Learn Computer Pre-Tech

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Introduction to Computer Pre-Tech

Over the next few weeks you will be studying Computer Pre-Tech. I have created this workbook as a classroom aid because some of the concepts presented are best practiced as often as possible. Without good notes they may be hard to remember, so I have tried to set everything up such that any particular idea that has been presented will have its own, easy to find section. This is about 50/50 lecture and hands-on activities course, so I've also tried to leave plenty of room for student notes.

Just remember, if you fail to write something down, that's no guarantee that it won't be on a test.

All examples, documents, and images used in this course are available for download from:
http://pctalk.info/Classes/Spock/Tech/

Acronyms

Acronyms are abbreviations that are formed using the initial components in a phrase or name. Make a note of all acronyms mentioned in class on this page.

Acronym	Definition of Acronym

Curriculum Outline Computer Pre-Tech

Version 2.9

Combined Class Lecture and Lab time will be 2.5 hours per class. If Lecture ends early, remaining time will be used for Lab.

#	Topics	Notes/Chapter	Workbook
1	**Intro** A. General Safety Guidelines B. Fire Safety C. Computer Equipment Disposal	Workbook	Case edges may be sharp, electrical safety. Get forum registration information.
2	**A+ Fundamentals** A. What do A+ Exams Cover?	Workbook Chapter 1-1	
3	**Internet Access** http://pctalk.info/ http://google.com/ http://www.hardwarecentral.com/	Workbook	Register for forum. Talk about search and education.
4	**Fundamentals** A. Numbering Systems 1 B. When to/not to upgrade C. Identifying components	Workbook Chapter 1-2	Numbering Systems are sometimes hard to understand, so extra time has been allowed for teaching them.
5	**Fundamentals** A. Numbering Systems 2 B. Basic Electronics	Workbook Chapter 1-2	An understanding of this lesson is essential to understanding later lessons.
6	**Fundamentals** A. Basic Electronics B. Tools	Workbook Chapter 1-2	Talk about a UPS. Student tools will be shown.
7	**Inside the Box** A. Motherboard B. BIOS	Workbook Chapter 1-3 Chapter 1-4	
8	**Inside the Box** A. Bus Structures B. Microprocessors	Workbook Chapter 1-5 Chapter 1-6	
9	**Lab Class** A. Intro to the console internals		Talk about drawing diagrams and why it is important.
10	**Inside the Box** A. Memory Systems	Chapter 1-7	
11	**Inside the Box** A. Storage Systems	Workbook Chapter 1-8	Bring SuperDisk and FlashDrive for demo.
12	**Inside the Box** A.Power	Workbook Chapter 1-9	
13	**Outside the Box** A. Ports	Workbook Chapter 1-10	
14	**Outside the Box** A. Input Devices B. Output Devices	Chapter 1-11 Chapter 1-12	Bring camera to class.
15	**Disassembly** Students disassemble and reassemble practice computers.	Workbook	
16	**Outside the Box** A. Printers B. Portable Systems	Workbook Chapter 1-13 Chapter 1-14	Bring Notebook computer to class.

#	Topics	Notes/Chapter	Workbook
17	**Disassembly** A. Diagramming the computer prior to disassembly B. Removing and replacing cards.	Workbook Chapter 1-15	
18	**Disassembly** A. Students disassemble and reassemble practice computers.	Workbook Chapter 1-16	
19	**Disassembly** A. Students disassemble and reassemble practice computers.	Workbook Chapter 1-17	
20	**Networking** A. Hardware side of Networking	Chapter 1-18	
21	**Preventive Maintenance** B. Hardware and Software	Workbook	
22	**Software** A.Windows Operating System Basics	Workbook Chapter 2-1	
23	**Software** A. Windows 9x and ME	Chapter 2-2	
24	**Software** A. Windows 2000 and XP	Chapter 2-3 Chapter 2-4	
25	**Networking** A. Making the Network Connection	Workbook Chapter 2-5	
26	**Troubleshooting and Review** A. Procedures and practices B. BIOS beep codes C. Course Review	Workbook	
27	**Final Part 1**		Rebuild a lab computer.
28	**Final Part 2**		Written test.

1) Each student will be responsible for supplying his or her own pens or pencils and notebook. Text used is "A+ Certification for Dummies". Each student should make every attempt to purchase their own copy, as they will find highlighting sections of the reading to be most helpful. Your instructor can get the books and is willing to collect money and purchase the books as requested if anyone is interested. Books may also be checked out of a library or borrowed from others if possible, but you would not be able to use it as effectively. There is also a class workbook that will cost $10 for materials. **These books are required.**

2) The Chapters listed next to each lesson are those recommended for reading prior to the start of that class. "Workbook" indicates that some of the material presented will not be from the book. All chapters in the book will be covered and thorough knowledge of their contents is encouraged.

3) It is the instructor's job (and desire) to teach and therefore must be easy to understand. It is the student's job to ensure they get the required information. If you have any questions pertaining to the lecture content during the lecture, please ask. There will be others, not nearly as brave, who will appreciate your questions.

4) Attendance will be taken each class and the presentation of a certificate of completion depends upon at least 80% attendance, good quiz scores, and a passing Final Exam grade. This course will be extremely challenging and any student who must miss a class will be expected to arrange an immediate one-on-one make up session with the instructor. Though not guaranteed, the students who do well and apply themselves may be able to pass the A+ Certification test. A+ Certified Technicians with some work experience can expect to earn anywhere from $25,000 to $40,000 a year.

5) The computers in the lab are owned by the City of Annapolis and each student must read forms and agree to limitations of use. Students will use the networked computers, as needed, during class for Internet access to find drivers, upgrades, hardware information, etc. There are several, disconnected computers in the room that will be used for practice. Each student should create a named folder on the computer they normally use to hold any work they do in class or anything downloaded during class. The folder should be created in the form My Documents\ ClassTech\ <StudentName>.

6) Students must all have their own email addresses and Internet access. All lab computers that are set up along the walls have Internet access. Students may use classroom computers already connected to the Internet to search for required hardware information.

7) The instructor will do his best to stay on-track with the syllabus but will also try not to discourage spirited classroom discussions that pertain to learning anything important having to do with basic computer repair. If a student has an immediate need for certain information, ask. The question can easily be worked into the course material.

8) Pre-Tech Students are expected to learn how to use the available forum as a means of getting and giving technical help. This can prove to be a valuable resource even after the class is over. **One new post, either asking or answering a tech question, will be required for each class day.**

9) Students tool kits are for use in the classroom only. Since there are only a few sets, some students may be required to share. Tools will be inventoried and returned to the storage drawer at the end of each class.

10) Students are expected to practice outside of the classroom to help them gain the additional skills they need. There are computers in the lab that have been left there specifically for the students to work on and learn from. They should not be touched, though, until the students have learned proper procedures.

11) Quizzes will normally be given every week. The quizzes are to assist the instructor in determining how well you are doing with the material. Some are open book, open notes, so well thought out and legible notes will help you to do well on these quizzes. Some are from memory only. All quizzes and both finals must be taken. A Certificate of Completion will not be issued if one is missing. Any missed Quizzes must be taken as soon as possible.

12) Students may desire to obtain a Flashdrive. If they do not have one and wish to purchase one, the instructor has access to Sam's Club where they are available far cheaper than anywhere else locally. Several students may wish to pool their resources to purchase a card of 4 and then divide them amongst themselves.

13) How to create an Emergency Boot Disk using floppies will be demonstrated by the instructor. If students wish to create one of their own, they need to bring a 3½" HD floppy disk to class. You may also download one from bootdisk.com

14) Students should do their best to arrive on time for class 14 and may want to dress up a bit as the instructor will bring a Digital Camera to class to demonstrate Digital Photography by taking class pictures which will be made available to the students at the end of the course.

Rules for Fighting Fires

Fires can be very dangerous. You should always be sure that you would not place yourself or anyone else at risk if you decide to try and extinguish a fire. These rules will help you make a safe decision if you discover a fire at home or your workplace.
[http://www.rocknet.net.au/~sollittr/ohs/Fire_exting/fe_rules.html]

A. Assist any person in immediate danger, to get to safety, if it can be accomplished **without risk to yourself**.
B. Call the Fire brigade by dialing 000 (Australia) or 911 (United States), and activate the building fire alarm system (or designating someone else to do this for you).
C. Ensure people in the building are aware of the emergency and are starting to move out.
D. Only after having done these three things, and if the fire is **small**, should you attempt to use an extinguisher to put it out.

If you decide to fight the fire, keep these rules in mind:
ALWAYS

- **Operate the extinguisher briefly** as you approach the fire, to ensure that it working properly.
  (With dry chemical powder type extinguishers it is possible that when initially operated, the powder may not allow the valve to fully close again, therefore you should be approaching the fire when you test the extinguisher.)
- Obtain assistance if possible before you fight the fire.
- Make sure that there is a clear escape path behind you.

NEVER ATTEMPT TO FIGHT A FIRE IF:

- **You don't know what is burning.** If you don't know what is burning, you don't know what type of extinguisher to use or what other hazards to expect. There may be something burning that will explode or perhaps produce toxic fumes. Unless you know what is on fire then let the fire brigade handle it when they arrive.
- **The fire has started to spread rapidly.** A portable extinguisher is only useful for small fires. If the fire is already spreading quickly, it is best to simply close the doors and windows to slow down the spread of the fire and evacuate the building.

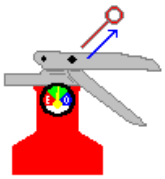
Do Not Fight the Fire If:

- **You don't have adequate or appropriate equipment.** If you don't have the correct type or large enough extinguisher, it is best not to try to fight the fire. (Always test the extinguisher to ensure it is serviceable before you go near to the fire)
- **You might inhale toxic smoke.** If the fire is producing large amounts of smoke that you would have to breathe in order to fight it, it is best not to try. Any sort of combustion will produce some amount of carbon monoxide, but when synthetic materials such as the nylon in carpeting or foam padding in a sofa burn, they can produce highly toxic gases such as hydrogen cyanide, acrolein, and ammonia in addition to carbon monoxide. These gases can be fatal in very small amounts.
- **Your instincts tell you not to.** If you are uncomfortable with the situation for any reason, just let the fire department do their job.

The final rule is to always position yourself with an exit or means of escape at your back before you attempt to use an extinguisher to put out a fire. In case anything unexpected happens, you need to be able to get out quickly, and you don't want to become trapped. Just remember, always keep an exit at your back.

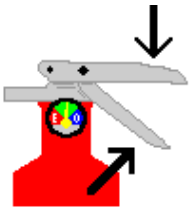
How to Operate an Extinguisher

PASS It's easy to remember how to use a fire extinguisher if you can remember the acronym **PASS**, which stands for **P**ull, **A**im, **S**queeze, and **S**weep.
[http://www.rocknet.net.au/~sollittr/ohs/Fire_exting/fe_use.html]

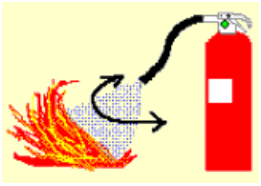


Pull the pin. This will allow you to operate the extinguisher.

Aim at the base of the fire. This is where the fuel is.



Squeeze the top handle or lever. This releases the pressurized extinguishing agent in the extinguisher.



Sweep from side to side until the fire is completely extinguished. Start using the extinguisher from a safe distance away, then move forward. Once the fire is out, keep an eye on the area in case it re-ignites.

You should always test the extinguisher briefly, to ensure that it operates correctly, before taking it to the fire.

If you are in a position where there is a high fire risk (e.g. working with flammable materials or heat), then you should arrange to attend a hands-on fire extinguisher training program.

