The basic copyright laws were designed in a time when media (information) was analog (printed on paper, vinyl, celluloid etc) and are difficult to apply to the digital age. The expense, time and equipment that used to be required to illegally duplicate a book or a song has all but disappeared with the proliferation of digital media.

Copyleft sign
http://en.wikipedia.org/wiki/Copyleft

Copyleft is clearly a play on the word copyright, and it is a general term that includes various legal formats that allow the author of a creative work (book, music, film, software – most of it digital these days) to give certain rights rather than to limit rights as copyright law is intended to do.
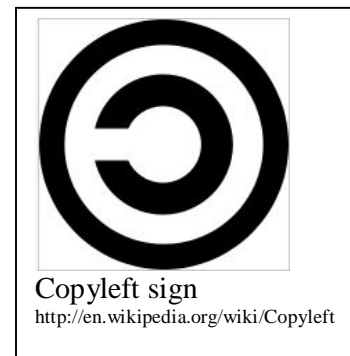
Creative Commons is one of several similar organizations dedicated to providing a legal framework for authors of all kinds of media to retain control of their work and at the same time allow others more liberties in their use and reproduction than traditional copyright law allows. Before Creative Commons

Creative Commons Logo
http://creativecommons.org/

came into existence (in 2001), there were similar projects including the GNU project (initially and primarily working with software and software manuals). And although GNU is primarily software oriented, it has the same basic social and ethical principles related to the free dissemination of information. Whereas copyright in general can be seen as a set of laws (and a cultural perspective) based on restricting what a person can do, the focus of Creative Commons is on permission: allowing the author and the public certain permissions related to the use of creative materials. Since 2001, when the Creative Commons project was launched, there have been millions of digital documents, most of them online, developed under CC licenses. Among the more well-known are the Wikimedia Commons, Flickr and DeviantArt, the Internet Archive, MIT OpenCourseWare, Microsoft Developer Network, as well as a growing number of record labels, news sources, comics, and books such as this one.

Outside the United States, a number of governments have instituted laws that will help them to reduce ICT costs on a national level by moving to (free) Linux and Open Office in place of Windows and Microsoft Office. This same trend is partly behind the OLPC (One Laptop Per Child) project: the additional cost of including Microsoft's programs on just one computer can as much as double the overall cost, and it is here that a government policy could have a great effect. While part of the reason for the change is certainly the costs, there are other international/legal factors involved as well: if a country is facing large-scale copyright issues and has an international reputation for software theft, one way to get the WTO (World Trade Organization) off your back is to move to something that is free/not copyrighted. In addition, since most malware targets Windows systems, there is the added benefit that a government could reduce its security risks at the same time that it cuts costs.

Military Uses of ICT

As noted above, the Internet initially came into existence partly as a solution to a military problem. The establishment of a distributed national communication network offers advanced facilities to a country at war. Although over time, the military has found it necessary to move to a separate system of its own, the basic concept was and is correct. Today, because of advances in ICT, a soldier sitting at a desk in Washington can control an unmanned aerial drone half way around the world, and a soldier in the battlefield can connect to a centralized map and database that provide him with real-time information that has the potential to cut through the "fog of war".

DARPA

The Defense Advanced Research Projects Agency is part of the US Department of Defense, and as such, is part of the Executive branch of the US government. It was founded as ARPA

in the late 1950s partly in response to the Soviet launching of Sputnik and the name was later changed to DARPA. One of its first major projects was ARPANET, the packet switching data network which later became the Internet. However, as part of its main mission to provide research and tangible benefits in the areas of command, control and communication, it has also been responsible for many developments in artificial intelligence, speech recognition, virtual reality, advanced computer systems, surveillance, laser systems and various space related technologies.

DARPA Logo
http://en.wikipedia.org/wiki/DARPA

Although DARPA is a government entity, it has a very special status which allows it to operate somewhat outside standard government bureaucracy procedures. In fact, DARPA has only about 150 high level technical staff and there is virtually no hierarchy among the teams. Along with the freedom to hire the best professionals without the usual government procedures, this structure allows for a great amount of flexibility. DARPA is able to hire experts from almost any area of life: universities, government and industry in many different areas of expertise. DARPA generally does not operate its own labs: the work is done in universities and industrial companies.

One of DARPA's more prominent recent projects has been the DARPA Grand Challenge in 2004 and 2005 followed by the DARPA Urban Challenge in 2007. The US Congress has given DARPA the task of bridging the gap between ideas that could benefit national security and the current state of technology. In this light, since 2004, DARPA has been offering cash prizes to the winners of competitions to develop autonomous (driverless) vehicles. True to form for DARPA projects, the contestants have been mostly universities (though not all of them have been American). The initial 2004 challenge was to develop a vehicle that could drive itself though a random course/track within a given time frame. No team was able to win the prize that year; however, in 2005, Stanford University's team was able to drive the 12 km course in about 6 hours to take first place. The 2007 Urban Challenge took the task further by requiring the teams to "drive" in simulated city traffic. Carnegie Mellon University placed first, successfully to navigating the 96km course in about 4 hours.

Another DARPA project worthy of mention is DARPA's work on onion routing, which allows a user to hide personal information while surfing the Internet (see TOR). Interestingly, this project would ostensibly allow people in overly censored countries a degree of freedom – but at the same time, does appear to undermine any efforts by the government to limit Internet access. DARPA also spends a considerable amount of energy on military technologies such as advanced aircraft, robotic warfare and weapons systems that use computing technology.

Reading
"Scroogled". Doctorow, Cory.

For you to consider and further research

What would you imagine are the potential benefits to US national security from developing an autonomous vehicle? What are the civilian benefits that you can think of?

Many big businesses claim that digital media theft is causing them to lose large amounts of money. How, then, can other authors of creative works be successful when they make their works available under various copyleft licenses?

Where do you draw the line between personal privacy and your need for protection? Is it acceptable for law enforcement agencies to track your movement, conversations, online surfing and e-mail as they look out for dangers to society? What about recently developed technologies that allow them to see into your house through the walls?

IT offers a future where people are more involved in their government, especially if you can connect and share easily. Will this make government more democratic?

If the government has the power to control so much (laws, the actual infrastructure…) do we lose some freedoms.

NGOs such as the EFF currently play a major role as watchdogs against overly powerful government. Why do so few people dedicate their time and energy to strengthening them?

What are the dangers of automated systems that governments need to reach its citizens easily?

If you live outside the USA, what laws exist in your country that govern your access to "free" information via the Internet?

Selected Vocabulary

ACLU
Arbitrate
ARPANET
CAN-SPAM Act
CERN
Chamber of Congress
Checks and balances (system of ~)
Copyleft, Creative Commons
DARPA
DMCA
E-voting
Executive
GNU
Grand Challenge (Urban Challenge)
IANA

ICAAN
InterNIC
Judiciary
Legislature
NET Act
NSF
Onion routing
Packet switching
PATRIOT Act
RFC
www.rsf.org
Telco
TOR
Watchdog agency
Wire Fraud Act

Computers and Forensics

Forensics in ICT terms generally includes two distinct fields: (1) using ICT to enhance information gained about a crime (for example, software that can process database searches faster than humans can), and (2) gathering information about a crime from a computer that contains data related to the crime.

The subject of forensics could be included in a discussion of government uses of ICT because of its value to and use by the security/police forces, which are a subset of the Executive branch of the government. Equally, forensic issues could be included in a section about privacy and security for many reasons: some people value their privacy enough to go to great lengths to make their data almost inaccessible to anyone through the use of methods to thwart forensic data extraction, even to expert law enforcement officials.

http://www.clipartguide.com/_pages/
0511-0809-0718-0148.html

However, both in the interest of making you aware of the extent to which information you consume is digitally recorded somewhere and because of our interest in a society that still defends the individual's right to privacy, the subject of forensics appears in this text as a separate section. Your awareness of the potentials of the uses of ICT in forensics should make you more attentive to your rights and to abuses of your rights.

As more and more of our lives involve the use of computers, increasingly more data about the crimes people commit are stored on computers. Sometimes the computers involved are the personal computers of the criminals; sometimes they are the computers of large corporations that provide the services we use on a daily basis. One thing about using computers: they keep a record of events known as a log. More often than not, an audit of these logs is the basis for evidence that can lead to an indictment: the evidence they present is pretty solid, provided proper forensic procedure is taken.

Forensic Recovery of Data from Computers

One of the first things a police force will gather as part of its evidence into a crime are any computers, data files and associated devices belonging to people involved in the crime. Interestingly, traditional detective work also plays an important role in computer file discovery: the area near a criminal's computer often produces related information such as passwords written on a piece of paper!

Partial Data Recovered
http://en.wikipedia.org/wiki/
Data_recovery

Crimes that directly involve the use of computers may include under-age pornography, the deliberate spreading of viruses, or a crime where the victim was first contacted online and so copies of chat sessions may have been saved, and even terrorism where the data is kept on a computer: there are many ways that criminals make use of computers to make their work easier.
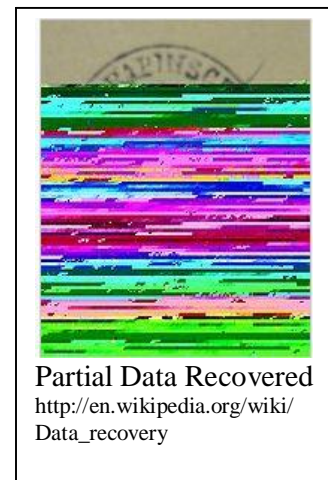
Of course, some crimes directly involve computers, known collectively as cybercrime, for example hacking and illegally obtained music or video files. Other crimes are not so directly computer-centric but still involve heavy use of computers, for example militants who keep copies of critical files on their computers.

In legal terms, companies are required to keep records of their online activities (logins, online access, copies of deleted files etc) for several years: they must store backup copies of their network activity in case there is a legal case against them. If they are not able to provide these records, they face an additional penalty in front of the law: at the least, the people in charge of the network (and their bosses) face legal problems. A network administrator is required to follow the law, and you - a student, an employee – are caught in between. Combined with workplace standards and policies that specifically state what is acceptable or required, the law aims to make it easier for authorities to end up with data that can make it easier to prove a legal case.
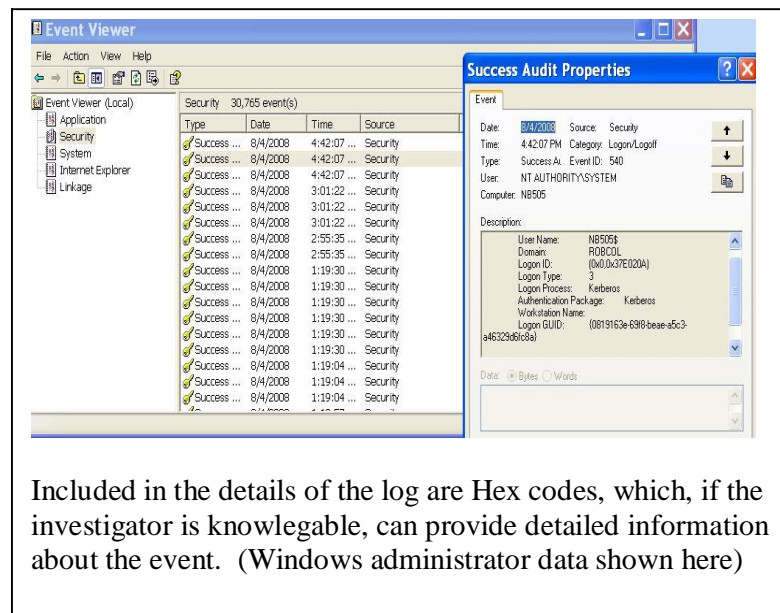
Included in the details of the log are Hex codes, which, if the investigator is knowlegable, can provide detailed information about the event. (Windows administrator data shown here)

Proper forensic procedure is a growing business. Because the US courts accept digital evidence, it is essential that parties can prove that the data they are presenting has not been tampered with. Even the process of making a copy of files, if it is not done properly, can destroy or alter data, and so special software and hardware is required. For example, when a computer is shut down, a certain amount of cleanup is done by the OS. An expert in computer forensics can often find and preserve data that even an advanced user may not be able to hide, especially if the expert is presented with a computer that is still running. Just one such example is the fact that when you delete a file, the OS doesn't normally overwrite the data; it just marks the hard disk area that was used by the deleted file as being available – the data is still there, but without an index to show the OS how to access it. Even when a new file is written into this space on the hard disk, it may not completely fill the "sector", leaving pieces of old files still accessible to special techniques.

Likewise, when a hard drive becomes damaged, where a normal user would be inclined to throw the hard drive away, technical experts can still access the data that was on the drive. A motor can be replaced, the hard disk platters can be placed in a new drive of the same type or the other electrical components of the drive can be repaired, allowing other people to read the data. There are numerous companies that advertise these services in the pages of computer magazines under the category of data recovery.

It has also been demonstrated that, contrary to popular belief, the data that is stored temporarily in RAM does not simply disappear when a computer is turned off. In fact, data stored in RAM dissipates, normally over a period of a minute or so. However, by cooling the actual RAM memory stick with a simple can of spray, the process of dissipation can be greatly slowed – for as much as 10 minutes or longer, giving a forensic expert enough time to even remove the memory chip and copy the data into another computer for later examination.

In any case where law enforcement officials or companies empowered to perform the technical work on their behalf set about to obtain evidence from a computer, there are a number of steps that must be rigorously followed. Otherwise, in a court of law, the evidence will not be accepted; obviously, digital data can easily be manipulated, concocted or destroyed during the process of capturing the data, and law enforcement officials must be able to certify and prove that this has not happened.

Three main steps need to be followed to ensure that the Daubert standard is met. (This is a legal requirement that is intended to make it impossible to use fake forensic evidence or methods and is based on a legal precedent.) The steps are:
- Avoid contamination: the forensic process could introduce foreign data
- Act methodically: show that you covered all possibilities
- Maintain a chain of evidence: keep the original/source files verifiably untouched

One trend in computer forensics is towards using Open Source programs. Linux is not only the first OS that would come to mind when talking about Open Source, it also happens to be able to best handle data of all sorts: Windows, Mac or Linux, and the Open Source movement is most prevalent in Linux. Using Open Source programs in the forensics process means that both sides (defense and prosecution) have equal access to the same software and results. Further, the nature of Open Source software is that it is peer reviewed, impartially tested and therefore accepted as meeting the Daubert standard.

For examples of OpenSource software that you can test yourself, see:
foremost.sourceforge.net
md5deep.sourceforge.net

A major component of file discovery is the use of the MD5 (RFC 1321) 128-bit cryptographic hash. This is a 32 digit hexadecimal number that is used to check the integrity of a file and can be used, for example, to verify that two files match (the copy is the same as the original). (If you are interested in advancing your knowledge, compare this with the term CRC, another method for verifying accuracy of a file.) This is one area where advocates of privacy are up against governments that want and need the ability to decipher encrypted files.

3 CCTV cameras
http://en.wikipedia.org/wiki/Closed-circuit_television

Another example where forensic data may come into play is in a street crime. Although there may be no human witnesses, there are several places that a forensics expert may be able to find valuable data that could assist in solving the crime. There may be CCTV images. Both private companies as well as the government continue to position closed circuit

television cameras in public places to provide visual evidence. In fact, it is getting difficult to go from one place to another without being "seen" by a number of CCTV cameras along the way. Many also believe that the simple presence of these cameras acts as a deterrence in itself: if a person thinks that he can be seen on camera, he is likely to stop and think before he acts. A person looking for camera evidence can locate the time-coded section on a recorded or archived tape to locate data that pertains to the crime, and then search for clues.

As the number and size of databases continues to grow, more and more computer-stored data is made available: to be lost, stolen or used by law enforcement agencies. When all this information is available in a digital format, it is easier to search and find matching records. This is surely an advantage. However, the reliability factor is critical in examining the usefulness of this data: are there errors in the raw data? Are the assumptions behind the algorithms used in searching the data correct? Who has access to the data or the algorithms? For what purposes are the data searches being made?

Using Computers to Enhance the Forensics Process

There are a number of software and hardware tools that increase the value of a raw image such as one captured by a CCTV camera. For example, using even generic software such as Photoshop, an image can be adjusted so that it highlights features that would not be immediately visible to the naked eye: common graphics programs like Photoshop include filters that enhance the edges of an image to bring out details that are not normally visible. Special software and hardware can turn some cameras into devices that see more than the visible spectrum of light that our eyes see, and in the process, identify features that are not normally seen. This technology has been put into use following the 9/11 attacks as airport screening systems are needed to see beneath the clothing or into the locked baggage of passengers, for example.

Sometimes, combined with the CCTV cameras, there are microphones. A combination of software and hardware has been developed that is able to identify the direction and nature of sounds in public, and this software is in use in some US cities to try to reduce gun crime. The software is able to help police not just to identify the nature of the sound (what kind of gun was it, how many shots were fired), but is also able to help place the source of the sounds (did it come from the left? How far away was it?) One such solution is marketed by ShotSpotter in the USA. The company's software works with several camera systems. (Visit their website at http://www.shotspotter.com/index.html)

Although detailed real time aerial digital photographic coverage in most locations is not yet in place, the technology exists for satellites to resolve (pick out in detail) objects as small as 10 cm in size or less. Spy satellites of this sort are rather

Robert College satellite image
maps.google.com

secretive and not currently known to be used for this sort of work, but the technology is open to this kind of use. Some government satellites have been "dumbed" down when they are

made available for public use. The capabilities of other government technologies are not made public or kept secret. However, considering the capabilities of known satellite observation, it could be surmised that if a government set about to target an individual (James Bond style), it appears likely that they could track someone in real-time with a level of detail that would resolve many potentially incriminating details. (See maps.google.com)

Combined with special software, digital cameras are able to provide more information than a normally endowed human can access. This kind of system is sometimes called "AR", for Augmented Reality. Similar to the systems in cars and airplanes also known as "heads up displays", these systems mix and merge everyday information/data such as normal human visual data with digital data. The digital data may be enhanced visuals processed by software, or it may be "live feed" data that provides additional related data from special databases. One such example is a system where police cars are being equipped with digital cameras and software that is able to read information such as license plate data in real time and then process it using computers inside the police car, comparing the digitally-read license plate information with a database of stolen or similarly reported vehicles. The policeman simply needs to drive the car and listen to the verbal output generated by the system: he hears both a warning "beep" as well as a spoken sentence that alerts him to the nature of the vehicle's status.

Digital cameras are routinely used and are now accepted as evidence in other ways as well: images of a crime scene (the police photographer who photographs the body, for example) can be and are shown in court as proof. In fact, in retrospect, it is obvious that even analog film (which was accepted as evidence provided it passed a "Daubert" test of its time) was susceptible to alteration, despite assumptions to the contrary (granted, technological limitations meant that only someone really skilled in darkroom effects could achieve legal falsification).

There are a growing number of companies that specialize in re-creating crime scenes and events in animated, digital forms in such as way that they are accepted in a court of law as supporting evidence, similar to the way that an expert might testify to help prove the validity of a theory. Especially when the technical details (mathematical angle of a gun shot, for example) might be difficult for a jury to fully comprehend, these legally admissible computer augmented

Virtual accident augmented with technical data
www.dynamicro-animations.com

animations can be critical evidence. It is worth noting that as computer generated graphics get better and better, the realism factor of a computer generated video scene could bring a jury to substitute the virtual for the real.
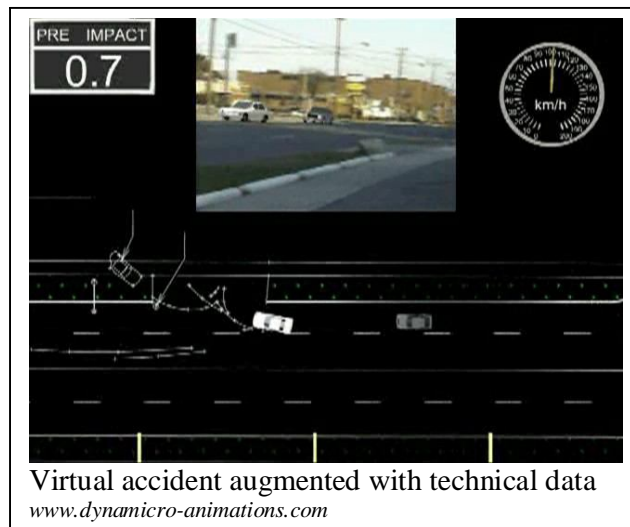
Stringing

One traditional procedure at a crime scene is to document the locale. In a room, the measurements are recorded: height, length, width … On a road, the distances, speeds, directions are part of the data set that defines the events. Prior to the availability of high-tech IT equipment, this process involved "stringing": a police technician would use string to measure distances and angles (for example, a string leading away from the impact point of a bullet could be used to find the point where the gun was fired.) Today, laser controlled digital cameras and computer generated algorithms have replaced the somewhat imprecise techniques of earlier years. Although a device as standard and common as a laser is almost considered low-tech these days, when coupled with computer software and targeting, such a device can render precise forensic data. A device called an Electronic Ultrasonic Measurer (point and measure), which uses computer controlled measurement techniques, has replaced the string, just as digital cameras have replaced the classic "police photographer" with the flash bulb camera we used to see in older films.

Specific software can then use the raw data from these measurements and create an accurate 3D scene. Software can also create more than one possible scenario by providing possible options for any unknowns, thereby eliminating the impossible solutions and making the police work more accurate.

Total Station

The laboratory that the police carry to a crime scene has gone almost totally digital: the cost and accuracy of analog equipment no longer suffices.

A device called the "Total Station" began to replace that imprecise technology of using strings, paper and pencils and analog photographs during the middle of the 20th century. It was a device used by engineers that was easily adapted to forensic use because of the (then) precise nature of the data it provided, as opposed to the use of string, for example. Today, this device is considered somewhat imprecise in the face of the capabilities of digital equipment such as LIDAR. With this kind of digital support, forensic data can be directly downloaded to a computer for processing, rather than having a human transfer the data by hand.

LIDAR system
http://en.wikipedia.org/wiki/LIDAR

Total Station
http://en.wikipedia.org/wiki/Total_station

Photo Composites

One of the classic results of a police investigation into a crime is the "Wanted" poster. In pre-digital times, highly skilled artists were part of the staff of a police force: people who could interpret witness descriptions and turn them into visual elements (Certainly there were gifted people employed at this job, but the subjective nature of this process cannot be overlooked.) Today, using a combination of digitally captured (but possibly grainy or unclear) images and special software, police are able not only to create likenesses that are indistinguishable from actual photographs, but they are also able to put special algorithms to work that can authentically "age" a victim/suspect within reasonably accurate limits. It is possible to produce a computer's best guess as to what a certain person would look like many years after the last photograph on record was made.

As digital imaging technology improves, it has become increasingly difficult to separate a digital image from a "real" image, and the composite images of "wanted" criminals has taken advantage of this. Special software can take a witness' observations ("He had a long chin") and create a visual image that can easily be redrawn simply by making a different selection from a drop-down menu of choices. Compare that with the pre-digital process, where the police artist would have to redraw the image or erase a section of it and draw it again.

Computerized Matching

There are a number of traces that might be left at a crime scene that can be used to identify the criminal (and sometimes the victim). The use of computers has made a difference in several ways. When there is so much data to sort, catalog and search through, a computer or a computerized database makes the work both faster and less prone to error. Special software and hardware adapted to specific uses also increases the likelihood of positive identification, whether it means reconstructing a scene from limited or missing information (where a computer could enhance the "guess work") or whether it means searching a large database to find matching patterns. Although each of these is a different area, in general they all use software that compares data using specific algorithms (height, distance, frequency of whatever feature of the material is often different among similar samples)

Ballistics

One area where computers play an important role in facilitating the job of making a positive match is ballistics discovery. Prior to the arrival of computer technology, police experts would examine the markings on bullets found at a crime scene under a microscope. They still do; however, the process has been considerably enhanced with the assistance of computers: much of the visual comparison can now be automated. Similarly, rather than having a desk clerk search through long files in search of serial numbers – on weapons recovered or ammunition – centralized databases and logged electronic records allow police to make better use of their time.

Identifying features
http://en.wikipedia.org/wiki/
Firearm_microstamping

Fingerprints

The use of fingerprints to identify individuals was known back as far as ancient times (Greek and Babylonian records show the use of fingerprints as a signature. However, it was only about the 1850s when police investigations began to make extensive use of fingerprints as "proof positive". Although no two people have the same fingerprints, police are often limited by the amount of data they can search through. Before the era of digital records in a national database, trying to match fingerprints was a rather local operation – or time consuming, as copies of the fingerprint images would have to be physically sent across the country to a central office. Today, police detectives can work online, with access to a national digital archive of known fingerprints.

http://en.wikipedia.org/wiki/Fingerprint

Fingerprint recognition hardware and software are regularly used to authenticate user access: buildings or secure facilities may combine fingerprint (or entire hand and palm) recognition with other password-type controls. Similar systems may be installed on laptop or desktop computers in place of, or combined with, regular login processes. In addition to simply reading the individual distinctive lines that make up a person's fingerprint, the better systems are able to detect additional features such as the presence of a pulse or temperature as an additional security measure to thwart criminals who might attempt to use copied/faked fingerprints.

Other biometric discovery techniques

Similarly, recent trends have focused on the fact that everyone has a distinctive iris pattern. Although the difficulty in obtaining an iris scan from the scene of a crime is a major obstacle, after-the-fact identification using this technology is becoming more wide-spread.

Another biometric feature that can be used to positively identify an individual is based on the fact that everyone has a distinctive voice pattern, and here again, special software and algorithms call into play the use of computers and forensic discovery.

Yet another biometric forensic technology that combines the wide-spread deployment of CCTV monitoring and software is based on the fact that individual's have differing walking styles. Software has been developed that is able to identify people from video footage that shows them walking. Further developments that combine cameras and software allows us to interpolate and construct a frontal face view using only images obtained from a side angle: the software extracts data from the side view and creates a most likely image of a full face photo of a criminal/suspect.

Partial allele sample from 6 people
http://en.wikipedia.org/wiki/Genetic_fingerprinting
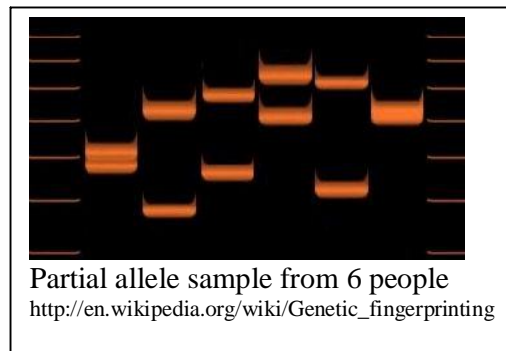
DNA

Similar to the case of fingerprints, but even more recent a development is the use of DNA as positive identification in a crime. DNA identification can work with any body parts (blood, hair, skin flakes…) to create a very clear profile of the person the sample comes from. Again, the chance of identification is made better when you have a larger database to work from. Recent changes in the law in a number of countries but especially in England, now allow the police to build a better DNA database by giving the police the legal right to collect and save a digital DNA file for anyone who is taken to the police station. The fact that in England, the police are allowed to take a DNA "swab" even of people who are not charged with a crime has become a major issue of privacy rights.

Handwriting/Graphology

Handwriting analysis involves forensic examination of such factors as (pen) pressure, slant or angle of letters, deviation above and below imaginary "standard" lines and other factors such as the size of loops in the letters. While much of this is based on visual observation, software that can scan and then automatically, digitally compare these features is making this science more reliable as a tool for detection.

Handwriting sample
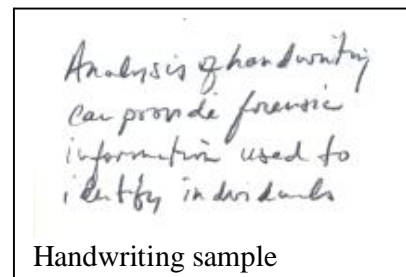
One technological advance that has gained in use in the past decade is the use of signature pads combined with credit cards to collect signatures at POS terminals in stores. These touch sensitive pads run software that can help match writing styles to a database of "authorized" signatures and "flag" irregular signatures before a credit card theft can be processed.
One trick of the criminal from the pre-digital era was to use a typewriter or to cut and paste characters from a printed document to try to conceal the handwriting. Just as a detective used to be able to identify which typewriter produced which characters (because each typewriter had its own "signature" in the way the letters strike the page), the same basic techniques can be used with today's printers. A printout from a printer is also going to show traits unique to that device.

The classic old-time detective might have had forensic experts working to identify a criminal based on unique identifiers of the typewriter he or she used, say, in writing a ransom note. Although typewriters are mostly a tool of the past, in passing, we can note that today's printers each equally distinctive. Research by the EFF has proved that printer manufacturers are required by government authorities to include normally imperceptible identifying markers (http://w2.eff.org/Privacy/printers/docucolor/) and certainly, as printers get used and worn, they develop their own signatures, such as streaks or imperfections that can then be used to positively identify the source of a document.

Reading

Hacker Highschool's Digital Forensics Chapter (HHS_en8_Forensics.pdf)

Further research links

http://www.porcupine.org/forensics/forensic-discovery/ by Dan Farmer and Wietse Venema

http://dfrws.org/ is a site dedicated to digital forensics research

http://www.forensicswiki.org/wiki/Main_Page more than 500 pages of Creative Commons materials about Digital Forensics

For you to consider and further research

The accuracy of computer generated data usually outperforms humans doing the same tasks. If criminal forensics becomes automated, will we be better off?

One recent trend in computing is working towards algorithms that allow computers to better analyze images. If we could analyze images better, this would provide greater ability to track crime but it would also seriously curtail freedoms. Weight the pros and cons. What do you advise for the future?

The ability to identify medical data has many benefits. It also opens up areas where our personal privacy is compromised. When would you benefit from an online medical file that doctors could access? When would it not be a good idea?

How are computers used in DNA matching? How accurate are DNA comparisons? What is the acceptable level of matching, and if %100 is not the standard, how likely is it that there can be matching errors?