The Fire Triangle

In order to understand how fire extinguishers work, you first need to know something about fire.

Fire is a chemical reaction involving rapid oxidation (burning) of a fuel

Four things must be present at the same time in order to produce fire:

- **FUEL** - any combustible material - solid, liquid or gas. Most solids and liquids must vaporize before they will burn.
- **OXYGEN** - Sufficient oxygen must be present in the atmosphere surrounding the fuel for fire to burn.
- **HEAT -** Sufficient heat energy must be applied to raise the fuel to its ignition temperature
- **Chemical, exothermic reaction** - This reaction can occur when all three of the above elements are present in the proper conditions and proportions. Fire (rapid oxidization) is the result of this chemical reaction.

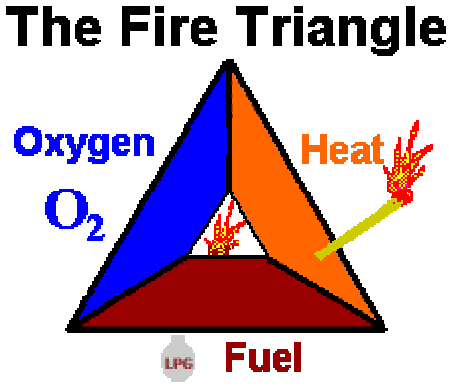


Illustration 1: The Fire Triangle

The combination of these three elements is frequently referred to as the "fire triangle". Add in the fourth element, the chemical reaction, and you actually have a fire "tetrahedron." The important thing to remember is that **if any one of these four things can be removed there will be no fire or the fire will be extinguished.**

Essentially, fire extinguishers put out fire by taking away one or more elements of the fire triangle/tetrahedron.

Fire safety, at its most basic, is based upon the principle of keeping fuel sources and ignition sources separate.

[Ross's Fire Safety Page: http://www.rocknet.net.au/~sollittr/ohs/Fire_exting/fe_triang.html]

Classes of Fires

http://www.orp.doe.gov/fire/safety/extingrs.htm

Fires are classified according to the material that is being burned. The four classes of fires, with the American and International symbols, are as follows:

 	**Class A:** Ordinary Combustibles - cloth, wood, paper, rubber, many plastics. **Extinguisher:** will put out fires in ordinary combustibles, such as wood and paper. The numerical rating for this class of fire extinguisher refers to the amount of water the fire extinguisher holds and the amount of fire it will extinguish.
 	**Class B:** Flammable Liquids - Gasoline, Oil, Oil-based paint, Cooking Oil. **Extinguisher:** should be used on fires involving flammable liquids, such as grease, gasoline, oil, etc. The numerical rating for this class of fire extinguisher states the approximate number of square feet of a flammable liquid fire that a non-expert person can expect to extinguish.
 	**Class C:** Energized electrical equipment, including appliances, wiring, circuit breakers, and fuse boxes. **Extinguisher:** suitable for use on electrically energized fires. This class of fire extinguisher does not have a numerical rating. The presence of the letter "C" indicates that the extinguishing agent is non-conductive.
	**Class D:** Combustible metals such as magnesium, sodium, lithium, hafnium, powdered aluminum, etc. **Extinguisher:** designed for use on flammable metals and are often specific for the type of metal in question. There is no picture designator for Class D extinguishers. These extinguishers generally have no rating nor are they given a multi-purpose rating for use on other types of fires.

Computer Equipment Recycling

There are many components inside a computer console, monitor, printer, etc that are harmful to the environment. There are also a few valuable, recoverable materials as well. Instead of throwing your old computer system in the dumpster so it ends up in the local landfill, why not consider donating it or have it recycled. ComputerHope.com offers not only advise on how to dispose of system components but also give contact information for those companies who will accept your old system for recycle or donation purposes.

http://www.computerhope.com/disposal.htm

Below are a few of the Recycle/disposal companies that can help provide you with information or help you recycle your computer equipment.

Battery Solutions (**http://www.batteryrecycling.com**)
Phone: (734) 467-9110
Fax: (734) 467-9104
Batteries Recycled: Able to manage every type of spent battery manufactured today.

Back Thru The Future Microcomputers, Inc. (**http://www.backthruthefuture.com**)
Phone: (408) 453-4511
Fax: (408) 453-4511
Address: Refer to web page (multiple locations)
Note: Back Thru The Future Microcomputers is one of the largest computer recyclers in the United States and are a women's owned business. The company recycles microcomputers for corporations, educational institutions, government, and individuals. With millions of microcomputers being displaced each year by newer technology, Back Thru The Future has committed itself to finding uses for this older technology and preventing it from becoming a high tech waste.
Parts capable of recycling: All computer equipment. For corporations, educational institutions, government, and individuals.

National Revitalization Services (**http://www.natrs.com/**)
Phone: (973) 275-1786
Address:
108 Baker Street
Suite 500
Maplewood, New Jersey 07040
Note: Company capable of recycling almost all non remanufactured laser and inkjet printer cartridges.

Share The Technology: (**http://sharetechnology.org**)
Phone: (856) 234-6156
Fax: (856) 234-5809
Address:
P.O. Box 548
Rancocas, NJ 08073
Note: See web site with database of organizations looking for donated computers.

A+ Exams

The A+ certification demonstrates competency as a computer technician. CompTIA A+ certification is a vendor neutral certification. It requires two tests to be passed: the A+ Essentials exam and a choice of one of three elective exams. CompTIA is vendor neutral but leans towards Microsoft operating systems although some Apple questions do appear on this new exam.

Exam details

The A+ certification exam was updated in late 2006, so the structure of the exam is different than it had been for the three years prior to the update. The good news is the old 2003 exams had an average pass rate of between 3% --> 10% depending on your sources. The new A+ exam has been redesigned to have a 30% pass rate. A+ certification currently entails two tests: **A+ Essentials** (220-601) and one of three elective exams, **IT Technician** (220-602), **Remote Support Technician** (220-603), or **Depot Technician** (220-604). Both of these tests must be passed in order to receive A+ certification. CompTIA suggests that one take the A+ Essentials exam before the other, but they can be taken in either order.

For the 2006 exam, the total cost was $158.00 for each test. If you are a student check with your school's Career Tech program, most public schools are Jobs+ sites. If your school is a Jobs+ site you can get the A+ voucher for half the price as you would retail. Also a lot of companies that offer training are CompTIA affiliate which can sell you the voucher to take the exam for less than retail. The CompTIA A+ Essentials consists of 100 questions, and the elective consists of 90 questions. A passing score on the CompTIA A+ Essentials exam is 675, on any of the electives is 700.

The test consists of 8 "domains":

Domain	Percentage of exam
Personal computer components	21
Laptop and portable devices	11
Operating systems	21
Printers and scanners	9
Networks	12
Security	11
Safety and environmental issues	10
Communication and professionalism	5
Total	100

Identifying hardware components

One of the essential requirements for A+ Certification is identifying names, purposes, and characteristics of specific hardware components, including the following:

- Floppy disk drive
- Hard disk drive
- Optical disk drive
- Motherboard
- Power supply
- Cooling system
- CPU
- RAM

- Display devices
- Adapter card
- Ports
- Cables

This is not a device:

- IRQ

Identifying Operating Systems

Although the examination focuses almost exclusively on Microsoft's Windows Operating System (OS), one should also know about differences among other operating systems.

Microsoft operating systems:

- Legacy Windows OS's (need only to know upgrade paths):
  - Windows 95
  - Windows 98
  - Windows ME
  - Windows NT 4.0
- Current Windows OS's (focus on these for the new exam):
  - Windows 2000
  - Windows XP
  - Windows Vista (not on the 2006 objectives)

Apple operating systems:

- Mac OS X (which is based on Unix-like system-exam question)
- Mac OS 9

Unix-like operating systems:

- BSD (and derivations like FreeBSD, OpenBSD, and NetBSD)
- NextStep
- GNU/Linux

For more information, see the Wikipedia page at **http://certification.comptia.org/a/default.aspx**

Registering for the PCTalk Support Forum

1) Open your Browser and go to **http://pctalk.info/**,
2) Click on the Support Forum button in the Navigation Bar on the right,

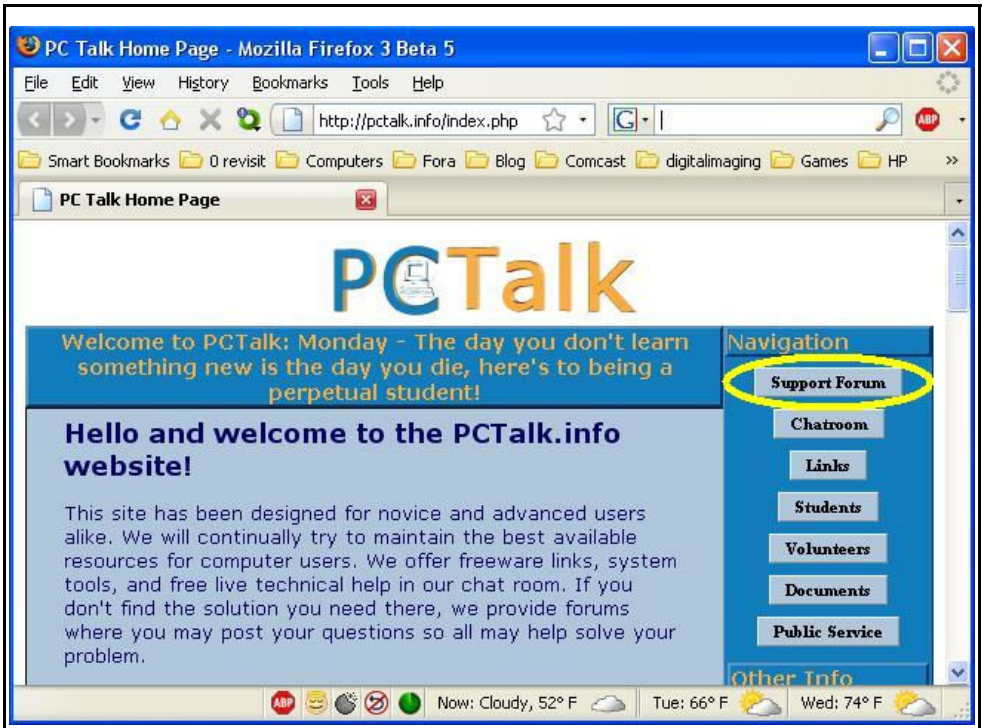


Illustration 2: PCTalk Support Forum button

3) Click on the Register link on the right side of the page,

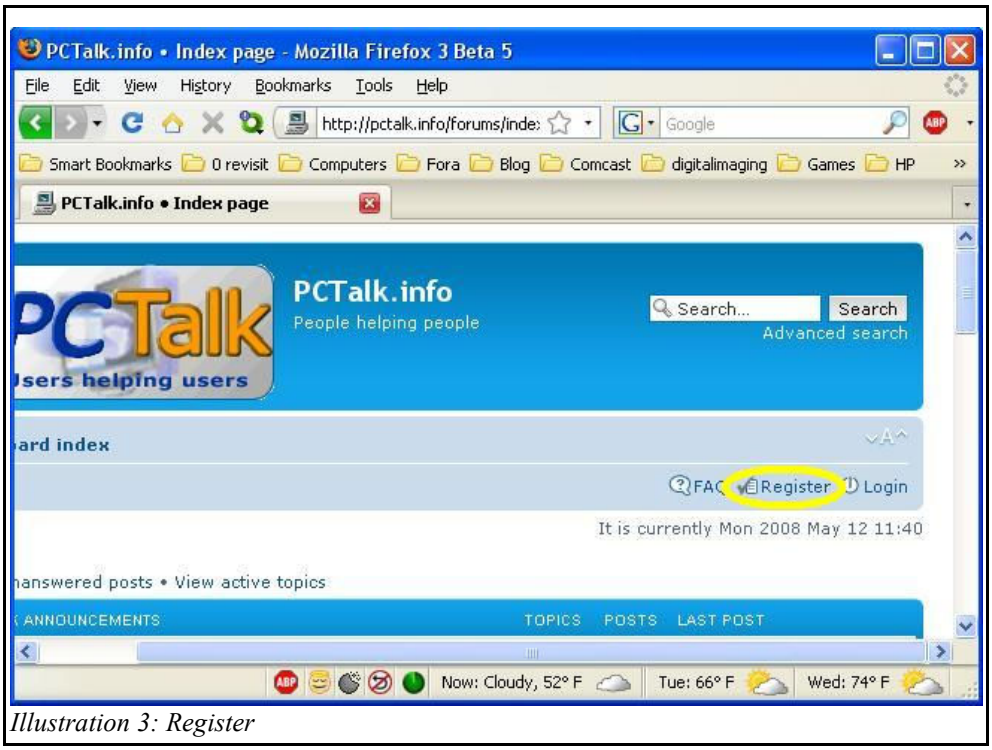


Illustration 3: Register

4) Click on the Before button to indicate the date you were born. If you are 13 or under (not too likely

in this class) you must bring a note from your parent or guardian giving you permission to join the forum,