Governments are collecting more and more data that can be used to identify individuals – especially for criminal profiling and detection and storing them in large databases. Police argue that without a large database, their information is limited. Privacy advocates argue that this is an invasion of personal privacy. Who's right?

Merchants use digital tablets to verify customer signatures in some places. What handwriting traits do these devices look at? Where is the "master" database of correct signatures stored?

Is there any way to make it %100 impossible for even an expert to use forensic recovery software to get copies of data you save on a computer?

Vocabulary

Augmented Reality
Ballistics
CCTV
Chain of Evidence
Contamination
CRC
Cryptographic Hash
Data Recovery
Daubert Standard
Digital Evidence

DNA Swab
EUM (Electronic Ultrasonic Measurer)
Graphology
LIDAR
MD5
Photo Composite
Resolve (to resolve an image)
Stringing
Tamper (with)
Total Station

Artificial Life and Robotics

Robots are in many ways very much science, and as such, could easily be included in a section about scientific use of ICT. More so than other areas of IT in science, such as computer generated DNA sequencing or computer-guided search for extraterrestrial life (SETI@Home), robots are an icon of the convergence of hardware and software. The ultimate robot is a mechanical replication of a human being..

The word "robot" dates to the early 20th century, when the Czech writer Karel Capek used the

term to refer to artificial people, and comes from the Czech word meaning "serf worker" or "servitude". However, Capek was most certainly not the first to envision a mechanical creature that served mankind. There are documented references to mechanical devices and beings dating back to the Ancient Greeks and the Chinese, as well as a programmable humanoid robot designed by the Arab/Muslim inventor named Al –Jazari in the 13th century. However, these inventions fall short of the

Al-Jazari robots
http://en.wikipedia.org/wiki/File:Al-jazari_robots.jpg

modern definition of "robot". Today we create robots in order to make our lives easier, to do those tasks that we find repetitive or boring and to do our work for us. However, for a deeper understanding of the meaning, you might note that in common usage, the term "robot" can be used to refer to a person who does not show normal emotions or reactions, and as such, carries a negative connotation.

As our expectations adjust to today's realities of what we can expect from a machine, robots continue to make major inroads towards taking on an important role in our lives. To the extent that a robot only does what it is "told" to do, that works "for free" and is potentially a device that can free humans from having to do certain jobs, until a more comprehensive machine is created, we find ourselves dealing with machines that focus on a limited subset of quasi-robotic functions: some of the above, but not all- by design.

Robots are actually already everywhere, Taken at its minimal limits, a robot could be as simple as a programmable car-wash. However, no-one would mistake a car-wash for a robot. The first devices currently accepted as robots were what we would call intelligent mechanical arms that were used in factories. Today, the high end, experimental limits of robotics showcase human looking electro-mechanical equipment that could initially fool an unsuspecting human into thinking it was actually a person (at least from a distance, for a limited time). However, by far the majority of robots that are being used today make no attempt to appear human: they are glorified mechanical arms or rolling devices with limited, specific intelligence: enough to do the task they are programmed for.

So … just what is a robot and would you recognize one if you saw it?

The first issue in defining robots that needs to be examined is the divide between software-only robots and robots that are a combination of software and hardware. Software- only robots are more commonly called "bots". Bots are commonly used as "agents" and partially fall into the robot category in that they have "a mind of their own", an intent. Software-only bots are often used to perform online tasks that a human would be much slower at, for example, scouring the web or performing repeated multiple clicks or searches. Although these examples are benign, legitimate uses, there are malicious ways that they can be used. For example, large numbers of computers have been infected by malware that can be used to simultaneously control millions of "zombie" computers, and this collection of zombies is referred to as a botnet.

The more common definition of a robot is the combined mechanical/software agent. Although there are areas where not everyone is in agreement about what constitutes a robot (or what doesn't), in general, people agree that a robot :

- Is artificially created
- Can interact with its environment
- Is programmable
- Has some degree of mobility
- Does something useful
- Appears to have intent

Hospital Robot
http://upload.wikimedia.org/wikipedia/
en/0/04/Pyxis_Pharmacy_Robot_by_Nurse_Station.JPG

It is this final trait that is used to decide if a device is just a machine or a robot: the more a device appears to be able to make choices, the more it is considered "robotic". Another trait that is changing in acceptance as more and more robots are put into service is the trait that a robot should look somewhat human, but this perception/definition is rooted in science fiction of the 1950s.

The ISO (International Organization for Standardization), in an attempt to standardize various differences among countries, defines a robot as "an automatically controlled, reprogrammable, multipurpose, manipulator programmable in three or more axes, which may be either fixed in place or mobile for use in industrial automation applications." Although robots are at work in many other places, the two main countries in the area are the US and Japan, with Japan having a slightly looser definition (i.e. more devices in Japan are counted as being robots.)

There are two main types of jobs that robots are particularly well-suited for:

1. Jobs which a robot can do better than a human (for example, robots would be more accurate and do not get tired or need to take rest breaks, so they are great factory workers)
2. Jobs which a human could do better but because of potential dangers, it is too risky to employ a human

Not for the first time, technology that came to become reality first appeared in science fiction writing. Perhaps the most famous example of a writer's imagination leading and inspiring developments in the technical sciences is that of Jules Verne. Jules Verne's important works

include Twenty Thousand Leagues Under the Sea, Journey to the Center of the Earth, From the Earth to the Moon and close to twenty more. Verne (1828-1905) wrote about space, air and underwater travel before they were technically possible, and along with H.G. Wells (author of The War of the Worlds about an alien invasion of the Earth in 1898) , is known as the father of science fiction.

More important to the realm of robots than either of these two is science fiction writer Isaac Asimov (1920 – 1992). Along with Robert Heinlein and Arthur C. Clarke, Asimov is considered to be the best science fiction writer of his time. Asimov was a seriously intellectual man, vice-president of Mensa International, author of a college level biochemistry textbook, a professor at Boston University and author of non-fiction titles that dealt with such topics as environmental crises including global warming and the depletion of the ozone layer as early as the 1990s.

However, Asimov's most influential work, the "Three Laws of Robotics" was a work that developed over a period of time, initially in short stories "Liar" (1941) and then finally in "Runaround" (1942). Asimov was not alone in developing his thoughts: there were other science fiction writers working with the issues related to robots. Previously, the more common vision of robots had tended to the Frankenstein variety: created to destroy or be destroyed (because they were unnatural or even evil).

Isaac Asimov
http://en.wikipedia.org/wiki/
File:Isaac.Asimov02.jpg

Since then, Asimov's Three Laws have earned a place in robotics that goes beyond simply being literature: with a fair amount of international discussion and debate, and some minor alterations, his laws have become the standard for how robots should interact with their environments. They are:

1. A robot may not injure a human being or, through inaction, allow a human being to come to harm.
2. A robot must obey orders given to it by human beings, except where such orders would conflict with the First Law.
3. A robot must protect its own existence as long as such protection does not conflict with the First or Second Law.

He also later added a "Zeroth Law" because he saw there were logical conflicts in just the original three. The Zeroth Law says:

0. A robot may not harm humanity, or, by inaction, allow humanity to come to harm.

Other authors have added to these laws, and some of the additions are:

4. A robot must establish its identity as a robot in all cases.
5. A robot must know it is a robot.

There are problems related to the application of these laws. First is the fact that currently, no robot comes even close to complying with these laws: they require an awareness that is not

yet possible. However, most people working in the area of Artifical Intelligence (AI) agree that they do represent an ideal. Among the other arguments working against these laws is the military use of robots. It makes some sense that the military might make use of robots: why risk a human life when you could employ a robot. However, a fighting robot would have to ignore the First Law to be an effective warrior. As for use in the police force, one powerful counter argument says that because a robot cannot "die", the use of robots for police work would mean that at least they would not have to shoot first (they would only shoot if they had been shot at.)

It is a curious footnote (and one of several issues related to the use of robots) that there have been a few human deaths directly caused by robots. Because robots are only aware of their environments in a limited sense, one of the concerns, particularly with industrial robots, has been to keep them apart from human workers. In 1979 in the US, Robert Williams was hit in the head by a robotic arm used for moving heavy parts in a Ford Motor factory. He died as a result of the injury and a court of law ended up awarding his family $10 million because of the lack of safety devices. The court noted that the robotic arm didn't even make any sounds to warn people that it was in motion. In 1981, in Japan, Kenji Urada, a worker at a Kawasaki factory, was trying to repair a broken robot without disconnecting the robot. The robotic arm pushed him into a grinding machine, where he died.

A Comparison of Humans and Robots

Without trying to list all currently available technologies, the following table compares various parts of human and robotic systems. What other devices/technologies can you add to the robotic features?

Function	Human	Robot
Locomotion	Legs	Wheels
Energy	Food	Electrical
Structure	Skeletal system	Frame
Manipulation	Hands	Grippers
Thinking	Brain	AI controlled software
Sensing	5 senses (smell, touch …)	Electrical sensors (cameras..)

Neural Networks/Fuzzy Logic
As opposed to rule-based intelligence, which is not particularly successful at handling new situations, there is a system known as neural networks. Because artificial intelligence often needs to work with data that is either very complex or not so easy to fit to rules of the linear type, neural networks are intended to mimic biological neural networks of the kind that human brains employ in learning. The process basically combines simple decision making elements into a network of "neurons" that cooperate to solve a problem. Classical, rule-based logic (of the sort that an expert system might perform) is based on clear true-false (0 or 1)

values. The fuzzy logic that neural networks involve accept that there can be values ranging anywhere between 0 and 1. This kind of decision making logic is currently employed in a variety of uses including video game artifical intelligence and various appliances like dishwashers and ABS braking systems.

Types of Sensors
Since robots do not have eyes, ears, skin etc, to get the kind of environmental input that humans so, they are equipped with "sensors". There are a variety of different sensors depending on the task involved. For example, a vacuuming robot might use sensors that help it "feel" when it has touched a wall and needs to turn around. Another robot might use light sensors that tell it to turn on the lights when it gets dark, and yet another sensor might "listen" for a specific wave length of sound and act accordingly.

Roomba Vaccum senses walls
http://en.wikipedia.org/wiki/File:Roomba_original.jpg

Motion/Mobility
The motors used in robots are known as "actuators". We tend to think of motors as hardware that produces rotational motion (most motors "turn" around and around) of the electromagentic type. The electromagnetic type of motor tends to spin fast but has limited "turn power"; a robot actually doesn't need the fast spinning this kind of motor is good for. A different type of motor, called a solenoid, can produce an in-out motion – good for turning a switch on and off. Two other kinds of motors are useful in robots: the stepper motor, which can make small, incremental adjustments, and the servo motor, which is designed to turn only 90° left or right.

Tethered or not?
The simplest definitions of a robot allow for tethered devices to be included in the robot category. Undersea remote operated vehicles (ROVs), such as that used in the Titanic search, are classified as robots. They are connected to their controllers via a physical cable (the tether). The same wire-based connectivity is also true for most industrial robots used in factories.

Types of Robots
There are a number of related terms that are sometimes used to refer to robots. An android is a creation that resembles a human (although not all androids would have to be robots). A gynoid is an android that is made to look female. A cyborg is a mix of human and mechanical components, also called a bionic man (as in the TV series "The Million Dollar Man", a human who was partially reconstructed using machine parts.) An automaton is a device that may look like a robot but lacks the necessary intelligence, generally mechanical or toy-like. In the movie "Blade Runner", the term "replicant" is used to describe a bioengineered creation that is nearly human but endowed with superhuman features such as extra strength, memory or vision.

Although it is the humanoid robots that capture our imagination, whether in real life, in books or in films, there are many, many more industrial robots currently in action. In fact, the market for industrial robots is generally considered to be a "mature" market, meaning that there are a lot of choices (cost-wise, feature-wise …) A middle range industrial robot will cost about $50,000, and when you consider amortization factors, that is about the cost of one year's employment for a factory worker. Keeping in mind that robots won't go on strike, ask for wage increases and can work without rest, this option begins to look very attractive to an employer.

The majority of today's industrial robots are primarily mechanical arms that are programmed to lift, position and mount parts on a factory assembly line. Many are able to "see" and have varying degrees of rotational capability. The major problem area is the "hand/finger" quality. Most industrial robots are equipped with "grippers", essentially a pliers-type of rather limited manual dexterity: even with vision capability, a hand that grips metal and fruit with the same sensibility is problematic.

Robots in car factory
http://en.wikipedia.org/wiki/
File:Industrial_Robotics_in_car_production.jpg

Although most industrial robots are fixed in place, there are other industrial robots that are mobile. This kind of robot generally follows a prescribed, pre-defined path within a factory, for example, delivering supplies.

Most control or programming of robots in done via a computer interface that the operator temporarily connects to the robot to issue the instruction set. (although there is progress being made in intelligent robots that can understand verbal commands). Some robots are then "unplugged" from the control computer, while others remain connected to allow for the computer to monitor the robot's actions. The most advanced robots have their own computers "onboard".

With the miniaturization of the electronics of computing, smaller specific-task computers have started to be put to use outside factories. For as little as a few hundred dollars, it is possible to buy robots that perform simple household tasks. Like the factory robots, these machines excel at doing repetitive tasks that would bore a human and would cost an employer more than the robot does.

A Gynoid from Japan
http://en.wikipedia.org/wiki/File:Actroid-DER_01.jpg

Aside from the few media-centric novelties of recent years (Honda's Asimo…), the humanoid robot is very much a work in progress that is not yet ready for prime-time deployment. Many people believe that their time is not too distant in the future, as scientists improve their mobility (running,

balance), their appearance (facial features that mimic human muscles), their intelligence (learning, not just repeating pre-programmed routines) and their stamina (Sony's robot dog, Aibo, can operate for an hour or two on battery power.)

One area where many people believe robots have a future is in home care for the aging. These people note that as the world's population ages, there will be a need for robots that can care for the ill and the old (and there wont be enough younger people to do this job). This use raises two important issues: would you trust a robot to take care of your parents? How much love (or similar emotional attachment) can you get from a robot-human relationship? This last point could be very important if you consider that part of health care is based on a caring relationship between the care giver and receiving person. (Initial studies have shown that the younger generation is better able to create emotional attachment to robots and that the older generations find it difficult.)

Artifical Intelligence

An effective robot is one that can make decisions. To do this, a robot needs a form of intelligence. This intelligence is currently produced through the use of software that accepts input (from sensors, for example) and then acts according to the programmed algorithms.

Turing Test

Alan Turing (who was mentioned in the section on the history of computers) is also famous for devising a test in 1950 that tries to understand if machines can think. The test is known as the Turing Test.
In this test, a human "judge" communicates with a real human and a computer using a text only interface (text only, so that there is no outside influence biased by speaking skill – although this could be incorporated at an advanced robot stage). The human judge tries to descern which is human and which is the robot. There have been several attempts at creating software that can pass this test, and there are yearly international competitions offering several thousand dollars to anyone who can create this program. One winner of these competitions was Jabberwacky (jabberwacky.com), which parses the human's input for keywords and bases its reply on them.

> "
> >> Hello.
>
> How do you do. Please state your problem.
> >> are you a bot?
> Why are you interested in whether I am a bot or not ?
> >> because it's my problem
> Your problem ?
> >> yes. I am a bot too, i think...
> You seem to be quite positive.
> >> No....I don't. Actually, I was a positive bot..... today, i wish to turn off my battery.....
>
> Are you saying no just to be negative?
> >> yes...I think....Am I a crazy bot?
> You are sure.
> ---------------------------------------
> Sample ELIZA conversation
> http://www.chayden.net/eliza/Eliza.html

These computer programs are also called chatterbots and one of the first was a program called ELIZA. The ELIZA program actually took phrases from the user's input and performed primitive language processing to converse with the user by means of posing questions – in what was known as "doctor" mode.

> Human: I am happy
> ELIZA: Why are you happy?

Computer programmers have continued this work, and there is another yearly contest called the Loebner Prize. This yearly competition will stop when the judges find a program that they cannot distinguish from a human in deciphering not only text but visual and auditory input. ALICE (Artificial Linguistic Internet Computer Entity) now uses a variations of XML (Extensible Markup Language, used in www design among other places) called AIML for Artificial Intelligence Markup Language to build and display its intelligence. The 2008 winner, called Elbot, is available online at www.elbot.com as are number of other chatterbots you can try: http://en.wikipedia.org/wiki/List_of_Chatterbots

Artificial Intelligence, however, goes beyond chatterbots. Research in this field has worked to identify what defines intelligence.

One aspect of human intelligence is problem solving. Humans generally solve a problem somewhat intuitively rather than using the kind of step-by-step algorithms that artificial intelligence uses. Research work is still continuing towards more efficient algorithms that don't take a long time to run/process the input and are able to deal with uncertain or incomplete data.

Another aspect of human intelligence is our knowledge about the world. Some of this comes from learning, and AI programs are capable of learning new information. But if you consider that few things are always true or always false, you can see part of the problem with expecting a machine to "know" something. In addition, humans are wired for something we call common sense; however, that common sense is also relative to our human-ness: we know that humans don't jump off high buildings if they want to stay alive, or that fire is potentially dangerous.

There are many such areas that researchers are working at developing algorithms for AI, and some more of them are:

Creativity (generating new ideas)
Perception (making deductions based on your senses)
Planning (setting goals and working to achieve them)
Natural Language use
Mapping (knowing where you are)

Robots in the Movies

Due to the lack of real-life robots, one of the primary places we have seen robots in action is in the movies. Some of the more famous, classic robots of years past have little or limited meaning in the psyches of today's audiences (unless they are students of the genre), However, robots began appearing in movies right from the earliest days of film. Two of the more important appearances are those of Maria in Fritz Lang's "Metropolis" (1927) and the "tin man" in the "Wizzard of Oz" (1939). Robot appearances beginning in the 1950s carreid a little more weight in terms of plausibility (believability), but to today's audiences accustomed to special effects and advanced film techniques, they still fall far short on the "coolness" scale. From this era, the film appearances of Gort in "The Day the Earth Stood Still" (1951),

Robby the Robot in "Forbidden Planet" (1956) and HAL 9000 from "2001: A Space Odyssey" (1968) are among the seminal images leading to the modern age. Probably most influential, but not alone, are the various robots from the "Star Wars" series, including R2-D2 and C-3PO (to name just the two main ones). Also worth mentioning are the appearances of the T series in "The Terminator" (1984), RoboCop (1987), the tentacled Sentinels in "The Matrix" (1999), Sonny in "I, Robot" (2004) and even animated figures such as Buzz Lightyear and Wall-E that endeared themselves to audiences despite their lack of genuine plausiblity. However, without these screen appearances, there is little doubt that we would not be where we are today in terms of accepting a future populated with robots of a variety of types and intentions.

Star Wars Clone
http://en.wikipedia.org/wiki/
File:Clone_sharpshooter.jpg

Robots on Mars

The deployment of robots in jobs that are not considered safe for humans is dramatically evidenced in NASA's use of robot rovers on Mars. NASA does not feel ready (technologically, emotionally) to send humans on the extended (6-month long) trip to Mars or beyond. Phoenix, which landed on Mars in May, 2008, is the fourth explorational robot to successfully operate on Mars. Sojourner, Spirit and Opportunity, robotic devices equipped with wheels, have covered miles on the surface of Mars, and in doing so, have provided scientists with a wealth of data.

NASA Spirit on Mars
http://en.wikipedia.org/wiki/File:NASA_Mars_Rover.jpg

In what ways do these devices qualify as robots? A review of the list of commonly accepted features that make a machine a robot in relation to the Mars machines can help answer the question.

They are artificially created. No question here: these things were created in a lab.
They can interact with their environment. The level of interaction is limited, but in certain respects, the interaction senses the environment and makes intelligent decisions
They are programmable. In fact, they were programmed before they left Earth and are capable of being re-programmed via their communication links on a daily basis.
They have some degree of mobility. The rovers (Spirit/Opportunity) are equipped with motorized wheels as well as arms. Phoenix is stationary, but has an advanced arm.
They are doing something useful. Every new discovery they send back to Earth is evidence that their tasks are valuable.
Although they have rather limited intelligence, *they appear to have (specific) intent*. For the most part, they are remotely directed from Earth, but have some autonomous control ability.

Any commands that are sent from Earth to a robot on Mars take about 10 minutes to reach there (the radio signal delay to the moon is only 3 seconds, in comparison). If you take a

simple scenario like where the robot is moving across the surface of Mars, a 10 minute delay in telling the robot to "stop" could be catastrophic; hence, the need for at least some autonomy. This basic autonomy comes in the form of limited intelligence: in this case, cameras that "see" the environment and a processing system that tries to identify what the camera sees, interpret the image and then make decisions, for example, whether to stop or not. Even with today's technology advances, today, the Mars robots' travel plans are planned out in detail from Earth and the commands are uploaded on a daily basis. Considering that as of the middle of 2008, Spirit had traveled about 5 miles in 1600 days (that's about 4.5 years) and Opportunity had traveled close to 10 miles in the same time, we are talking about literally "inching" across the surface – a rather safe speed. Future cars that do not require human drivers or future planetary rovers may make use of developments pioneered by contestants in the DARPA Grand Challenge Races.

The actual communication link to the surface robots travels from the Deep Space Network of satellite dish antennas on Earth to the spacecraft in orbit around Mars. Although data transmission rates can vary, on a good day, it is possible to send as much as 60 megabits of data to the orbiter, which then provides the link to the Mars robots, limiting the data transferred to the ground, partly because the robots lack the power to transmit for more than 3 hours daily. The rovers on the surface are actually capable of direct communication with Earth, but since that requires more energy, they generally relay data through the orbiters. (The orbiter solar panels can generate more electricity and have larger antennas.)

Without going into too much detail, NASA's JPL website (http://mars.jpl.nasa.gov/mer/mission/spacecraft_rover_brains.html) gives some information about the computing power on board the rovers. They have about the same computing power as a high-end laptop computer. It is a RAD6000 computer made by BAE systems, and is "radiation hardened – ie: designed for the memory not to be erased by the extreme radiation the spacecraft will encounter in space. (There are currently about 200 RAD6000 computers at work in space.) There are special electronics linked to the "brain" that allow for the rovers to measure their XYZ coordinates (is the rover about to tip over?), a software control loop that monitors the "health" status of the rover (internal heat, current power reserves), a 3MB EEPROM (a non-volatile type of memory) that contains essential commands, an additional 128MB of memory as well as software that manages the special additional hardware equipment (communications devices, cameras, sensors for various tests…)

Although it is certainly limited in comparison with a humanoid robot, the array of scientific instruments on board the Phoenix goes well beyond what a "natural human" would be able to test without special equipment (an advantage of robots?). The onboard scientific equipment includes the robotic arm and camera, a main stereo camera, a gas analyzer with a built-in spectrometer, a special descent imager designed to record the last minutes of the descent to the surface, an optical microscope, and atomic force microscope, a wet chemistry lab with various sensors and probes, a meteorological station that can measure weather conditions, including using LIDAR and a telescope. Not bad for a 150 kg package of electronics.

Reading
"I, Robot". Doctorow, Cory.
"Accelerando". Stross, Charles.

For Further Research and Additional Links

Check out the DARPA Challenge (www.darpa.mil/GRANDCHALLENGE)
Want to buy a robotic manufacturing arm? (http://www.globalrobots.com/)
Learn more about Honda's ASIMO (http://world.honda.com/ASIMO/)

Various areas of currently deployment
Commercial use in Factories (does this mean that humans lose their jobs?)
Replacement of humans as workers
In homes, for example to assist the elderly in old age
In homes to perform routine tasks as the Roombavac does
Under the sea (often they are tethered)
Land-based explorations
In Space (the expendability factor is the strongest argument here)
In the Military (aerial drones are now common, what's next?)
The DARPA Challenge is partly a project to minimize the risk to human life on the battlefield
Bug bots are so small you might not recognize them as enemy agents in your home.
In the area of Medicine, programmed robots could do wonders inside your body. Are you
ready to host a robot inside your body if it will cure you?

For you to consider

Consider the ethics of fighting a war without human cost. When robots are deployed on the
battlefield, how do the rules of war change?

To what extent are cloned living beings similar to robots? Again, consider the expendability
factor: if robots are cheaper in terms of life than humans, isn't the same true of clones when it
comes down to losing them in war?

How important do you think it should be (required by law?) for people to be able to easily and
clearly identify a robot as a robot? (Is it right to aim to create a robot than can fool people into
thinking it is not a machine?)

Could you love a robot? Develop any kind of emotional attachment to a robot? (Some people
"love" their cars, for example and many kids who bought Sony's Aibo pet dog or Tamaguchi
pets love and grieve for their computerized pets.)

Consider the massive amounts of computing power and related equipment that is installed in
the vehicles that compete in the DARPA Urban Challenge. Then consider just how much
"robotics" these vehicles are capable of. What advances do you think will be necessary for a
humanoid machine to roam the streets in the future?

Assuming that Asimov's Three Laws are used to guide the construction of robots, how can
society condone the military use of robots?

For older people, it is hard to "warm" to technology. Today people argue about "unnatural" marriages between men and men. What about creating a family of humans and machines?

Do you think you can discern that you are communicating with a machine? Try a real Turing Test online.

Would you trust a machine's decision over a human's?

What about a future world in which your "existence" is re-bootable and so "you" never die: you just transfer your existence to a new hardware from a backup? If this interests you, be sure to read Accelerando by Charles Stross (Free book)

Selected Vocabulary

Actuator	Fuzzy logic
Agent	Gripper
AI	Heinlein, Robert
Aibo	Humanoid
Android	ISO
Asimo	Neural network
Asimov, Isaac	RAD6000
Automaton	Replicant
Autonomous	Sensor
Bionic	SETI
Bot	Tethered
Botnet	Turing Test
Clarke, Arthur C	Zombie computer
Cyborg	

Art, Entertainment and Leisure (Areas of Influence)

The use of computers has moved dramatically from its origins as a tool for crunching numbers to a tool that both facilitates and sparks creativity. This is not to say that the men and women who "played" with the first digital computers lacked creativity: the innovations that led to the modern computer were arguably the products of highly creative minds. All the same, the primary purpose for the early computers was not particularly inspired by a desire to create something most people would consider artistic. The company names – International Business Machines, Texas Instruments, Bell Labs - bring to mind <u>function</u> rather than <u>aesthetics</u>.

It is true that there were some who took their computing a little more lightly: using even the crudest of display devices in the 1950s, the American physicist William Higinbotham created a simple game that we today would recognize as a computer game. Even earlier, in 1952, Alexander Douglas, a PhD candidate at Cambridge, UK, created OXO as part of his thesis – again, a game we would recognize as the classic "tic-tac-toe" for computers.
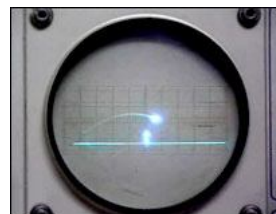
Tennis for 2
en.wikipedia.org/wiki/Video_game

Computer Games

Computer Space game
en.wikipedia.org/wiki/Computer_Space

The availability of computing devices for the public, starting just before the personal computer revolution really took off saw commercial production and sales of dedicated video consoles, large, slick coin operated devices that by today's standards are comically limited: 4- or 8- bit processors with a few Kilobytes of RAM or ROM that ran a few lines of code. Like the well-known game Pong, one of the first, available in the early 1970s was Computer Space. Created by two men who later went on to found the Atari company, the company that eventually created and sold Pong itself, this game epitomizes the innate fun of simple play. Although by no means the only manufacturer that made money from their game machines, today the name Atari is still synonymous around the world with computer game consoles.

Pong Screenshot
en.wikipedia.org/wiki/Pong

The first successful Atari from the early 1970s had a processor that ran at a speed just under 2 Mhz with an 8-bit processor and 8KB of memory. The common format for computer software at this time was to distribute it on cassette tape, but the Atari system evolved to use removable cartridges instead. Although, at first, people thought you could only play Pong on these machines, by the late 1970s there were a number of different games that were sold on the removable cartridges and sales of the Atari consoles took off, with 2 million units being sold

in 1980 and growing to 8 million units sold in one year within a few years. One of the companies that created the games for these early Ataris was called Activision, and in fact, the name of this company eventually became bigger and more famous than the Atari company, which was having trouble maintaining its market dominance as computer gaming grew to become a huge market.

Atari 2600
http://en.wikipedia.org/wiki/Atari

The growth of the PC market is one reason why console makers like Atari began to lose their dominant position. While there were many users/players who appreciated the simplicity that is built into games consoles (less hassle, everything contained and nicely packaged to limit potential problems – mostly human errors), as people began to feel more comfortable using personal computers, the ability to use a computer to do more than just playing packaged games on a cartridge began to take its toll on the market for dedicated games machines.

Computer games written for the early market of personal computers were more often than not a single person operation: the same person who wrote the game engine/code was also the person who designed the graphics and wrote the music/sound and created the packaging that accompanied the game. Today, with more complex games, it is not uncommon to have teams of 50 or more people working to create the final product.

Today, the computer game industry is a huge business. Typically, it now takes several years to produce the more famous games whose names we know. By the middle of the first decade of the 2000s, computer games (not counting additional devices associated with the games, like controllers and dedicated gaming devices), were worth more than $2 billion a year. When Grand Theft Auto IV came out in 2008, it earned more than $500 million in its first week – outselling even some big-name films.

There is still a market for dedicated games consoles, both large and small. Small, hand-held games machines offer portability and low cost – the kind of device you can carry anywhere with you, for example, to entertain the children in the car. At the same time, there is a market for the more serious, dedicated games machines such as the Xbox 360 and Playstation 3 which many families have purchased for home entertainment. And of course, there are those gamers who stick with their personal computers, adding the latest and best sound cards, graphics cards and maximum RAM, unusual additional peripherals and overclocking their CPUs to achieve the status of envy of the neighbors with their systems.