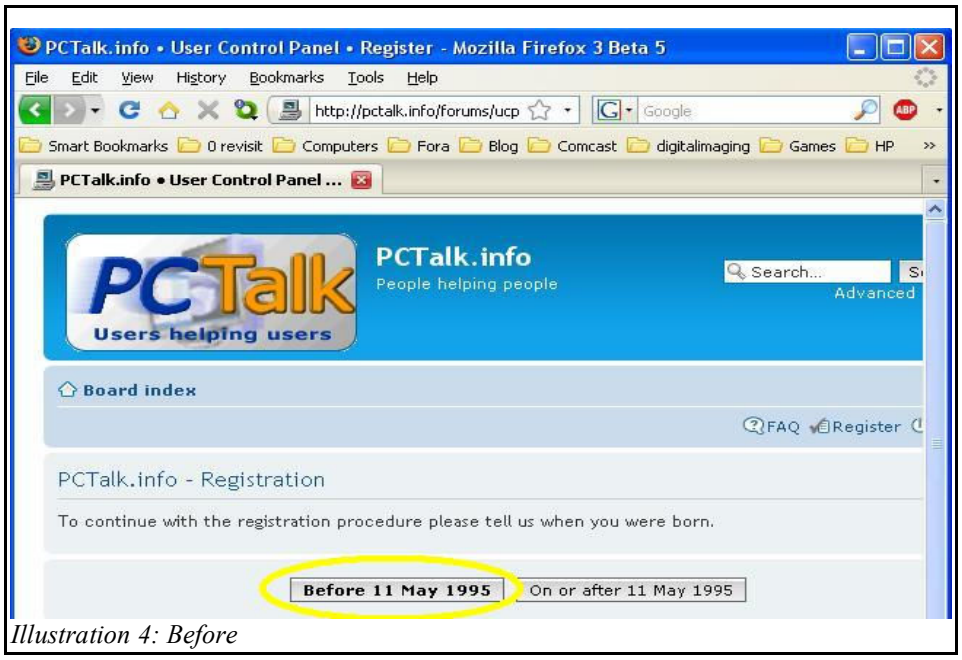


Illustration 4: Before

5) Read the Registration agreement and click on the "I agree to these terms" button,

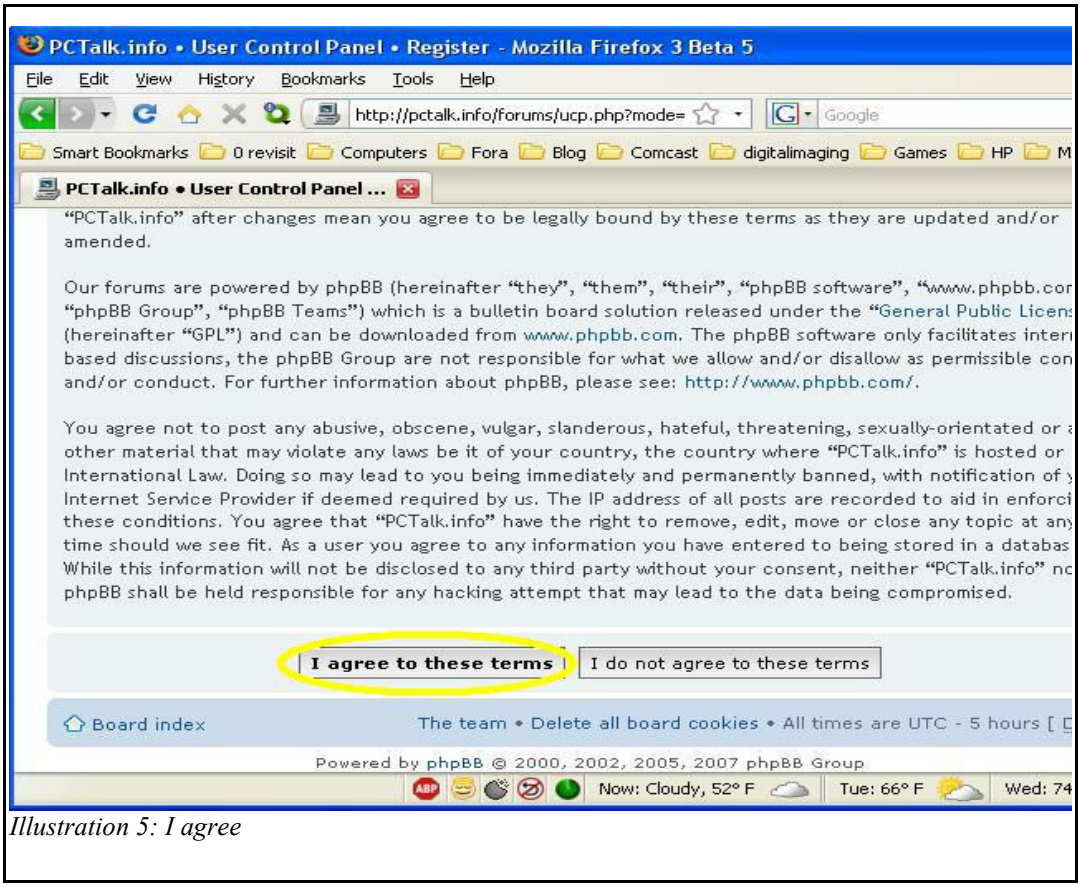


Illustration 5: I agree

6) Fill in the Registration form. You may use the tab key to move from one block to another but **you must never use the Enter key**. The only information that **must** be accurate is your email address. The registration will send you an email to respond to and if it bounces registration will be denied,

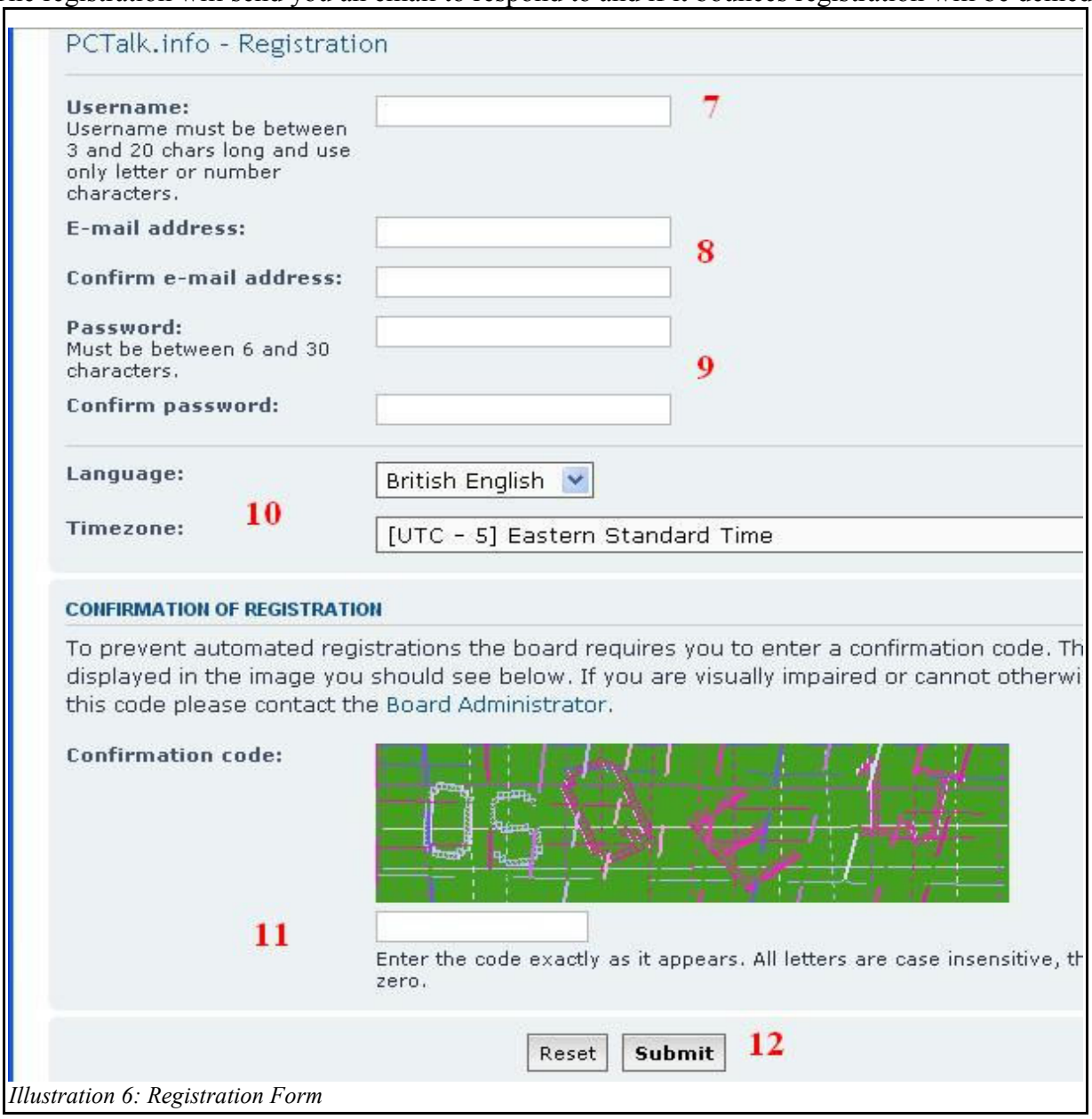


Illustration 6: Registration Form

7) The Username may be anything you wish it to be but I recommend you do not use anything that might enable anyone to know your identity, i.e., do not use your real name. My Username is Spock for various reasons that I will explain in class. You should start with a capital letter and should make it short enough to be convenient for you. Remember, you will have to type it in every time you login. **Write it down on the Student Forum Information sheet at the end of this workbook**,
8) The Email address will have to be entered twice for verification,
9) Your password may again be anything you wish it to be but it should be easy for you to remember. If you do forget, there will be a link you can click on that will send an email to your registration Email reminding you what your Username and Password is. **Write it down on the Student Forum Information sheet at the end of this workbook**,

10) The Language and Timezone entries should be left as is,
11) Enter the code you can see in the colored rectangle into the white box underneath it. There will be various letters (possibly in mixed case) and numbers at odd angles. This is designed to attempt to keep computers from automatically registering for multiple accounts so they can get free advertising on the forum. Sorry, you may have to try multiple times before getting this portion right. If you get it wrong, an error message saying, "The confirmation code you entered was incorrect." and you will have to reenter a new confirmation code to try again,
12) Click on the Submit button.