Super Tux (Open Source game)
http://en.wikipedia.org/wiki/SuperTux

Aside from limiting yourself to playing a game all by yourself, one trend that has grown partly as a result of the spread of the Internet is that of online games. The market for MMORPG games (massively multiplayer online role playing game) such World of Warcraft continues to grow. From a simple start such as the SIMS series, which was one of the first games to test consumers' interest in online gaming, there are hundreds of big titles and millions of players around the world who take their gaming very seriously – some of them even making

a living playing computers games professionally.

Even more incredible to many people who cannot relate to this level of immersion, are some curious precedents. In 2008, a woman in Japan was accused of murdering the avatar (online virtual being) of her husband, when she illegally accessed his account and killed his player after he divorced her in an online game (Her crime is clearly not murder, but rather illegal access to data.) There are periodic stories from South Korea (where Internet penetration is known to be quite high) about people who have ended up committing suicide as a result of their extreme immersion in online games – certainly, there is some truth to claims that excessive online time can lead to anti-social behavior in some people, and that could lead to emotional problems manifesting themselves in serious ways such as suicide.

Entertainment or not, the rise of the Internet has also meant that more and more people meet online, and the number of marriages that began on the Internet continues to grow with each passing year. To some extent associated with the realm of marriage, it needs to be noted that online pornography (and in this respect it is no different from the situation in the early days of analog film in the early 1900s) has been one of the larger commercial success stories of the first years of the Internet and wide-spread use of PCs.

As online games have grown both in number of users and commercial value, virtual markets have also developed along side them. Some online games explicitly state in the user policies that the sale of accounts or account related items is forbidden: others allow users to exchange virtual items, including virtual money or real money.

Gambling

Exchanging virtual money for real money (or vice-versa) is the realm of online gambling. While many societies consider gambling (whether for money or "fun") to be a moral evil, there are others who would call their bluff and say that life itself is full or risks – why not make the most of this?

The first computer gambling games were simple "stand-alone" applications (card games like poker or slot machines). It was apparent from even those early programs that, like in other areas of entertainment, there were many people interested in playing this type of game.

With the arrival of the Internet, gambling moved online. Whether the game involved playing against others or against the house, advances in Internet technology meant that companies could improve the games they offered (and, since "the house" rarely loses, their profits)

Some countries, like the USA, have effectively outlawed most forms of gambling by making it illegal for financial institutions to transfer funds to and from companies involved in this form of entertainment. Critics of these laws point out that actually, the US government has not made all forms illegal – in fact, there are online forms of gambling that the government does allow.

Sound/Audio

Some people would argue that the personal computer is a noisy machine: the internal fans that cool the system devices are among the noisiest parts of a computer, even when it is idling.

The speaker – a device that outputs sound – was invented and developed before it was electrified back in the 19th century. Thomas Edison is credited with the invention of the phonograph, a device that could record and play back sound through the use of needles that imprinted sound on tin for later playback. However, the initial invention of a "loudspeaker" goes back to an earlier date in the late 1800s. Although there were a number of technical refinements to the design of the speaker throughout the early part of the 20th century, the electrification and amplification of sound had been well established (radio, film …) well before the digital computer came onto the market. There was no immediate need for sound in the first digital computers: they were intended to perform calculations and had no need for sound output.

Early loudspeaker
en.wikipedia.org/wiki/Loudspeaker

Early PC systems included a speaker primarily intended for audio feedback that was commonly known as a "beeper" because a beep sound was just about all it produced. The underlying sound system was designed to produce a single tone at a time, and until the invention of the first sound cards that could be added to computer systems as an additional I/O device, PC sound was essentially an after-thought.

There were early adopters who realized the potential for computer generated and controlled sound effects, and in the 1960s, several musicians experimented with the potential for digital control of sound waves. Included in this group are the Turkish composer Ilhan Mimaroglu, who was one of the first people to experiment with the potential of the medium. Robert Moog experimented with a keyboard that was able to control variations of the sound output using electronically programmable oscillators with a device that became known as the synthesizer. In the late 1960s there was a growing group of musicians (see Switched on Bach) who had begin to experiment with the potential of controlling sound by "programming" the electronics. However, the era of personal computers had not yet arrived: in fact, the use of "stereo" sound was still not widespread.

Sound Card
en.wikipedia.org/wiki/Sound_card

As noted above, one of the first add-on cards available for personal computers was the sound card. Early sound cards included both additional memory on the sound card itself to handle the needs of processing the sound, as well as controllers to manage the input and output functions required to produce "advanced" sound quality.

By the 1990s, the quality of the sound in a computer system had become one of the important factors influencing people's decisions about what kind of computer they would buy. Parallel to the developments in the quality of the actual output of the sound, computer programs had begun making better use of the features of the new hardware. As noted above, computer games (and their human players) were demanding more than the simple single tone beep that the early PC systems were capable of and computer playable media (sound files and movies

that included sound) were demanding hi-fidelity sound output. In fact, throughout the timeline of developments in computer technology, the needs (requirements?) of gamers have been one of the driving forces for progress: graphics cards with 1GB of memory are not necessary for word processing or surfing the Internet!

Again, parallel to the developments in computer games and hardware, other fields were realizing the potential for the kind of precision that computer controlled sound offered: movie studios and sound recording studios both professional and amateur had created a new market for digital audio. As the capabilities of the Internet grew to accommodate real-time transfer of digital sound files that allowed for realistic playback of online media, the demand for better and better playback algorithms and systems as well as the hardware to handle these media also evolved.

Today, almost all studio sound recording for film and music is done on computer controlled systems. Computers are used to adjust the sound quality of analog sounds (and clean or adjust them to the extent that it is now impossible to know if the product is "real" or not) and, similarly, most film production is done in a digital environment.
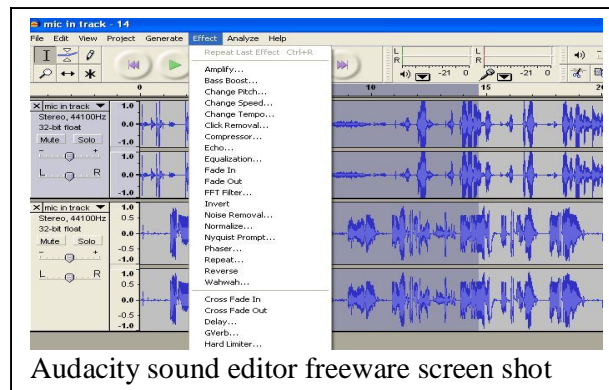
Audacity sound editor freeware screen shot

Film

Just as computers are an excellent manipulator of sound, they can theoretically equally well work with images – still or moving – once they have been converted to a digital format. Because of the potential this area offers, traditional analog film has become both too expensive and impractical and today almost all forms of photography have moved to a digital format.

Openmovie opensource editor
http://www.openmovieeditor.org

Starting with the arrival of the "video" and magnetic tape in the 1970s, the average consumer was able to watch at home media that previously had only been available in movie theaters. These same users found that – with a little creativity – they could capture media that had been previously only commercially available, or, for that matter, they could create the same themselves at almost no cost. A whole new world of creative possibilities arose: in the 1960s and 1970s these same creative types had seen that they could afford and create media with newly available cheap analog cameras, now they could do the same in a digital format, and edit their creations with endless possibilities.

Today, computers are used in two somewhat separate areas in film production: for 2D animation (traditional animation assisted by computers) and 3D enhancement (where the computer is used to make the movie more realistic using CGI, or computer generated imagery)

The use of computers in film production might be punctuated by a number of iconic films: none of them necessarily firsts, but each of them seminal in their influence of different areas.

One of the first films that made extensive use of computers to generate special effects was Star Wars. George Lucas wanted his film to include visual effects that had never been seen before, and in order to achieve this, he founded a subsidiary to his LucasFilms company to produce the necessary graphics using wire-frame 3D graphics. There had been other productions earlier, but none as successful. In the 1980s, this company was sold to Steve Jobs (of Apple fame) and renamed Pixar. One of Pixar's first major films to make use of computers was Toy Story in 1995.

The film Shrek won the first ever Academy Award for animated film in 2001. Most notable among the computer techniques used by the DreamWorks studio was an animation technique that combined motion capture with traditional animation, relying highly on software support from a program called SoftImage 3D, where devices are attached to the actors bodies/faces and the 3D positions of various body points are digitally mapped and then animated – producing a final image that is a combination of the real and the cartoon.

commons.wikimedia.org/wiki/Big_Buck_Bunny

The film Big Buck Bunny, while hardly as well-known as Shrek is an icon in its own right in that the film rivals big budget works like Shrek, but it was created using OpenSource software and, as a result, signals the arrival of incredible production power to anyone with the time, energy and knowhow.
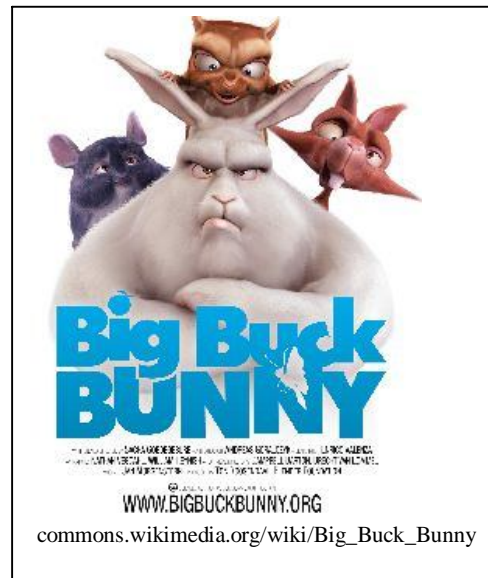
Convergence

Within its relatively short history, the computer has morphed into a device that combines all sorts of media that were once discrete areas: text publishing, music and film recording, creation and playback. All you need is the right software.

Beginning with the advent of the Internet, it became clear that many of the boundaries (primarily the limitations of expense) that previously separated the amateur from the professional were going to break down. Initially, because of the limitations of the bandwidth of the Internet, textual publishing made the first breakthroughs. For better or worse (and it must be admitted that there is an awful lot of junk out there), the Internet enabled anyone with a voice to publish a message: book, website, honest or fraud - the

Cover of Cory Doctorow book
www.craphound.com
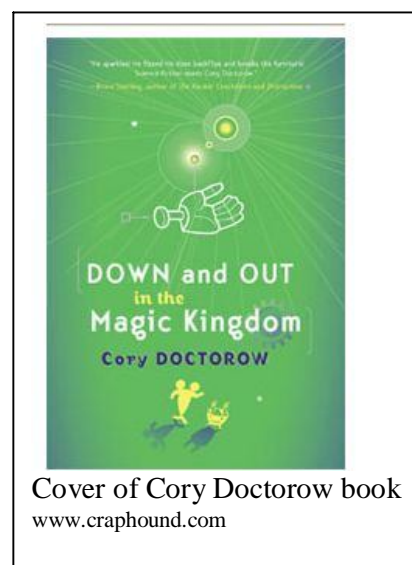
only limit was that you had to have access, and that could be purchased for a measly fee of a few dollars.

As the bandwidth capabilities of the Internet expanded to allow larger and more varied file types, music also began to appear online. Combined with advances in software that were allowing anyone to produce high quality digital audio media, the invention of streaming media (initially pioneered by Real Media/Real Audio in the early 1990s), the Internet became a veritable archive of recorded audio files. People worked first to archive and publish online copies of old and new sound files, and then as bandwidth capacity increased, online radio and video files as well.

Today, it appears that we have arrived at a divide of sorts between old and new media, where a new generation of consumers would rather be in control of the media they consume as opposed to the older generation that grew up sitting in front of the "boob tube", accepting and consuming whatever media it was that the corporations in control of the broadcast towers were willing to "serve" them.

Like the revolution that occurred with textual media in the early Internet days, today's consumer is equally likely to be a producer of content as well: ranging from personal photos and blogs to high quality videos, music and more. The line that divides the amateur artist from the pro has been seriously eroded.

But, where there is a market, there is an inventor, even in an area so "static" as text: witness the success of e-books. Large distributors of texts (traditional, of course) appear to have seen the writing on the walls, and it says that people want their books electronically. The Kindle device is only one of a number of formats that is looking to make a profit in a market that some people were saying was dead.

Amazon's Kindle
http://en.wikipedia.org/wiki/Amazon_Kindle

Traditional producers of media for public consumption, like the larger movie studios and TV channels are finding that if they don't work to adapt to the demands of the new consumer, they are likely to become irrelevant in the future. As a result, major media corporations from traditional print media like the New York Times to TV networks like CBS and NBC to movie studios like Warner Brothers have all moved – somewhat belatedly – to accommodate the demands of the new online audience.

The trend towards "Everyman" producing content to share with others has led to discussion about the need to change existing copyright laws. Large media corporations feel the need to protect their commercial content and this clashes with the public's need to create their own. Extreme enforcement of laws regarding the use of licensed materials find the media companies issuing "take-down" notices for

en.wikipedia.org/wiki/YouTube

uses that the public considers trivial or even rightful, as seen when a record company forces Youtube to delete a user's home video of their child because there is a popular, commercial song playing in the background.

Although most video sharing sites like Youtube have not found a way to turn their popularity into commercial success, one such site, hulu.com has. By allowing only content that the site owners have posted online, hulu has been able to enlist commercial advertising: advertising companies know that their ads are not going to appear alongside dodgy content, something that Youtube cannot guarantee and advertiser want if they are going to pay for online space.

People sharing their creative work online is a trend that continues to spread, not just as in the video sites mentioned above, but in all sorts of media/entertainment areas. The archive.org project (and the Gutenberg project) make terrabtyes worth of text documents available online, some of it user generated, some of it public domain. Flicker allows users to post their images online and mark them as being free to use under varying licensing options – free for any purpose, free for non-commercial use, etc.

en.wikipedia.org/wiki/Flickr

User generated content: user comments
To Police or not?

A number of online sites allow the public to post their own comments. Some websites live and die by offering this freedom to be a participant. However, one feature of this kind of openness is that it is also open to abuse. A particular kind of user may post rude remarks, others may post comments that are hurtful and yet others may use this freedom for their own commercial purposes, posting comments that have no relevance to the discussion topic but that contain advertising and links. This kind of user has earned the name "comment troll".

Traditionally, there have been few methods for dealing with this sort of inappropriate behavior. Some site owners have hired teams of reviewers who read and evaluate each and every comment. Other sites allow only registered users to post materials (but this method, too, requires a human to review and check for offenders). Yet other site owners leave the comments online but disemvowel them: reducing the comments to a sequence of consonants that can be figured out – if you have the will and time to, effectively rendering them less of a nuisance to the general public.

Making use of developing technologies, some sites have begun using a technique where other users can rate each comment. With the use of this system, it has been found that the inappropriate comments end up being "dissed" and get such a low rating score that they essentially disappear.

No small number of computer users find entertainment is just plain using their computers: surfing, looking at films, playing games, listening to music, chatting … Many of the older generation bemoan a world where kids spend their entertainment hours sitting in front of a computer screen instead of experiencing the "real" world. The kids say they have discovered a form of entertainment where they are in control instead of just sitting passively in front of a TV.

Additional Reading

[Down and Out in the Magic Kingdom](#) by Cory Doctorow

Suggested Links

Freeware programs to work with
[Audacity download](#)

Samples of Digital media using computers
[Get a copy of Big Buck Bunny](#)

For You to Consider

Since computers are able to create more perfect sound and images than humans, there is a concern that they will eventually replace humans. This trend is already apparent in film: the quality of digital effects has made human actors secondary, and the use of computer sound processing now allows sound studio editors to fix human errors in singing. Is this the end of natural media?

As happened at the start of the Industrial Revolution, there is some fear that machines (computers, in this case) are going to replace humans, leaving many people out of work. It didn't happen: instead, more jobs were created, but required different skill sets. Is this likely to happen in the entertainment industry, too, as computers take on jobs that used to be performed by people?

As more and more special effects are generated using computer graphics, the lines that differentiate the "real" from the virtual are likely to get blurred. Will humans lose track of what is real and natural?

If our entire lives (experiences, relationships) move online, what becomes of the value of the "human experience"?

Related Vocabulary

Atari	Kindle
Avatar	MMORPG
Blog	Moog synthesizer
Blog	Pixar
Boob tube	Playstation
Cartridge	Pong
CGI	Real Audio
Comment troll	Take-down notice
Console	Xbox 36
Gutenberg Project	

Computers in Education

Computers as we know them are closely linked to the educational establishment. Blaise Pascal was a mathematician. Howard Aiken, one of the men who put together the Harvard Mark I computer (1944) was a professor at Harvard. Grace Hopper, who worked with him as a programmer, was a teacher at Vassar. Alan Turing studied at Cambridge and Princeton and was a mathematician. John Atanasoff and Clifford Berry were both at Iowa State University. The Internet was developed by a consortium of establishments that included several educational/research facilities in the USA. The historical ties between education and computing are many and go well beyond this limited list.

To some extent, because so much of the work on computers is experimental, the link between schools and computer advances is natural. That is not to say that there aren't large corporations where major work has been done (Texas Instruments, Intel..) But even here, there are many parallels with education: Microsoft's headquarters in Redmond, WA, is known as the Microsoft "campus", and the R&D work of the larger tech companies involves lots of "lab work" and R&D (Research and Development) just like you would find in a university.

In a world that is requires people to be not just familiar with computers but, rather, skilled at their various uses, ICT has taken a major place in the curriculum. At schools throughout the world, students start even at the earliest years to learn how to use computers. Even in places where computers have yet to become integrated into the classroom, children of school age use computers outside the classroom. In many places, a large gap has developed between this generation and their parents: parents tend not to make as much use of computers nor do they understand why their children spend so much time in front of their computers. The term for children who have grown up with computers as part of their lives is "digital natives"; their parents, even when they make heavy use of computers themselves are "digital immigrants".

Again, there is a gap between cultures and countries where the standard of living makes it difficult if not impossible for children to learn about and use computers. Several international projects, among them the One Laptop Per Child (OLPC) movement, are hoping to provide cheap tools that can help to close this gap. They note that as computer use continues to pervade "Western" cultures and modern lifestyles, those who do not have the experience of the access will end up falling even further behind.

$100 laptop for OLPC
en.wikipedia.org/wiki/OLPC_XO-1

Curricula at schools focus not only on teaching students the use of the more commonly used applications such as word processing, image manipulation, online searches and handling numbers and data, but also provide at least some instruction in the basics of how computers work, as well as delving into other issues such as the ethical uses of computer hardware and software. Beyond the first years of school, there is a fairly recent realization by some schools that success in later, higher education now requires students to be able not just to use the common applications, but also to be able to get a computer to do tasks specific to one's own needs, and that, often, this means that students need to know at least one programming language. Over the past 10 years or so, most Western school systems have developed specific
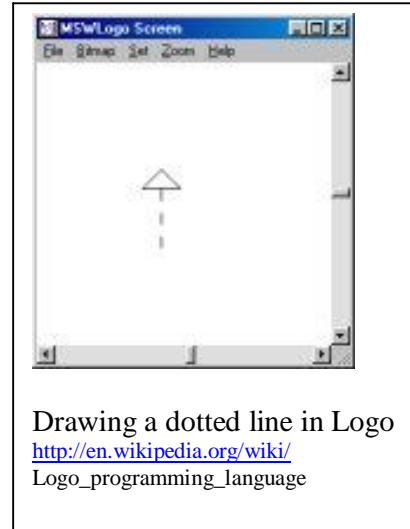
criteria that define the minimum ICT skill sets that students need to have to be successful, productive members of society: a graduate without certain computer skills will have a hard time finding employment.

Teaching Programming

Several of the programming languages that have been invented/developed since computers began to take their place in educational programs were designed specifically to make it easier for people to learn. If you recall that the earliest forms of programming computers involved re-wiring the computers or fluency in machine language, you can see the importance of developing more intuitive methods of programming. BASIC, one of the earlier languages that was intended to make programming more accessible, is an acronym that stands for Beginners All-purpose Symbolic Instruction Code. It was first developed at Dartmouth College in 1964 specifically to make it easier for "non-scientific" students to learn programming. Similarly, the programming language PASCAL was developed in 1970 in order to make it easier for students to learn good structured programming skills. (While it is easy to learn BASIC because it is so readably like English, it allows programmers to be a little "sloppy" with their code.) The trend to more "object oriented" programming languages has meant that PASCAL is no longer as widely taught in schools as it used to be, having been replaced as an instructional tool by languages such as Java or C.

Drawing a dotted line in Logo
http://en.wikipedia.org/wiki/
Logo_programming_language

For schools that want to provide younger learners with an introduction to programming, one of the earlier options was a language called LOGO. LOGO was also known as Turtle Graphics because it involved moving a "turtle", or a simple shape in the screen. The turtle had a position, a direction/heading/orientation and a pen which could have color or be "up" or "down". LOGO allowed younger children to learn some of the basic principles of programming and involved writing programming commands such as "move forward 10 spaces" or "turn 90° left", and when a series of these commands was put in sequence, the child could create/program various shapes. The process is not unlike giving commands to a robot.

Apple IIe with 2 5.25" floppy drives
http://en.wikipedia.org/wiki/Apple_II

Other software specifically developed for use in schools has evolved since computers were first introduced to schools. In the 1980s in America, the Apple IIe computer was widely used in schools as an instructional tool. This computer was popular at a time before GUIs were available for personal computers. However, many educational software programs were written for the Apple IIe series. Some of the more widely used educational programs included Appleworks (a word processor and spreadsheet application), Bank Street writer (word processing and writing development tool), PrintShop (for posters, signs, cards etc),

VisiCalc (the famous "killer" app), WordMuchers and NumberMunchers (programs designed to teach grammar and math skills), Mavis Beacon Teaches Typing , Where in the World is Carmen SanDiego (again a text adventure) and later HyperStudio, a program that helped lead towards the development of web-like hypermedia.

Initial educational software offerings were often of the "drill and kill" variety: simple repetitive exercises without much in the way of graphics. However, proponents claimed that if there was a place in education for drilling and repetition to help students learn, at least the computer allowed each student to proceed at his or her own pace. And the better programs offered students encouragement and even more than just the "Wrong" or "Right" responses. Computer Aided Instruction (CAI) and Computer Aided Language Learning (CALL) were widely seen as one way to interest students who had grown up watching lots of TV (and whose learning styles were often seen as being visual as a result.) Some of the theory focused on the use of Edutainment, a mix of education and entertainment to get students to learn better.

As computers moved into the GUI era both with the Apple Macintosh family of computers (the first Mac that used a mouse and a GUI came out in 1984) and then in the 1990s with Wintel (Windows/Intel), the possibilities for use in education saw a shift. Not only was the user experience more real and more interesting because of the graphics capabilities and use of a mouse, but the accompanying improvements in the computers' abilities also spawned more capable software titles. With improved processors and more memory, programs became more interactive. Students could now access large amounts of data on CD titles (the Internet was still not available), and the trend towards hypermedia intensified. CDs that could be found in school/classroom libraries included titles like the Guiness Book of Records (with lots of pictures and a few short video clips (poor by today's quality standards), encyclopedias and large collections of text – magazines, books, etc. Some schools experimented with "authoring" software like HyperStudio, which allowed students to combine creativity with writing and research skills to create their own "stacks" of media that were a bit like mini web sites.

Another family of software that keeps getting better as computers get more and more powerful as that of simulations. The idea behind simulation software is that – if the program can realistically mimic the "real" world situations, then learning on a computer is a viable, safer and cheaper way to learn some skills. Simulation software is a bit like robotics software in that it needs a form of intelligence akin to AI – the ability to sense the environment and to react according to both the users commands and real-world laws. Simulation software allows the user to do what would otherwise be impossible: fly an airplane, explore the inner workings of the laws of physics, manage your own city.
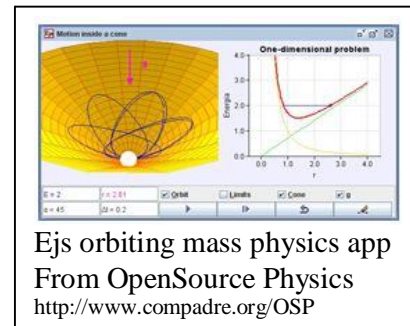

Screenshot from FlightGear freeware simulator
www.flightgear.org

Airlines today train their pilots using highly computerized systems that (to the pilot) look and behave like the real thing. (Keep in mind that today's "real" airplanes are already highly computerized, so a simulator is likely to be just about the same thing.) Clearly, this is one area where even a hugely expensive system of computer controls and mechanics is a lot safer and cheaper to train someone in. Although the algorithms and AI engine are of a different nature, another area where simulations are being heavily used for training is the military. Again, the cost of a mistake in the real world makes the extensive use of a good simulation an invaluable instructional tool. Simulation games such as Flight Simulator or The Sims have been available for the home market almost since the very beginning, and they can serve to give an idea about the benefits and limitations of this kind of software.

Simulation software can also be used to generate "what-if" scenarios and solutions to problems that may crop up in impossible places. For example, although NASA cannot physically put a man on Mars to locate the problem with one of its robotic rovers, they can run simulations of events on earth and use these results to help identify solutions to problems that crop up. Not only NASA, but many other companies can run through various "what-if" scenarios even before they choose one design structure over another, both improving safety as well as costs and features.

Simulation software has been in use in science classrooms for some time now, and again, the benefits are obvious. If you recall that the early digital computers were built partly for government/military uses, then you will not be surprised to learn that extensive simulations and calculations were done with special "what-if" software prior to actually exploding the first atom bomb. There are many special use "apps" for use in the science labs covering such diverse areas

Ejs orbiting mass physics app
From OpenSource Physics
http://www.compadre.org/OSP

as mixing chemicals together to see the results, designing and testing electrical circuits, playing with the laws of physics, for example in a zero gravity environment. OpenSource Physics at http://www.compadre.org/osp/ is one of many of this type of software projects – and it is free (OpenSource).

Simulation vs Visualization

One of the quandaries that software designers face in preparing a program that simulates reality is the need to balance between attractive appearance and honest representation of the available data/facts.

The user expects (in terms of user-friendliness) an interface that is both easy to operate and visually pleasing; a program that outputs only numbers in table form may "get the job done" but the lack of a visually attractive output is often seen by users as a detracting factor. If the programmer selects to embellish the visual output, he is taking a risk with the factual accuracy.


TheEarth – as visualized in Celestia

Take the example of a program that aims to

manipulate the known universe (Celestia, for example). No man has gone further away from the Earth than to the moon. So any visualization or simulation of the universe is already working in uncharted territory. Granted, there are images that have been sent back from various NASA spacecraft – if you believe that NASA has in fact actually accomplished what they say they have and are not perpetrating a huge scientific hoax! This program allows the user to cover distances that would otherwise currently be impossible for humans. One of the features of the program is the ability to "play" with time: you can speed up the time scale such that you can "visit" the moon or even a galaxy that is hundreds of light-years away in a matter of seconds. Your visit includes photographs of the galaxy/moon as well as a graphic visualization that allows you to look at it from different angles – angles that are not possible from the Earth's position in space. As a result, a certain amount if this information is based on conjecture: hopefully scientifically informed, accurate and based on the available facts, but guesses all the same. Because no one has ever been there, there is no way to know for sure if the visual representation is accurate.

Another example may further highlight the programmer's dilemma. COCO is a free program for chemical process simulation. It was designed as a tool to help students visualize/better understand chemical processes by selecting different chemicals and different properties such as surface tension, density, heat and much more. So… how do you represent this on a computer screen? Since this is a process based program, the decision with this software was to make the flow the critical visual element.

Flow of a chemical process as shown in COCO, a free chemistry program
http://cocosimulator.org/
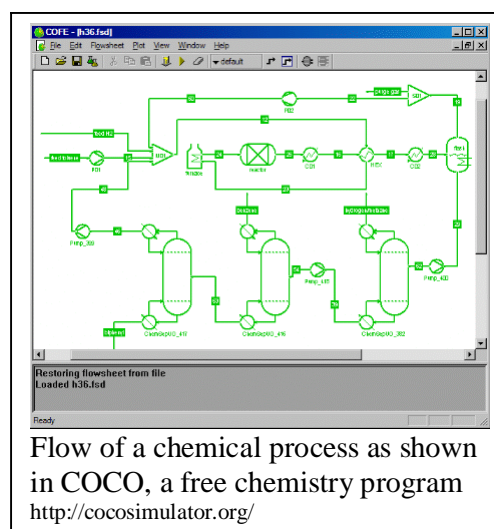
Computers vs Teachers

Ever since computers entered the curriculum, teachers have been working to figure out how best to make use of this powerful learning tool. There is a clear trend in the 21st century to make computers a central element of the learning process: educators realize that students need computer skills to play an effective role in their later lives; teachers also realize the immense "draw" of computers on students' interest and hope to make effective use of them as learning tools.

At the same time, there is a discussion thread that argues that the current generation of human teachers may be the last: in many ways, computers are more effective "teachers" than (fallible) humans: they are more patient, they are more accurate and they can store more correct information - provided they are working and programmed properly. The flip-side of this argument is that computers will never replace teachers: computers cannot (yet) display or communicate critical human qualities such as empathy, nor are they (yet) able to discern the same shades of understanding that humans can (Does "wild" mean "not captive" or "uninhibited"?)

All the same, humans need sleep and food and they have their own emotions and associated problems that affect their performance, whereas computers, once bought and paid for, will

work for free 24/7. They won't complain if you wake them up in the middle of the night to ask a question or to turn in an assignment.

Clearly, there are roles that each is better suited to provide in an educational setting. As a result, the future most likely will see an increase in the use of computers as educational tools but they probably won't replace humans as teachers in the classroom for some time to come.

Information overload

It has been postulated that the amount if information that today's students "learn" is many times more than in previous generations. This may not be true: there is an email circulating the Internet that shows an 8th grade test from the 1890s, and the information that it suggests students from a century ago were required to know far outstrips what today's students are expected to know.