You should receive an email shortly welcoming you to the forum and repeating for you the Username and Password you used to register. Keep it in a safe place for future reference in case you forget your password. Once you receive your registration email, there will be a link in the email you must click on to activate your new account. Once that is done, you may now login to the forum.

Logging in to the forum

1) Open your Browser and go to **http://pctalk.info/**,

2) Click on the Support Forum button in the Navigation Bar on the right,

3) Click on the Login link on the right of the page or, if you prefer, there is a place for your username and password at the bottom of the page,

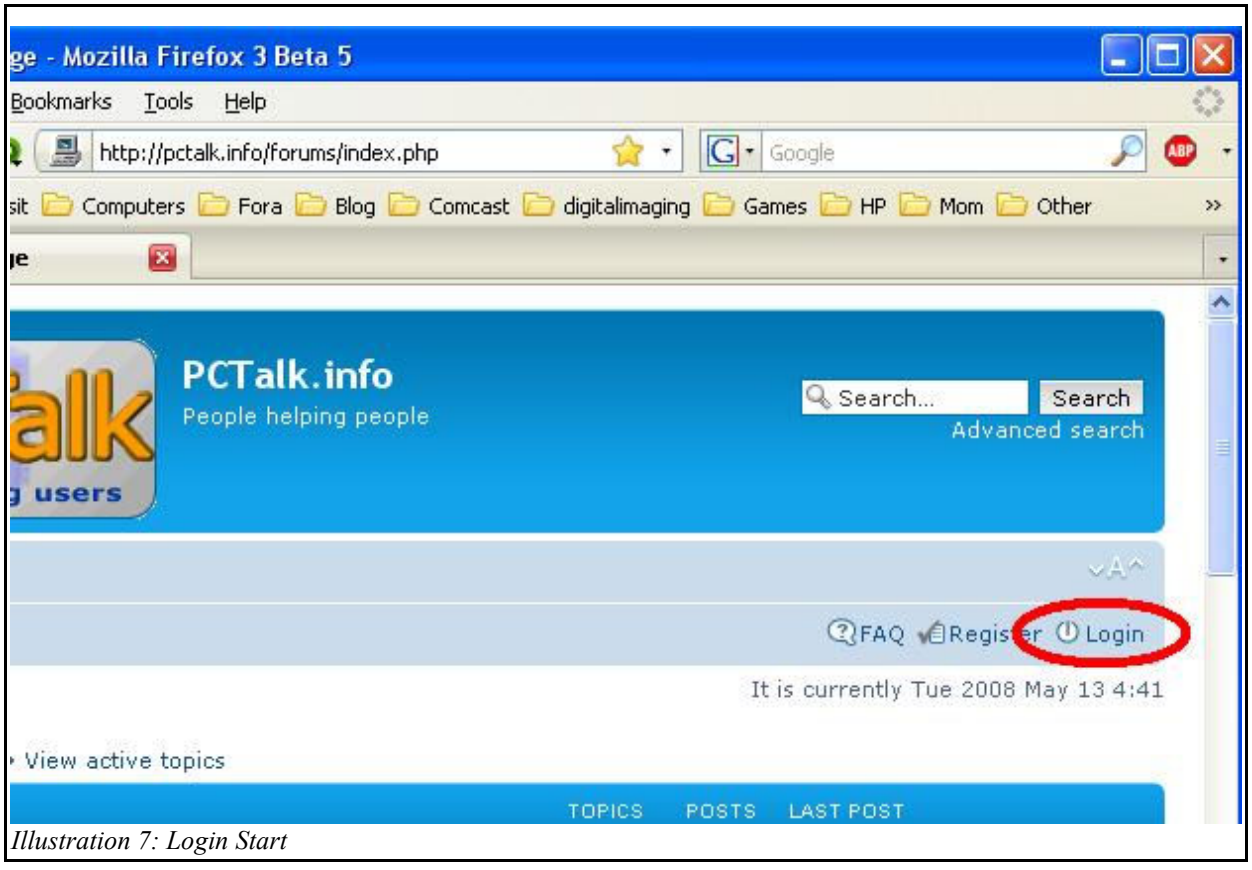


Illustration 7: Login Start

4) On the Login page, Enter your Username,

5) Enter your Password (remember, case counts),

6) If you have forgotten your password and lost your registration email, you can click on the "I forgot my password" link to receive a reminder to the same email address you registered with,

7) If you are using a safe computer that no one else uses and is password protected, you might want to select the "Log me on automatically each visit" selection box. Please never do this on a public computer or one where others may gain access to your account,

8) There is another selection box that you should probably never select. That is the "Hide my online status this session". It hides your online identity to other forum members and the public only. All Admins and Super Moderators will know who you are regardless but none of the other members will know you are there,

Illustration 8: Login page

9) Click on the Login button to now gain access to the forum.

When you first access the forum, you will be in a "holding" area called Prospective Members. This is an area that is hidden to all full forum members and is what I call part of my Spam Trap. You must make at least one post in there telling me who you are, where you found out about the forum, and why you want to join before I move you up to full membership. While restricted to the Prospective Members forum, you will have very limited access to the forum tools.

As members of my class, I will know what your usernames are, so almost anything will be accepted but your "acceptance post" will be moved out of Prospective Members and into the New Users forum to introduce you to the other forum members. You should never give out any personal information but you might want to give enough information so others with similar interests will want to strike up a friendship.

Help with using the forum

Illustration 9: Using the forum

1) You are now logged into the forum, you know this because you can see the Logout link next to your username.

2) There is a Frequently Asked Questions (FAQ) link that may answer some of your questions about how to use a forum.

3) Every time I login to the forum, the first link I click on is the "View new posts" link to see what has been posted since I was last in the forum. I find that if I do that every time I login, I will be able to keep up with what has been happening. If you login and then logout almost immediately, all posts will be marked as read, even if you haven't read them. The link should probably indicate, "View new posts since last login" to be most accurate.

4) There is a User Control Panel (UCP) where you may update certain information about your account such as changing your password, adding or changing an avatar, etc. If you change your email address, you will be locked out of the forum until your new email is verified, so it is not a good idea to change it unless you let me know first as the re-authorization process has to be done manually.

5) There is an area where any new Personal Messages (PM) will appear. Click on the link to access old, new, and sent. There is a limit to how many of each may be stored on the forum. Once that limit is reached, old ones will be removed to make room for new ones. If you want to keep any for any reason, you might want to selectively prune them yourself.

Numbering Systems:

Binary:

N	2^N																	
0	1																	
1	2																	
2	4																	
3	8																	
4	16																	
5	32																	
6	64																	
7	128																	
8	256																	
9	512																	
10	1024																	
11	2048																	
12	4096																	
13	8192																	
14	16384																	
15	32768																	
16	65536																	
		65536	32768	16384	8192	4096	2048	1024	512	256	128	64	32	16	8	4	2	1

Hex:

N	16^N					
0	1					
1	16					
2	256					
3	4096					
4	65536					
		65536	4096	256	16	1

Decimal	Binary	Octal	Hex
0	0000	0	0
1	0001	1	1
2	0010	2	2
3	0011	3	3
4	0100	4	4
5	0101	5	5
6	0110	6	6
7	0111	7	7
8	1000	10	8
9	1001	11	9
10	1010	12	A
11	1011	13	B
12	1100	14	C
13	1101	15	D
14	1110	16	E
15	1111	17	F
16	10000	20	10

1 BIT = 1 Binary digit
1 Nybble = 4 BITs
1 Byte = 8 BITs or 2 Nibbles

1 Nybble uniquely defines a single Hex digit.
Binary: Base 2 number system.
Octal: Base 8 number system.
Decimal: Base 10 number system.
Hexidecimal: Base 16 number system.

Practice session:

$377_8 = 255_{10}$ Prove it!

$7 \times 8_0 = 7 \times 1 = 7$
$7 \times 8_1 = 7 \times 8 = 56$
$3 \times 8_2 = 3 \times 64 = \underline{192}$
255_{10}

Now, Convert the following numbers to all other bases:

Binary	Octal	Decimal	Hexadecimal
			$03F8_{16}$
	221_8		
		1024_{10}	
11011011_2			
			22_{16}
	46_8		
		31_{10}	
11101110_2			
		512_{10}	

Rules: (X = any number)
1. X times 0 = 0
2. $X^0 = 1$
3. $X^1 = X$
4. X^2 = X times X
5. X^3 = X times X times X

Identifying Computer Components

Computer hardware is the physical part of a computer, including the digital circuitry, as distinguished from the computer software that executes within the hardware. The hardware of a computer is infrequently changed, in comparison with software and hardware data, which are "soft" in the sense that they are readily created, modified or erased on the computer. Firmware is a special type of software that rarely, if ever, needs to be changed and so is stored on hardware devices such as read-only memory (ROM) where it is not readily changed (and is, therefore, "firm" rather than just "soft").

Most computer hardware is not seen by normal users. It is in embedded systems in automobiles, microwave ovens, electrocardiograph machines, compact disc players, and other devices. Personal computers, the computer hardware familiar to most people, form only a small minority of computers (about 0.2% of all new computers produced in 2003).

Typical PC hardware

A typical personal computer consists of a case or chassis in a tower shape (desktop) and the following parts:

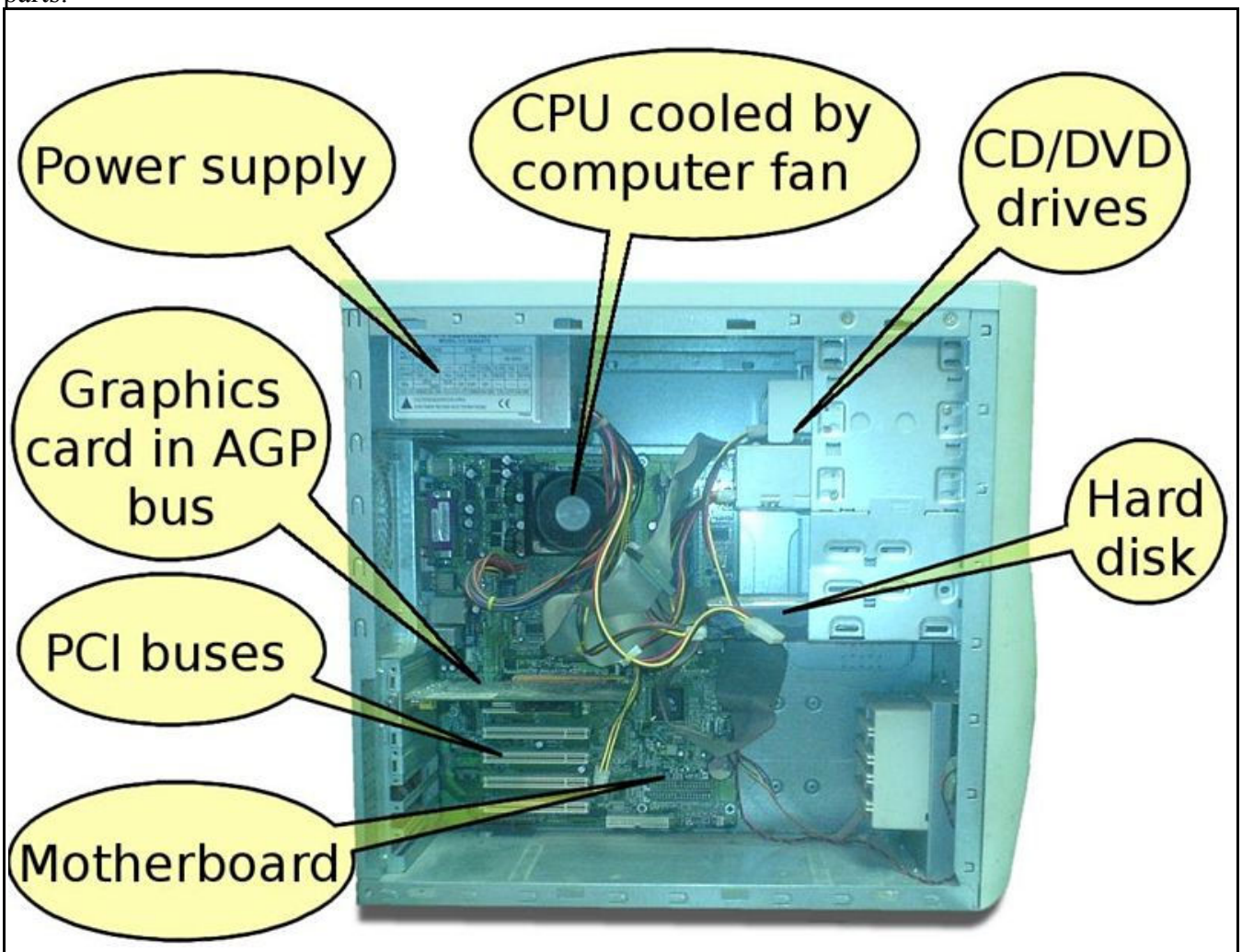


Illustration 10: Internals of a typical Personal Computer

Motherboard/Logicboard/Mainboard

- **Motherboard** - the "body" of the computer, through which all other components interface.
- **Central processing unit** (CPU) - Performs most of the calculations which enable a computer to function, sometimes referred to as the "brain" of the computer.
  - Computer fan - Used to lower the temperature of the computer; a fan is almost always attached to the CPU, and the computer case will generally have several fans to maintain a constant airflow. Liquid cooling can also be used to cool a computer, though it focuses more on individual parts rather than the overall temperature inside the chassis.
- **Random Access Memory** (RAM) - Fast-access memory that is cleared when the computer is powered-down. RAM attaches directly to the motherboard, and is used to store programs that are currently running.
- **Firmware** is loaded from the Read only memory ROM run from the Basic Input-Output System (BIOS) or in newer systems Extensible Firmware Interface (EFI) compliant.
- **Internal Buses** - Connections to various internal components.
  - PCI
  - PCI-E
  - USB
  - HyperTransport
  - CSI (expected in 2008)
  - AGP (being phased out)
  - VLB (outdated)
- **External Bus Controllers** - used to connect to external peripherals, such as printers and input devices. These ports may also be based upon expansion cards, attached to the internal buses.
  - Parallel port (outdated)
  - Serial port (outdated)
  - USB
  - Firewire
  - SCSI (On Servers and older machines)
  - PS/2 (For mice and keyboards, being phased out and replaced by USB.)
  - ISA (outdated)
  - EISA (outdated)
  - MCA (outdated)

Power supply

A case that holds a transformer, voltage control, and (usually) a cooling fan, and supplies power to run the rest of the computer, the most common types of power supplies are AT and BabyAT (old) but the standard for current PC's are ATX and micro ATX. smps (Switch Mode Power Supply)

Storage controllers

Controllers for hard disk, CD-ROM and other drives like internal Zip and Jaz conventionally for a PC are IDE/ATA; the controllers sit directly on the motherboard (on-board) or on expansion cards, such as a Disk array controller. IDE is usually integrated, unlike SCSI which is found in most servers. The Floppy drive interface is a legacy MFM interface which is now slowly disappearing. All these interfaces are gradually being phased out to be replaced by SATA (Serial AT Attachment) and SAS.

Video display controller

Produces the output for the visual display unit. This will either be built into the motherboard or attached in its own separate slot (PCI, PCI-E, PCI-E 2.0, or AGP), in the form of a Graphics Card.

Removable media devices

- CD - the most common type of removable media, inexpensive but has a short life-span.
  - CD-ROM Drive - a device used for reading data from a CD.
  - CD Writer - a device used for both reading and writing data to and from a CD.
- DVD - a popular type of removable media that has the same dimensions as a CD but stores up to 6 times as much information. It is the most common way of transferring digital video.
  - DVD-ROM Drive - a device used for reading data from a DVD.
  - DVD Writer - a device used for both reading and writing data to and from a DVD.
  - DVD-RAM Drive - a device used for rapid writing and reading of data from a special type of DVD.
- Blu-ray - a high-density optical disc format for the storage of digital information, including high-definition video.
  - BD-ROM Drive - a device used for reading data from a Blu-ray disc.
  - BD Writer - a device used for both reading and writing data to and from a Blu-ray disc.
- HD DVD - a high-density optical disc format and successor to the standard DVD. It was a discontinued competitor to the Blu-ray format.
- Floppy disk - an outdated storage device consisting of a thin disk of a flexible magnetic storage medium.
- Zip drive - an outdated medium-capacity removable disk storage system, first introduced by Iomega in 1994.
- SuperDisk - an outdated storage device also known as the LS-120 and the later variant LS-240, the SuperDisk was introduced by 3M's storage products group (later known as Imation) circa 1997 as a high-speed, high-capacity alternative to the 90 mm (3.5 in), 1.44 MB floppy disk. SuperDisk's main claim to fame was that in addition to being able to read and write its native 120 MB (later 240 MB) disks, the drives could read and write the 1.44 MB and 720 KB floppy formats that were still popular at the time. They also seemed to read and write faster to these sorts of disks than conventional 1.44 MB or 720 KB floppy drives. The newer LS-240 drives also have the ability to read and write regular 1.44 MB floppies at much higher densities.
- USB flash drive - a flash memory data storage device integrated with a USB interface, typically small, lightweight, removable and rewritable.
- Tape drive - a device that reads and writes data on a magnetic tape, usually used for long term storage.

Internal storage

Hardware that keeps data inside the computer for later use and remains persistent even when the computer has no power.

- Hard disk - for medium-term storage of data.
- Solid-state drive - a device similar to hard disk, but containing no moving parts.
- Disk array controller - a device to manage several hard disks, to achieve performance or reliability improvement.

Sound card

Enables the computer to output sound to audio devices, as well as accept input from a microphone. Most modern computers have sound cards built-in to the motherboard, though it is common for a user to install a separate sound card as an upgrade.

For more information, see the Wikipedia page at **http://en.wikipedia.org/wiki/Computer_hardware**

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Basic Electronics

Embedded in the fundamentals of computer troubleshooting, repair, and maintenance is a knowledge and understanding of electricity, electronics, and number systems. You need to have a basic knowledge of electricity and electronic principles to even begin preparing yourself for the A+ Certification exams. Although no specific electronics or electricity questions are on the test, many questions assume a basic understanding of electricity concepts and terminology and the function of a few electronic components. Even if you know enough about electricity to repair a PC without destroying either the equipment or yourself, you may need a refresher on the names, definitions, concepts, and applications of electricity and electronics.

> Note that binary and hexadecimal number systems are used in the PC for addressing and data display. You may be asked to convert a binary number or two on the exam, and you can count on seeing binary and hexadecimal references in several questions.

Understanding electricity

Everything inside or attached to the PC system unit runs on electricity. Electricity is both the lifeblood and the mysterious evil of the personal computer. It's a flowing entity, measured in amps, ohms, and volts that should be approached with respect, if not outright fear.

Nothing helps you understand a complex technical topic better than a real-life analogy that you can relate to. Electricity flowing through a circuit is very much like water running through a hose. When you open a water faucet, the pressure in the water line forces the water to flow at some gallons-per-minute rate into the hose. Friction reduces the force and rate of the water before it exits the hose. When electricity flows into a wire from a source such as a battery, some of its pressure is lost to resistance in the wire.

The "electricity is like water in a hose" analogy points out the forces of electricity that can be measured. These forces are measured in volts, amps, and ohms. At the risk of running the analogy into the ground, Table 1 lists the water hose analogous element against its electrical equivalent.

Table 1: Water versus Electrical Forces

Water Forces	Electrical Forces
How much pressure?	What's the voltage?
How much water is flowing?	What's the volume of the electrical current in amps?
Is there any friction in the hose?	What's the wire's resistance in ohms?

Table 2 may put this analogy into a little better perspective. The electrical measures are listed with a description and an example of how they're applied on the PC.

Counting electrons

The forces of electricity inside the computer can be measured, and each type of measurement tells you something different about the computer. The electrical measurements in Table 2 provide you with an introduction to these units of measurement.

Table 2: Common Electrical Measurements

Measurement	Description	Application
Amps	Measures a current's strength or rate of flow	The amount of current needed to operate a device; for example, a hard-disk drive needs 2.0 amps to start up, but only 0.35 amps for typical operation.
Ohms	Measures a conductor's resistance to electricity	Resistance of less than 20 ohms means that current can flow through a computer system.
Volts	Measures the electrical pressure in a circuit	A PC power supply generates four levels of voltage: +5 volts (V), –5V, +12V, and –12V.
Watts	Measures the electrical power in a circuit	A PC power supply is rated in a range of 200 to 600 watts.
Continuity	Indicates the existence of a complete circuit	One of the pins in a DIN connector registers 5V on a digital voltage meter (DVM or multimeter) when grounded to another pin.

Measuring the current

The primary measurements of electricity are volts and amps. Volts measure pressure, and amps measure current. Current isn't needed to have voltage. When a water faucet is off, water pressure still exists. There is just no current. Likewise, when an electrical circuit is open, voltage (pressure) is still in the line although no current is flowing. If you touch the wire and close the circuit, the current begins to flow, and you can feel all of its pressure as a shock.

You can use a variety of devices to read the power and fury of an electrical current. Ammeters, ohmmeters, and voltmeters measure specific properties, but using a multimeter or DVM is more efficient for you to use because it combines these instruments into one tool.

Switching from AC to DC

Current is the flow of electrons in a wire. Electricity has two current types: AC (alternating current) and DC (direct current). AC is what you get from the outlets in your house or office, and DC is the type used inside the computer.

In alternating current, the current changes directions about 60 times per second, moving first one-way, and then the other. The voltage changing rapidly from a positive charge to a negative charge causes the

current to also switch the direction of its flow in the wire. AC power exists because it has advantages for the power company and for your household electrical appliances, but these advantages have little value on a low-voltage system like a PC.

When the flow of the electricity is in one direction only, it is direct current. What happens in direct current is that negatively charged particles seek out and flow toward positively charged particles, creating a direct electrical current flow. DC power maintains a constant level and flows in only one direction — always, predictably, and measurably, from a negative charge to a positive charge.

For example, wire a light bulb to a battery, and the current flows from the negative terminal to the positive terminal through the light bulb. Because the current of electricity causes heat and light in the right materials, the lighter materials in the light bulb glow.

The PC uses DC power. The PC's power supply converts power from the AC wall outlet into DC power for the computer. Peripheral devices, such as printers, external modems, and storage drives, including CD-ROM and Zip drives, use an AC power converter to convert AC power into DC power.

Okay, so the computer runs on direct current electricity. What does this fact have to do with the A+ exam?

When answering a question about the power supply, you must know what 3.3V, –5V, +5V, –12V, and +12V represent (3.3 volts, minus 5 volts, plus 5 volts, minus 12 volts, and plus 12 volts, which are DC power levels produced by the power supply).