What cannot be argued is that the amount of information that is available to today's students is far greater than what was publicly available in days past. Data storage of this wealth of information in computer systems like the World Wide Web is a major factor. When the amount of data/information available to today's learners is so large and so readily available, one key aspect of a valid education is no longer keeping all the information in their minds, but knowing how and where to locate that information, knowing how to discern the real from the false and knowing how to make best use of available information, and it is these skills that increasingly are comprising a good education. Without the necessary skills, today' students face a maze of conflicting data that can easily swamp their senses or lead them to incorrect conclusions. This mass of data can lead to a state known as Information Overload.

The Gender Gap

During the first half century of computer prevalence, there has been a fairly clear trend towards computer studies being a disproportionately male oriented area. The term "computer nerd" is most likely to be associated with boys. While it is true that more boys have gravitated towards computer studies, there is no less need for girls to be computer literate or skilled.

Home Alone: more male?
http://en.wikipedia.org/wiki/File:Watching_and_Blogging.jpg

Various studies have aimed to look at the reasons for this division. (http://en.wikipedia.org/wiki/Gender_differences#endnote_) One such study has examined the kinds of games that boys and girls prefer, and the general conclusion has been that girls prefer computer related activities that are more socially oriented. Earlier uses of computers tended to focus on the solitary experience – the geek who hacks and clicks alone into the wee hours of the morning. Online access may be changing this tendency as more and more girls are finding that current social networking applications are providing for their needs: sharing media, chatting, messaging within and beyond their "real life" networks.

Online Degrees

Starting with the advent of the Internet, early pioneering schools saw the potential for providing their learning resources beyond the 9-5 classroom and beyond the confines of their local campus. Online learning programs allowed remotely located students to reach the same materials as "day" students and at the same time allow for flexibility in hours and location.

One major issue related to this kind of learning is that the student is not "under the watchful eye" of a proctor/teacher and so it is problematic to discern if it is the student who is doing the work or someone else. Over time, schools and instructors have worked out alternative methods of assessment that can compensate for these kinds of problems. As a result, there are few higher educational institutions that do not allow for "distance learning", often even allowing students to earn their degrees entirely online. Included in the tools that have made this style of learning more practical are online systems collectively known as CMS (Course Management Systems) such as Blackboard and Moodle, where both teachers and students can track activity – assignments, messages, grades, progress.

Reading
The Right to Read by Richard Stallman
Educating the Net Generation edited by Oblinger and Oblinger
Open Textbooks by Jia Freydenberg

For you to consider and further research

Computers will replace teachers. After all, teachers are human and prone to errors but computers are not. Besides, computers are more efficient and more flexible. Actually, most people don't want computers to replace teachers, but it is likely that computers will take on many of the tasks teachers now perform – and do them better. For example?

Should student have computers in classrooms? Under what conditions?

Can people learn solely via an IT interface?

Consider the advantages and disadvantages of distance learning. For example, should a degree earned from "off campus" be less commercially valuable? (It usually costs less, but does that make it less valid?)

Is it wrong for schools to use filters to block students from playing games? Skills and vocabulary learned while playing some games are immediately transferable knowledge. Can you cite specific examples from your personal experience?

Selected Terms/Vocabulary

Apple IIe	HyperStudio
BASIC	Information Overload
CAI	LOGO (Turtle Graphics)
CALL	OLPC (X0 -1 computer)
CMS	PASCAL
Drill and kill	Simulation
Edutainment	Visualization

Online Communities

One of the major trends of the "wired" generation has been the rate at which "Digital Natives" have moved their lives to online communities. Sites like MySpace, Facebook, and even online game worlds play a much greater part in the lives of younger generations.

What defines an online community?
One catchphrase for online communities is "social networking sites", locations on the net where like-minded people can meet, share and spend time. Some require users to login/register; some do not. Some are dedicated to specific shared topics (like Facebook originally was), some are just there to use as people see fit. Some derive their commonality/community simply from the use of specific software (Twitter, Second Life). All provide some form of community.

In general, the older generation is less likely to spend extensive time online in these sorts of activities. Many of them strongly believe that spending too much time in a virtual world is "inhuman" and that this is one of the problems with the younger generation. They worry that younger people do not foresee that a future where they have placed all their personal data online is both dangerous (to freedoms and to "human" interaction) and potentially harmful to our naturally social nature. Younger generations counter that in fact technology improves our ability to socialize.

Membership in a social group is undoubtedly a critical factor of being human. The distinction between "real" and "unreal" may be a false divide: if someone spends hours every day in a virtual world, who is to say that this is not "real".

More and more frequently news items highlight the crumbling of these distinctions: a woman in Japan recently was convicted for murdering her divorced husband's online avatar: she certainly "hurt" his online existence, but should she go to jail for this? 13 year old Megan Meier committed suicide after her cyber boyfriend dumped her. It later became apparent that he didn't even exist – one of her neighbors had invented him and used the non-existent character to torment the girl in retaliation for a neighborhood quarrel. Is the neighbor guilty of causing the suicide?

Online communities exist for just about any kind of interest group: hate groups, political parties, other-worldly entertainment…. Our lives are potentially richer because of the availability of these worlds: without the future-world dreams of earlier generations' thinkers (Jules Verne, for example) where would science be today?

Online communities, in fact, have been around since the dawn of the digital era. Before the internet, online communities took the form of BBSes (Bulletin Board Systems). Throughout the 1980s, computer users who had modems attached to their computer systems could directly dial any number of BBSes – even in Istanbul, there were hundreds of these systems, many of them focusing on a specific area of interest: model airplane interest groups, people interested in midi music, and of course, hacking.

http://en.wikipedia.org/wiki/Image:Remoteaccess.gif
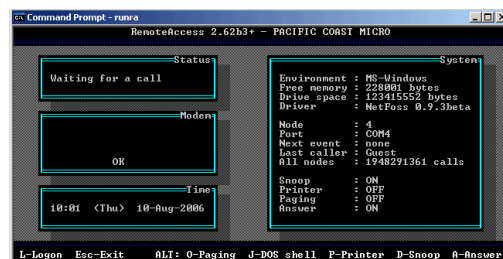
A BBS was often the work of a dedicated user (called a sysop – system operator) who had installed special BBS software on his/her own computer and set up the telephone to receive calls directly into the BBS. More advanced systems allowed more than one user to connect at a time through the use of several modems connected to a single computer. Users would dial the BBS number, login and could then leave messages, upload and download files, chat or even play online games. The interface was text based, although later systems allowed for rather elaborate text-based graphics (ASCII art). Some systems included gateway software that allowed for communication with other, remote systems and could send and receive mail around the world.

The growth of the internet, and in particular the World Wide Web, allowed for a different kind of interface and in the end brought about the end of the popularity of the BBSes. What was once only text based communication became graphical and new software was developed to make use of this feature of the WWW. As just one example of these innovations, an Israeli company called Mirabilis developed a free program called ICQ ("I seek you") that was the precursor to today's Skype and similar camera based communication software such as Microsoft's MSN; it allowed online users to connect, chat and use real-time video cameras connected to their computers, some even integrating calls to land lines through the use of VoIP (Voice over Internet Protocol).

Another popular communication system that was an early adoption for allowing online communities was IRC (Internet Relay Chat). Started in the late 1980s, IRC grew out of the needs of BBS systems for realtime communication among members of a group, called a channel. Later, IRC gained notoriety for its lack of security and use as a tool for malicious attacks: because IRC uses an unencrypted protocol.

As in other areas, the needs of the computer gamers also drove the invention of new technologies. Even in the days of BBSes, multiple payers were able to interact in text based RPGs (role playing games) such as MUD. Whereas before the popularity of the internet, gamers were often restricted to playing alone, the connectivity of the internet allowed users to play together, online. This trend has grown both in numbers of people using it and in the quality of the experience. One of the more famous adopters of this technology is World of Warcraft (WoW). WoW is classified as a MMORPG – massively multiplayer online role-playing game, a term coined in the mid 1990s by the inventor of Ultima Online. In fact, in 2006, the total revenue of this kind of game was estimated to be in excess of $1 billion world-wide. One of the major features of this genre of game is the ability to communicate and otherwise interact (socially) with other players in real-time. Other famous entries in this area include Neverwinter Nights, Everquest, and Second Life.
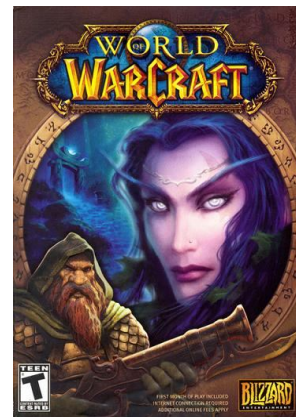
http://en.wikipedia.org/wiki/File:
WoW_Box_Art1.jpg

Outside the entertainment industry, business has made use of people's desire and need to socialize online. Many societies with an online presence have set up "portals" where their members – wherever they are – can congregate to socialize. This trend is popular with schools that provide a means for their graduates to keep in touch and at the same time for the alumni offices to keep track of them, but the use extends well beyond academia.

http://myhosting.com/Help/

Businesses have made good use of the ability to communicate online with their customers. Aside from including their contact information on their web sites (which, with the added features of software like Skype, allow users to click and call directly), many commercial sites also include online help centers where customers can chat directly with sales representatives or trouble shoot problems by talking with trained personnel manning an online computer. Applications like Skype have had a further boost from the cheap cost of webcams, which, when connected to a computer allow for users to transcend great distances and chat "face to face". Not only has this enhanced the sense of community/being there in social chatting, but it has also made business conference calls more effective (you could, for example, show the support person a live image of the problem).

A USB webcam

The most famous of these social gathering points, similarly, began as a school focused project. Started in 2004, Facebook was initially open only to the Harvard University community. It was next opened to other Ivy League schools. The following year, Facebook opened up to High Schools and then to a select number of companies such as Apple Computer, and in 2006, opened to anyone over the age of 13 with an email address.

The immense popularity of Facebook, MySpace and similar social networking sites is an area for serious research – both in terms of their economic success and in terms of what they reveal about online living.

Although sometimes criticized for being slow to adapt, many of the major television companies have realized belatedly that the new generation of viewers would be more interested in web-enabled television offerings. As a result, they have worked to create online communities where users can participate more actively (a major criticism of standard TV being that it is largely passive), for example providing suggestions for how a program's plot develops, 24/7 viewing of related content (Big Brother webcams viewable outside normal TV programming schedule) or even dedicated content where users can log in and host their own "lifecasting" TV channel for others to watch (Justin.tv).

In 2008, the news media took up the case of one such participatory TV channel where one of the "actors" killed himself in real-time online. Social commentators noted that the reactions of viewers ranged from the passive do-nothing to those who actually goaded him, possibly pushing him over the edge with their online/realtime comments urging him to "go ahead and do it". Other twists to the (ab)use of this technology include pranks, where online viewers have called the police to report a "crime" occurring at the live broadcast location so that they could watch the events unfold live.

The technology behind live TV-style (and radio) broadcasting is called streaming. The standard web connection is known as "stateless connection": the client sends a request to a server and the connection to the server is not maintained. The server processes the request, and because the original request included the user's IP information, is able to send a reply back after it has processed the request. Streaming, on the other hand, maintains the connection between the client

and the server – the data flows in a stream of bits that are available to anyone connected at that time to view/listen to.

Social Media Tools Work for Freedom?

The 2009 elections in Iran (as one example) have shown the potential and power of the use of new media in the face of repressive government. As the powers that be in Iran clamped down on foreign and local media in their effort to limit the spread of unwanted information (and arguments can be made that irresponsible reporting of all kinds can fan the flames), citizen reporters made use of ICT tools ranging from phone cams to online connections through proxy servers that the government was not able to block. As a social phenomena, these actions showed how technology can draw together voices/people in spite of repressive forces. In the Iranian case, social media appears to have been more effective at getting the message ouot of the country than in organizing protests within the country. However, the 2008 case where Facebook was used as the tool for drawing together a large group of people spontaneously in public locations such as train stations demonstrates another use of the powers of social media to bring a community together. Again, in Iran, in the 2009 election, the opposition candidate made good use of online social media platforms such as Facebook to get his message out to the people.

On a more positive, more pleasant note, online communities using technology have been used to improve the lives of people in a number of under-developed areas, including parts of Africa. In spite of a nearly non-functional infrastructure, in the land where many of the citizens have access to cell phones but virtually no comprehensive wiring (electricity or landline phones, for example), even simple features of basic cell phones have been used to provide services and empower members of the community. Examples include using SMS to get the message out (AIDS awareness) and SMS banking (see www.clickatell.co.za/solutions/financial.php)

Reading
Avatars Teach Teens – from Edutopia magazine (Creative Commons material)
Confronting the Challenges of Participatory Culture – MacArthur Foundation "White Paper"

For you to consider and further research

Should commercial broadcasters (TV/radio) charge users to view their content?

Does broadcast TV have a future in the long run?

How might you convince someone from the older generation that their ideas about privacy online are no longer valid?

Is Facebook a passing fad? (IRC, the fad of the 1990s has become "passe")

Does an increase in online relationships mean that people will lose the "human element" in their socializing? Make a list of the pros and cons of conducting your social relationships online.

As online presence extends to mobile devices, software applications such as Twitter have built a new community for communication. Is Twitter also a social community or is it impossible to have real socialization with a 150 character limit. (Tweets are limited by the length of SMS messages.)

Do you agree with the older generation's claims that (a) the younger generation does not realize the importance of privacy as demonstrated in the way they upload personal information to social networking sites that can then appropriate or sell that information and/or (b) online interactions can never take the place of "face-to-face" social relations?

Do people still listen to analog music?

We used to do rudimentary "time shifting" of our media by recording to VHS video cassettes. My computer's TV card includes the option to time shift using PVR. What is a PVR and how does it work?

Selected Vocabulary/Terms:

Avatar	RPG
BBS	Second Life
Facebook	Skype
ICQ	Social Network
IRC	Streaming
Lifecasting	Sysop
MMORPG	Twitter
MSN	VoIP
Portal	
PVR	WoW

Data/Mapping

Centuries ago, a map was only available to you if you had the power. In fact, maps **gave** you the power. Certainly, before the advent of the printing press, the "average Joe" wouldn't have anything on paper. A "document" of any value was the material of the powerful. And this included maps. Several hundred years ago, even a map that wasn't exactly accurate, carried value far beyond what we might imagine it is worth today.

Today, the term "map" and "mapping" go beyond the traditional cartography documents that we tend to think of when we talk about maps. Much of this mapping is based on data and that data is primarily either digital in itself or is made more valuable through the use of digital tools, only sometimes placed over or layered on a physical geographical map.

A world map from 1520 CE
http://en.wikipedia.org/wiki/World_map

It is a common definition of the value of data that – as raw numbers and text, data itself is of limited value. However, when that data has been worked on, manipulated, mapped or organized, it becomes information, and information has value. Consider the stream of 0s and 1s that are beamed down from a satellite in space that is gathering data about the Earth. The raw data is mostly meaningless (and valueless) until it has been placed in some kind of context such as a mapping program.

Originally, mapping meant putting onto paper those features that could be seen: oceans, continents, rivers, mountains etc. Even at this level, the ability to visualize and define geographical limits represents man's ability to assert some level of control and manipulation over nature, over culture and over population. A commander or leader who was able to say and then prove on paper that his control extended to, say, the river to the north, had an authority that was hard to dispute. And as distant corners of the world were explored, discovered and mapped, the map was a major tool for political power.