Focus on the following electrical terms or concepts:

A. Voltage and volts
B. Amperes or amps
C. Electrical resistance
D. Ohms
E. Watts
F. Alternating current
G. Direct current
H. 5 or 12 volts DC current

Power Supply Unit:

- Field Replaceable Unit (FRU) - never service.
- AC - coming from wall.
- DC - PSU changes from AC to DC and lowers the voltage.

Type	Measured in	Symbol	Formula
Power	Watts/Wattage	P	I*E
Volts	Volts/Voltage	E or V	I*R
Current	Amps/Amperes	I	E/R
Resistance	Ohms	R	E/I

- If R is constant - as E increases, so do P and I
- If V is constant - as R increases, I and P decrease, and vice-versa.
- Good circuit = 0 ohms; blown fuse will read about 1 ohm.

Full Wave Bridge Rectifier

A diode bridge or bridge rectifier is an arrangement of four diodes connected in a bridge circuit, that provides the same polarity of output voltage for any polarity of the input voltage. When used in its most common application, for conversion of alternating current (AC) input into direct current (DC) output, it is known as a bridge rectifier. The bridge rectifier provides full wave rectification from a two wire AC input (saving the cost of a center tapped transformer) but has two diode drops rather than one reducing efficiency over a center tap based design for the same output voltage.

The essential feature of this arrangement is that for both polarities of the voltage at the bridge input, the polarity of the output is constant. The following description uses hole flow rather than electron flow. Electron flow would show the arrows in the opposite directions.

Basic Operation

When the input connected at the left corner of the diamond is positive with respect to the one connected at the right hand corner, current flows to the right along the upper colored path to the output, and returns to the input supply via the lower one.

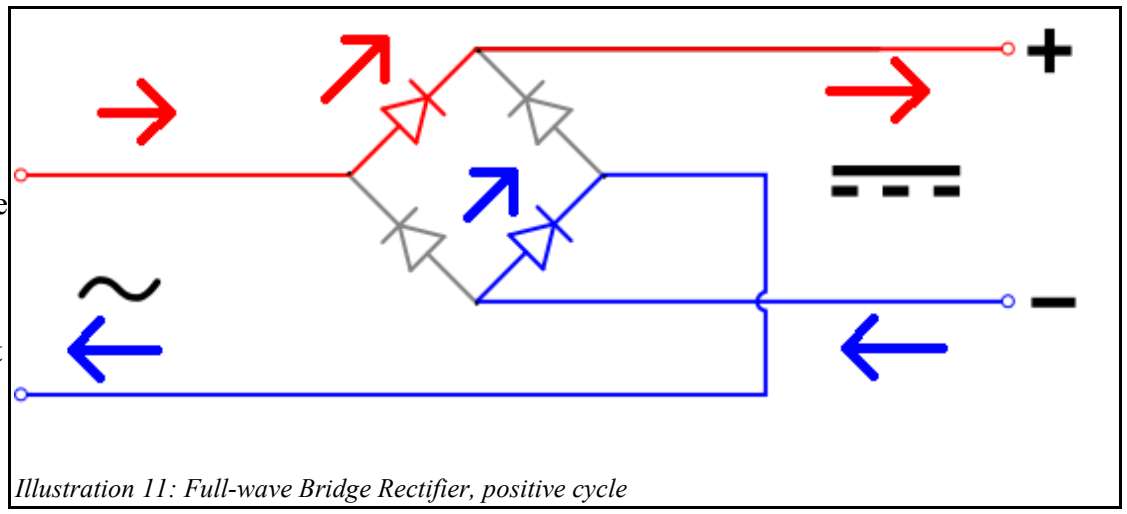

Illustration 11: Full-wave Bridge Rectifier, positive cycle

When the right hand corner is positive relative to the left hand corner, current flows along the upper colored path and returns to the supply via the lower colored path.

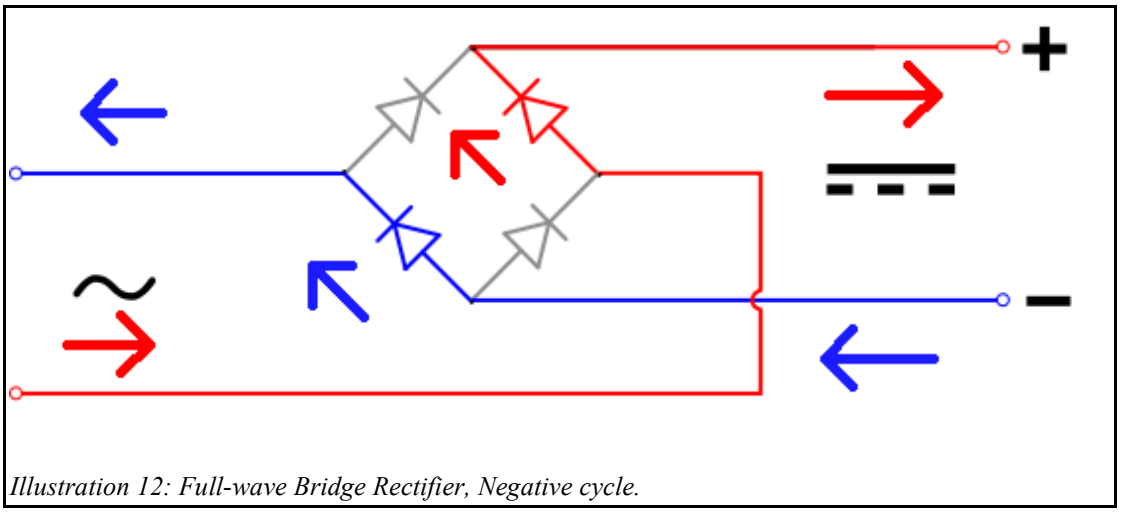

Illustration 12: Full-wave Bridge Rectifier, Negative cycle.

In each case, the upper right output remains positive with respect to the lower right one. Since this is true whether the input is AC or DC, this circuit not only produces DC power when supplied with AC power: it also can provide what is sometimes called "reverse polarity protection". That is, it permits normal functioning when batteries are installed backwards or DC input-power supply wiring "has its

wires crossed" (and protects the circuitry it powers against damage that might occur without this circuit in place).

Prior to availability of integrated electronics, such a bridge rectifier was always constructed from discrete components. Since about 1950, a single four-terminal component containing the four diodes connected in the bridge configuration became a standard commercial component and is now available with various voltage and current ratings.

Output smoothing

For many applications, especially with single phase AC where the full-wave bridge serves to convert an AC input into a DC output, the addition of a capacitor may be important because the bridge alone supplies an output voltage of fixed polarity but pulsating magnitude (see diagram to the right).

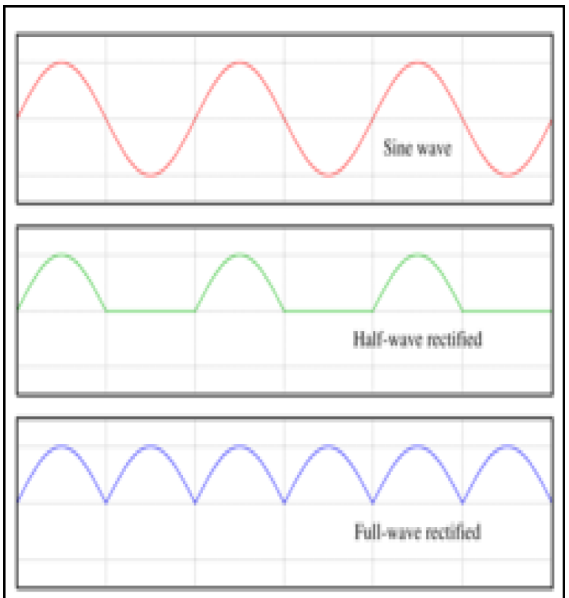

Illustration 13: Rectified waveforms.

The function of this capacitor, known as a 'smoothing capacitor' (see also filter capacitor) is to lessen the variation in (or 'smooth') the raw output voltage waveform from the bridge. One explanation of 'smoothing' is that the capacitor provides a low impedance path to the AC component of the output, reducing the AC voltage across, and AC current through, the resistive load. In less technical terms, any drop in the output voltage and current of the bridge tends to be cancelled by loss of charge in the capacitor. This charge flows out as additional current through the load. Thus the change of load current and voltage is reduced relative to what would occur without the capacitor. Increases of voltage correspondingly store excess charge in the capacitor, thus moderating the change in output voltage / current. Also see rectifier output smoothing.

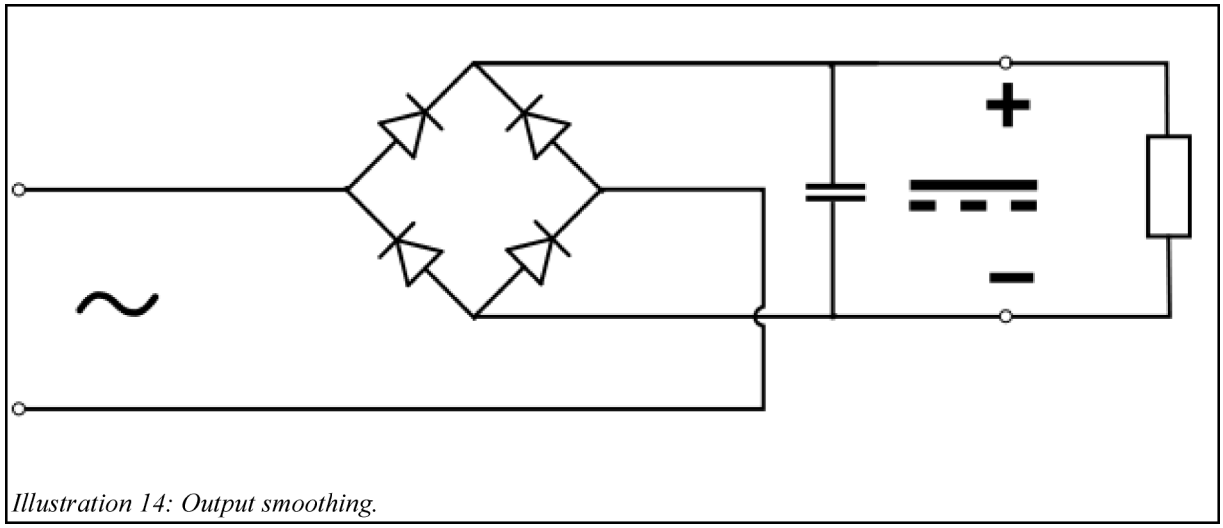
Illustration 14: Output smoothing.

The simplified circuit shown has a well deserved reputation for being dangerous, because, in some applications, **the capacitor can retain a lethal charge after the AC power source is removed**. A practical circuit should always include an assured way to safely discharge the capacitor. If the normal load can not be guaranteed to perform this function, perhaps because it can be disconnected, the circuit should include a so-called bleeder resistor connected as close as practical across the capacitor. Because a bleeder sets a minimum current drain, the regulation of the circuit, defined as percentage voltage change from minimum to maximum load, is improved.

The capacitor and the load resistance have a typical time constant $\tau = RC$ where C and R are the capacitance and load resistance respectively. As long as the load resistor is large enough so that this time

constant is much longer than the time of one ripple cycle, the above configuration will produce a well smoothed DC voltage across the load resistance. In some designs, a series resistor at the load side of the capacitor is added. The smoothing can then be improved by adding additional stages of capacitor–resistor pairs, often done only for sub-supplies to critical high-gain circuits that tend to be sensitive to supply voltage noise.

The idealized waveforms shown above are seen for both voltage and current when the load on the bridge is resistive. When the load includes a smoothing capacitor, both the voltage and the current waveforms will be greatly changed. While the voltage is smoothed, as described above, current will flow through the bridge only during the time when the input voltage is greater than the capacitor voltage. For example, if the load draws an average current of n Amps, and the diodes conduct for 10% of the time, the average diode current during conduction must be 10n Amps. This non-sinusoidal current leads to harmonic distortion and a poor power factor in the AC supply.

In a practical circuit, when a capacitor is directly connected to the output of a bridge, the bridge diodes must be sized to withstand the current surge that occurs when the power is turned on at the peak of the AC voltage and the capacitor is fully discharged. Sometimes a small series resistor is included before the capacitor to limit this current.

Output can also be smoothed using a choke, a coil of conductor enclosed by an iron frame (similar to a transformer in construction). This tends to keep the current (rather than the voltage) constant. Due to the relatively high cost of an effective choke compared to a resistor and capacitor this is not employed in modern equipment. Some early console radios created the speaker's constant field with the current from the high voltage ("B +") power supply, which was then routed to the consuming circuits, rather than using a permanent magnet to create the speaker's constant magnetic field. The speaker field coil thus acted as a choke.

For more information, see the Wikipedia page at **http://en.wikipedia.org/wiki/Diode_bridge**

Normally the ac input is actually the output of a transformer as shown here.

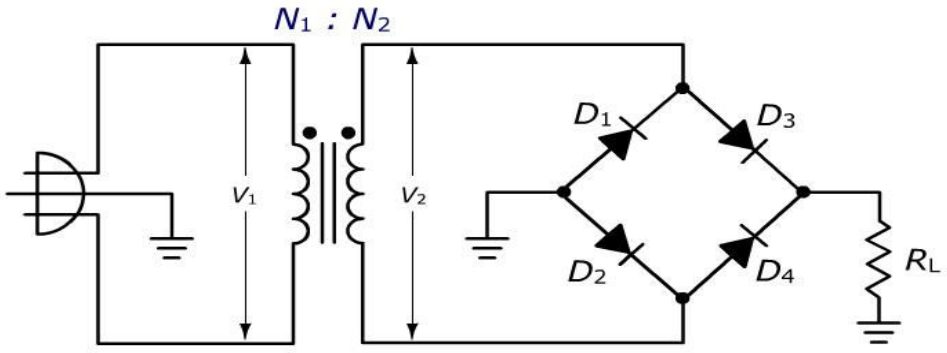

Illustration 15: Transformer used for input to Bridge Circuit.

Motherboard power connector(s):

One of the following will be found:
AT -Two smaller connectors labeled P8 and P9 *(2 black wires go together)*. Supplies +/-12V and +/-5V. The fan pulls air from inside the computer and blows it out through the fan leading to dust buildup on internal components. Should be plugged in while working on inside of case to provide the best ground. Can leave plugged in while servicing. No power to the motherboard.

ATX - A single, keyed connector. Supplies +/-12V, +/-5V, and +3.3V. The fan sucks air into the case thereby semi-pressurizing the case, which helps to keep the internal components cleaner. There are also additional voltage and power lines used to signal and control the power supply. It is turned on and off electronically, not with a power switch. Should be unplugged because the power supply applies power to the motherboard even when turned off. It must be unplugged while servicing. Power is still applied to the motherboard even if the PC is turned off.

Connectors:
Molex - standard peripheral connector for powering internal hard drives, CD-ROM drives, and DVD drives. *Used for devices that need more power.*

Berg - a small, flat connector typically used for powering floppy drives and internal Zip and SuperDisk drives. *Used in devices that need less power.*

Color or component	Voltage
Yellow wire	+12
Blue wire	-12
Red wire	+5
Purple wire	+5VSB
White wire	-5
Orange wire	+3.3VDC
Brown wire	+3.3VDC default Sense
Grey wire	PWR_OK
Motor	+/-12
Circuitry	+/-5

Misc.
- ESD (electrostatic discharge) can destroy circuits, memory, processors, and transistors.
  - ESD is very high in dry non-humid environments.
  - Don't wear ESD wrist strap when working on CRT monitor.
- You should use an (UPS) uninterruptable power supply, it protects against power interruptions (brownouts and failures), overvoltages (spikes), and undervoltages (sags).
- Be aware of EMI (electromagnetic interference) and RFI (Radio Frequency Interference).
  - These cause spikes that exceed the computer's capability.
  - Use a line conditioner to control against EMI and RFI (not blackouts).
- To protect against damage from lightning-disconnect all external cables.

Tools

Use this page to create an inventory of the tool pouch and explain what each tool is and for what it is used.

Motherboard

A motherboard is the central or primary circuit board (PCB) making up a complex electronic system, such as a modern computer. It is also known as a mainboard, baseboard, system board, planar board, or, on Apple computers, a logic board, and is sometimes abbreviated as mobo.

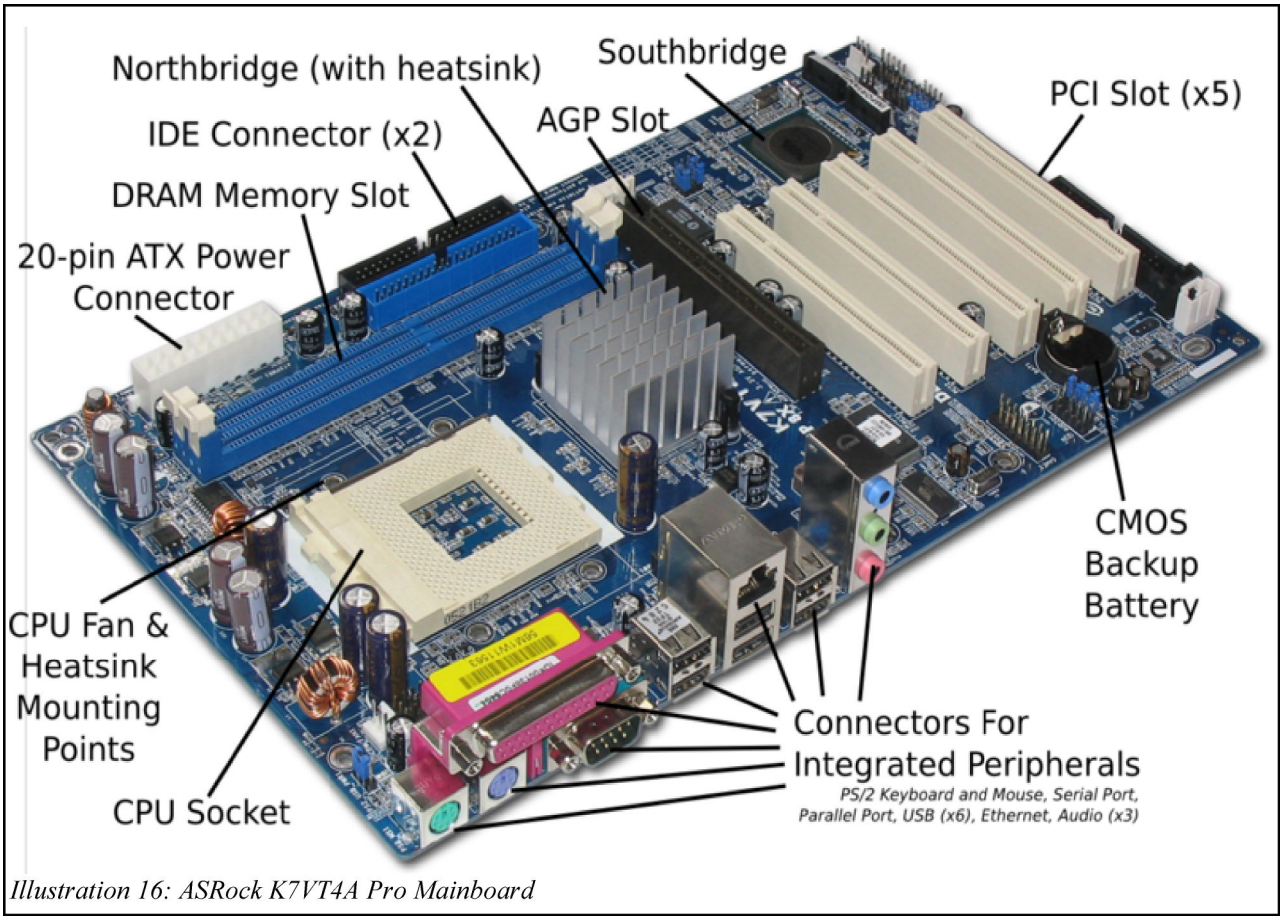

Illustration 16: ASRock K7VT4A Pro Mainboard

Most motherboards produced today are designed for so-called IBM-compatible computers, which held over 96% of the global personal computer market in 2005.

A motherboard, like a backplane, provides the electrical connections by which the other components of the system communicate, but unlike a backplane also contains the central processing unit and other subsystems such as real time clock, and some peripheral interfaces.

A typical desktop computer is built with the microprocessor, main memory, and other essential components on the motherboard. Other components such as external storage, controllers for video display and sound, and peripheral devices are typically attached to the motherboard via edge connectors and cables, although in modern computers it is increasingly common to integrate these "peripherals" into the motherboard.

Components and functions

The motherboard of a typical desktop consists of a large printed circuit board. It holds electronic components and interconnects, as well as physical connectors (sockets, slots, and headers) into which other computer components may be inserted or attached.

Most motherboards include, at a minimum:

- Sockets (or slots) in which one or more microprocessors (CPUs) are installed.
- Slots into which the system's main memory is installed (typically in the form of DIMM modules containing DRAM chips).
- A chipset which forms an interface between the CPU's front-side bus, main memory, and peripheral buses.
- Non-volatile memory chips (usually Flash ROM in modern motherboards) containing the system's firmware or BIOS.
- A clock generator which produces the system clock signal to synchronize the various components.
- Slots for expansion cards (these interface to the system via the buses supported by the chipset).
- Power connectors and circuits, which receive electrical power from the computer power supply and distribute it to the CPU, chipset, main memory, and expansion cards..