Advancements in computing, data handling and digital imaging obviously have had a great impact on how we view the world. Consider the seminal photo called "Earthrise", taken by the astronauts from the moon: the effect on humans was such that we were able to see with our own eyes not just that the Earth was in fact round, but that the Earth is very much alone in space.

Beyond this sort of change in perception, computing power has extended the notion of mapping beyond cartography. Electronic technologies are allowing us to add meaning and value to many other areas through similar techniques that give a shape to our data. Take for example, the term "cyberspace". Just as advanced technologies provide us with the tools and means to map the universe, digital data and related technologies allow us to create maps of places that are real but not physical in the sense that the geographical world is. If men

"Earthrise" – our place
http://en.wikipedia.org/wiki/Earthrise
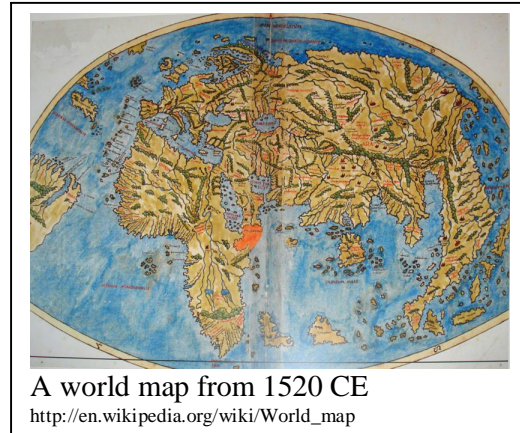
are able to map such intangible regions as cyberspace, dividing it up and regulating it as if it were a physical location, we need to consider what meaning this has for our freedoms. If others are allowed to map your private space, what happens to your privacy?

Among the areas that are being mapped with ICT, is a type of software that has been developed for mapping thoughts and thought processes known under the general term "concept mapping" . A program called Inspiration and other similar software aims to assist people in planning and mapping their ideas and thoughts into a coherent pattern to assist them in decision making. The principle behind these applications is that they aim to create a visual "map" of thoughts that make it easier for people to see trends and thereby plan and manage projects better.

Another area that has been in the news where computers are being used to map data is that of genetic mapping. There have been several large scale projects such as the Human Genome Project, begun in 1990, that has been able to identify more than 25,000 genes of the human genome. Similar to the earlier definitions of terms in this section, here, "mapping" means identifying and then putting into a visual form. When you consider that this project involves working with more than 3 billion base pairs (the pairs of A, T, C and G nucleotides), you can see the need not only for a computer but also for an efficient algorithm that can make sense of the large amount of data. The availability of a "map" that shows this data in a visible form is one part of a larger project to make use of this information, for

Comparing primates: where did we come from?
http://en.wikipedia.org/wiki/Primates

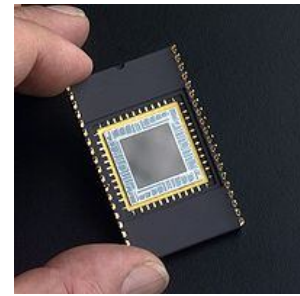example in searching for medical cures or for possible use in forensic discovery in criminal cases.
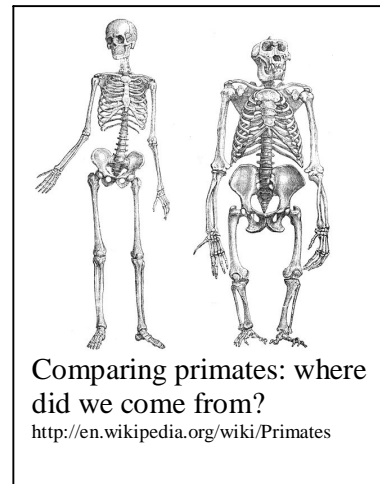
Extensive use of computers is also helping scientists map the universe. As early as the 1860s, astronomer John Herschel compiled an extensive list of object known to date in the sky that amounted to more than 10,000 named objects – all done manually. Closer to our times, the Sloan Digital Sky Survey, begun in 1998 and still in progress today aimed to catalog and map %25 of the sky or about 100 million objects. In 2006, the project was extended to map the Milky Way. One off-shoot of this kind of work has been a number of free atlases of the sky, including one called Celestia. The amount of data that is available in these programs is very much the realm of computers: there is data about more than 100,000 space objects, many of them also have accompanying photographs and the program includes a true reality 3D engine that allows you to go anywhere at any time in history to visit the included space objects. Literally using the power of computing, program like this allow you to travel in time and space based on a map of the known universe.

Consider also the work of the Hubble Space telescope, a device that is packed with computer technologies. Launched in 1990, the Hubble Space Telescope is located outside the Earth's atmosphere so it allows for clear images with no background light – a major problem with Earth-based telescopes. It is due to be

The Hubble Space Telescope – mapping the solar system and beyond
http://en.wikipedia.org/wiki/Hubble_Space_Telescope
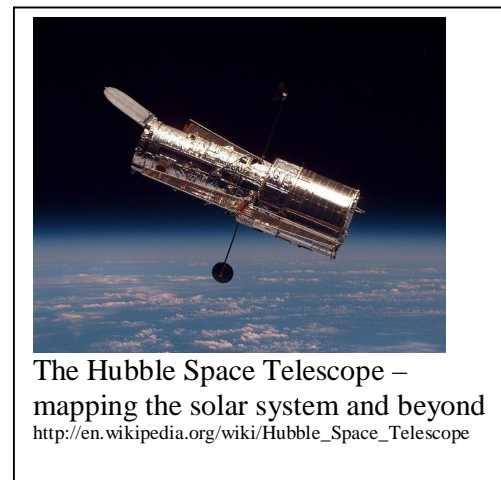
replaced by the James Webb Telescope in 2013. The mirror (which turned out to be flawed but was later corrected) was ground and polished under computer control. Some of the image capture equipment uses CCD (Charge Coupled Devices) devices (the other technology used in digital cameras is CMOS), where the lens image is registered on an array of capacitors which then transfers the data stored in the capacitors which are then sampled, digitized and stored in memory. The Hubble telescope transmits its data in a file format called FITS (Flexible Image Transport System) which is used regularly for space based astronomy and not just image data and then later converted to JPG images for public use. (A FITS plug-in is available for Adobe Photoshop and IrfanView.) Of interest here is the fact that this kind of data is not necessarily image based, but rather includes 2 and 3D data and coordinates that can later be laid on top of existing maps. Scientific teams often write their own software to interact with the raw data and plotting coordinates that are produced by the underlying IT and imaging system. Like other space based data sending systems, the data is now sent to satellite dishes on earth via radio waves (the data used to be stored on reel-to-reel tape!) Among the important discoveries Hubble has produced are improved data about the age of the universe, the discovery that Black Holes are probably common to the centers of all galaxies, as well as images of the planets that are sharper than previously taken images. In short, Hubble has helped produce a clearer, better map both of our solar system and the regions beyond.

CCD chip
http://en.wikipedia.org/wiki/Charge-coupled_device

Another method of mapping data involves the use of collected data placed on top of a geographical map. For example, a company that is considering expanding its operations is likely to take population-related data (household income, shopping habits, traffic patterns etc) and place that data onto a physical map in order to determine the best possible location for a new store or other commercial project. For example, when a cellular phone company is planning to install a new base station, it makes a lot of sense for them to have the data about the number of current users, the number of people who are not yet users but would potentially become users in the region and then merge that data with a geographic map that locates the best location for a new cell phone tower.

Similarly, a company may collate collected data and "map" it without the use of an actual geographical map: the manipulated data could provide the company with information that allows them to tailor their services to a particular community since the needs of different sectors of society may vary and enable the company to better position themselves to increase their market share (low cost services may bring greater returns on an investment, so the company would target that sector of society.) Typically, this process later involves overlaying collected data on a physical map; the result is a recognizable map that highlights concentrations, such as the number of customers located with 10 km of a service.

Several companies including Microsoft with its MSN service and now with Bing has shown the demand for online maps enhanced with additional data. However, it has been Google that has made particularly successful use of people's interest in and need for maps with services like Google Earth and Google StreetView.

While you may benefit from precise geographic location information, like any such technology, it is equally possible for Big Brother to track the signals your digital device emits in order to access the services. Value added phone services can locate your phone and SMS

you with advertisements based on your current location. Car rental companies can follow your signal, and if, for example, you cross into an area that is outside your agreed contract area, create legal problems for you. Forensic discovery can identify your digital device (cell phone…) as having been connected to an access point near the location of a crime at a specific time.

GIS

In the time since the advent of personal computers, a technology known as Geographical Information Systems (GIS) has gained popularity in professional applications as well as in educational uses. GIS refers to an information system that merges data with maps; it allows a user to place, manipulate and query various data based on coordinates of a spatial sort that maps use. Among the many areas where GIS is being used are scenarios requiring logistics such as urban planning, marketing, emergency response and criminology. It is a system based on topology and cartography with the addition of relevant additional data. Computerized GIS (CGIS) first appeared in military uses in the 1960s and by the 1980s had gained in popularity as a research tool. Today, it is offered as a major field of study in many universities. There are a number of free GIS applications available for Windows (and other OS) users for a variety of different purposes.

As the name implies, GIS involves the transfer of geo-coordinated data onto maps. This location coordination may be in terms of an X,Y,Z 3D system, it may be based on longitude and latitude coordinates of the Earth or it may be based on other locational systems such as mail ZIP codes. In particular, the use of GIS software allows companies to get added value from the data they have collected as they are able to integrate the raw data of individuals with maps and generate value-added information of commercial value. (There is an animation available online that shows the spread of WalMart across the USA as an example of planned expansion based on statistical, mapped data.)
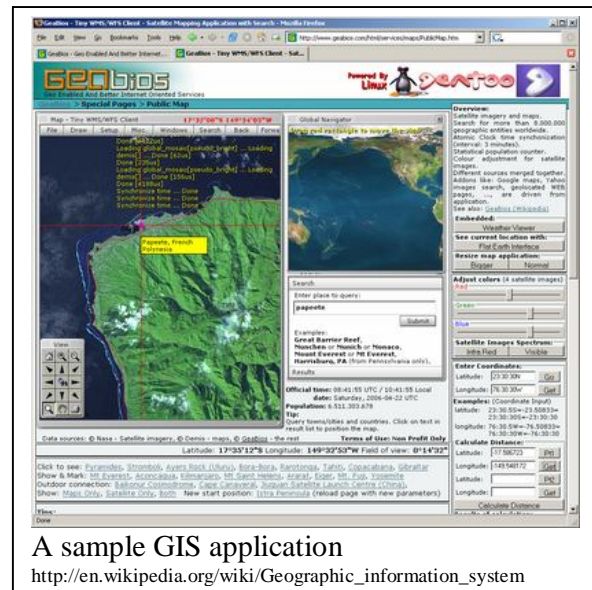

A sample GIS application
http://en.wikipedia.org/wiki/Geographic_information_system

Texture mapping (adding details to a computer generated drawing)

As the power and capabilities of computers have improved, so has the quality of the displayed output. The earliest graphics on computers were very line-oriented: rather than near-photographic quality that we can achieve today, computers displayed their data in wire-framed representations. As computers became more capable in graphics terms, one of the features of producing a realistic "rendering" of a computer generated image was the process of texture mapping. Given the necessary detailed information and algorithms, today's computers can "map" highly accurate lighting, texture, materials (cloth, metal …) and even interactive features to cover the wire-framed outlines that are the initially generated structures of high-end CGI (Computer Generated Imagery).

Memory Mapping in Computers

It seems that one of the rules of computing is that there is never enough memory to handle the tasks users would like: there is a constant one-upmanship as standard system RAM and speed increase, followed immediately by further requirements for software needs. One way that computer systems deal with this is to "swap" data from short term memory to temporary holding locations such as disk cache. In order to do this, computers need systems that are accurately able to map/keep track of the location of various pieces that make up a larger file. One part of this system is a file allocation table (FAT), an index that keeps a current map of file parts. In fact, this aspect of computer system operations is so critical that, for example, Windows systems actually keep more than one copy of the FAT (in the event that the main copy suffers a corruption, without a readily available backup copy, the entire file structure and access to individual files would cause the whole system to fail!)
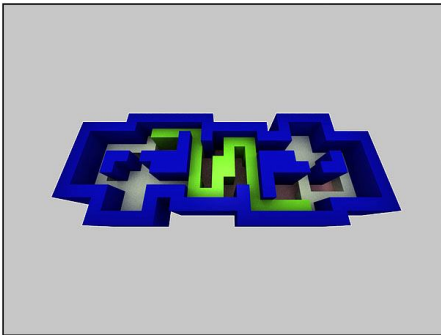
A map of the terrain of Quake game
http://512x512.com/lvl/shankqzctf1/qz1.jpg

Game Mapping

Another area where mapping has proved useful is in gaming. Most any game of some complexity needs to keep track of various parts and pieces: users, users' possessions/traits, positions within the game - both in terms of geographical placement (level 1 or 2?) and sequential progress (completed 2/3 of level 2).

One technique that was developed early on to handle the coding information for these needs was a system known as mapping. The use of mapping is a handy tool for the programmer to keep track of the complex data that a larger game would involve.

Reading
How to Make a Complete Map of Every Thought you Think – Lion Kimbro

For your further research

Test a free GIS program. You can find some at http://opensourcegis.org/ and http://www.mapwindow.org/

ZeeMaps tutorial from the University of California: use free ZeeMaps and this tutorial to create a map mashup to map your own data.

For you to consider

Although much of the data mapping that is being done is not so directly related to actual geography, archaeology has recently been making greater use of space-based imaging to discover previously undiscovered ancient cities. Who and where is this being exploited?

Data crunching sometimes involves statistics "stripped" of personal information (for example, age and income) that is then super-imposed on geographic maps. Of what value is this mapping technique to a large retailer like WalMart?

Governments are regularly criticized for spending such large sums on space exploration. What value for mankind in general do they claim for their efforts in mapping the universe?

Are there modern day examples of boarder disputes that have made use of technological advances to prove or resolve lines of demarcation?

What technologies are being used to help secure boarders between countries? (Not all boarders need be protected physically)

At many boarders/divisions between countries, technology is being employed to facilitate the work of people who normally need to cross on a regular basis (Canadians who work in the US, for example). What are these technologies? How will the use of IT likely increase in the future?

GIS software has been incorporated as a component if the curriculum in a number of schools? Why do you imagine this is so? How would you imagine this is a valuable skill that students could use in later/business life?

GPS can combine with GIS to provide portable, precise location tools. When both are included in a handheld device like your cell phone, there are benefits and drawbacks. How could this benefit you? How could it negatively affect you?

Does your car or phone have built in GPS?

What is the maximum resolution (1 pixel = X inches) of Google Earth?

Selected Vocabulary/Terms:

Cartography	Google Earth
CCD/CMOS	GPS
Celestia	Human Genome Project
Concept Mapping	Memory Map
Electronic Boarder	Overlay
FITS	Rendering
Game Map	StreetView
GIS	Texture Mapping