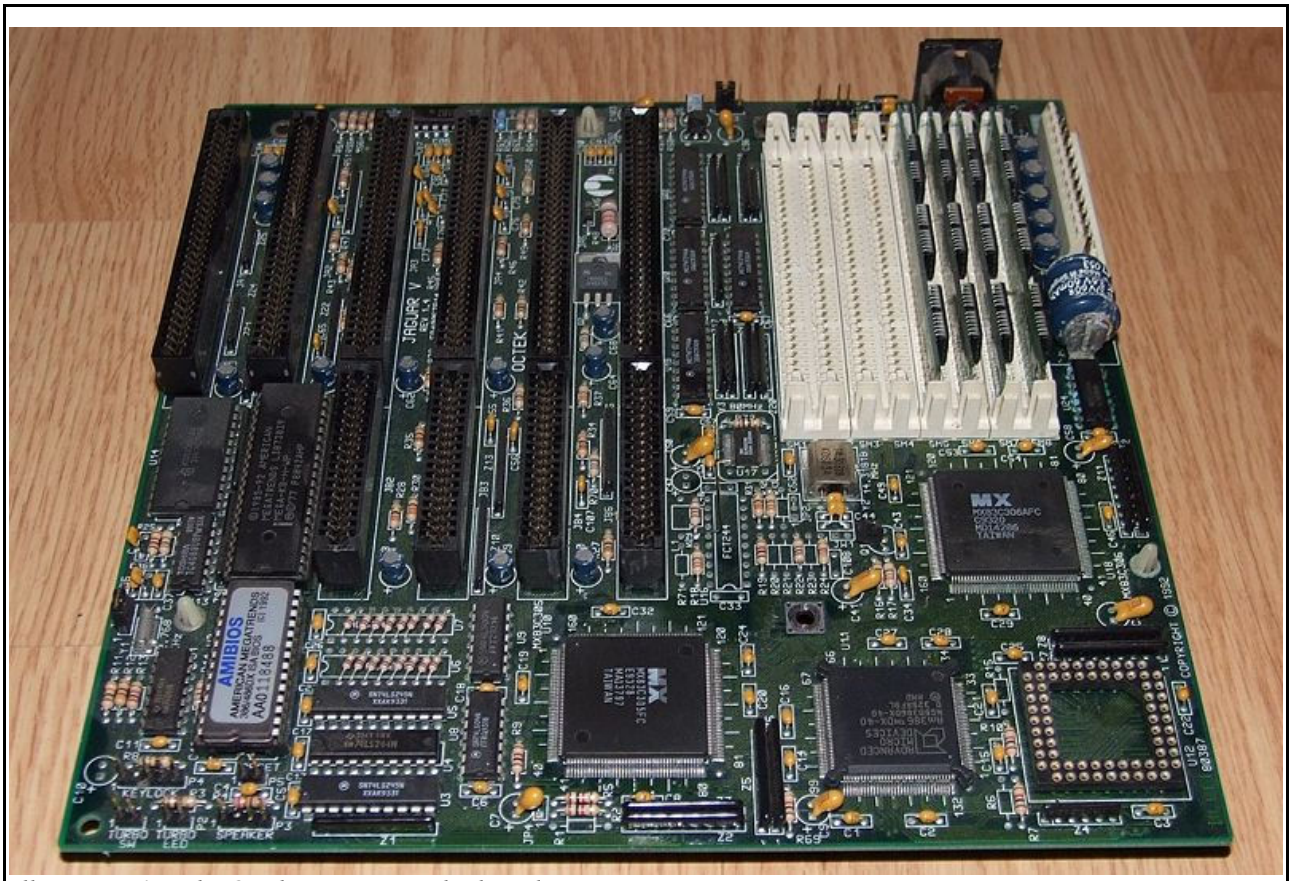

Illustration 17: The Octek Jaguar V motherboard.

The Octek Jaguar V motherboard shown above is from 1993. This board has 6 ISA slots but few onboard peripherals, as evidenced by the lack of external connectors.

Additionally, nearly all motherboards include logic circuitry and connectors to support commonly-used input devices, such as PS/2 connectors for a mouse and keyboard. Early personal computers such as the Apple II or IBM PC included only this minimal peripheral support on the motherboard. Occasionally

video interface hardware was also integrated into the motherboard; for example on the Apple II, and rarely on IBM-compatible computers such as the IBM PC Jr. Additional peripherals such as disk controllers and serial ports were provided as expansion cards.

Given the high thermal design power of high-speed computer CPUs and components, modern motherboards nearly always include heatsinks and mounting points for fans to dissipate excess heat.

Motherboard Form Factors

PCXT - 1st motherboard. It had no 16-bit slots.

AT - A motherboard patterned after the original IBM AT motherboard. It only has a single on-board connector, the 5-pin DIN keyboard connector, uses CMOS for configuration, and early versions only used DIP memory chips and DIP CPUs and co-processors. Later versions might be configured with any or all of the following: ISA (16 bit)/EISA (32 bit) slots, PCI slots, AGP slot, PGA CPU socket, AT and/or ATX power connector, I/O connectors, SDRAM slots, SIMM slots, and DIMM slots. Any ports are on the motherboard but must be connected internally, using the proper cables, to either internal devices or to connectors attached to the card-edge connectors. Usually 12" x 13.8"

Baby AT - A smaller version of the AT motherboard used in clone machines. These boards can be found in a wide variety of configurations just as with the AT motherboards. Since they are smaller they do not have as many expansion slots as a full sized board would have.

LPX (low profile or slimline) - Developed about the same time as the Baby AT boards, the LPX uses a riser card to install expansion cards into so the case could be lower than the expansion cards. Also uses the PS/2 style keyboard connector instead of the 5-pin DIN connector. The LPX and mini-LPX were developed for use in the Slimline and low-profile desktop cases. (Video, parallel, and 2 serial ports are at the rear of the board).

NLX - Replacement for the LPX board designed around the Pentium II processor. IT supports DIMM and AGP technology.

ATX - Smaller like the Baby AT board, but installed with a 90-degree rotation. This motherboard allows for easier installation of full-length expansion cards and cables because the CPU is positioned out of the path of long expansion cards and is easier to cool. It is also extremely easy to identify even when the case is on the computer. It is the only board, so far, that has most of the basic peripheral connectors attached to the motherboard at the board edge. On the board edge you will find:

- PS/2 keyboard and mouse (6-pin mini din),
- At least 1 (possibly 2) serial DB-9,
- A Parallel DB-25,
- Sometimes even a pair of USB connectors, and
- Sound card I/O.

Other ATX features:

- Power supply to motherboard w/ 1 keyed 20-pin connector.
- CPU is closer to cooling fan on PSU.
- I/O ports are integrated into motherboard.

Integrated peripherals

With the steadily declining costs and size of integrated circuits, it is now possible to include support for many peripherals on the motherboard. By combining many functions on one PCB, the physical size and total cost of the system may be reduced; highly-integrated motherboards are thus especially popular in small form factor and budget computers.

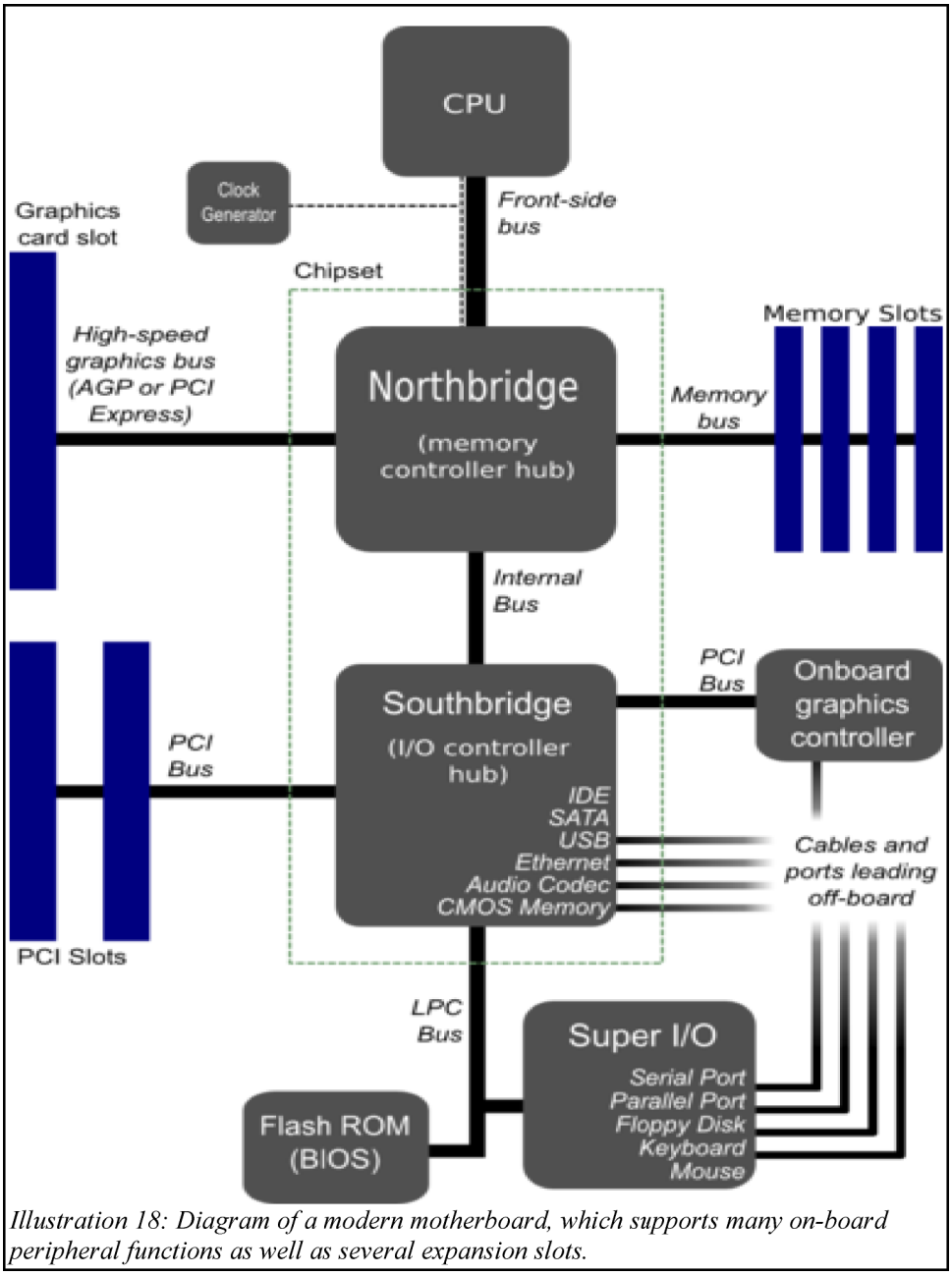

Illustration 18: Diagram of a modern motherboard, which supports many on-board peripheral functions as well as several expansion slots.

For example, the ECS RS485M-M, a typical modern budget motherboard for computers based on AMD processors, has on-board support for a very large range of peripherals: disk controllers for a floppy disk drive, up to 2 PATA drives, and up to 6 SATA drives (including RAID 0/1 support)

- integrated ATI Radeon graphics controller supporting 2D and 3D graphics, with VGA and TV output
- integrated sound card supporting 8-channel (7.1) audio and S/PDIF output
- fast Ethernet network controller for 10/100 Mbit networking
- USB 2.0 controller supporting up to 12 USB ports
- IrDA controller for infrared data communication (e.g. with an IrDA enabled Cellular Phone or Printer)
- temperature, voltage, and fan-speed sensors that allow software to monitor the health of computer components

Expansion cards to support all of these functions would have cost hundreds of dollars even a decade ago, however as of April 2007 such highly-integrated motherboards are available for as little as $30 in the USA.

For more information, see the Wikipedia page at **http://en.wikipedia.org/wiki/Motherboard**

Components of the motherboard

- BIOS - used to configure Hardware
- Processor slots - CPU installed here
- Memory slots-where system RAM is installed
- L2 Cache- where CPU stores frequently used data and instructions
- PCI slots- slots for 32 bit PCI cards
- ISA slots- slots for 16 bit ISA cards
- Keyboard connector- 5 pin DIN or PS/2 Port (6-pin mini DIN)
- Mouse connector- PS/2 port
- Serial Port- DB9 or DB25 male (D-shaped connector)
- Parallel Port- DB25 female connector
- USB Port- peripheral designed to be PnP and to eliminate Expansion cards
- Chipset- integrated circuit. Provides system board's core functionality
- AGP slot- video card adapter slot
- Power supply connector-connects power to system board
- Floppy drive connector-connects floppy drive to system
- EIDE connectors-connects fixed hard drives (IDE/EIDE) and removable drives (just EIDE) (i.e. CD-ROM) to the system board

Enclosure Styles:
Desktop, Full tower, Mid tower, Micro tower

CPU - brains of the PC. 3 parts:

1. Retrieves programmed instructions from PC's memory, decodes, and executes the instruction.
2. Arithmetic and Logic Unit (ALU).
3. Sends results back to rest of PC.

BIOS

BIOS (pronounced baious), in computing, stands for **Basic Input/Output System**.

BIOS refers to the firmware code run by an IBM PC when first powered on. The primary function of the BIOS is to identify and initiate component hardware (such as hard disk, floppy and optical disk drives). This is to prepare the machine so other software programs stored on various media can load, execute, and assume control of the PC. This process is known as booting, or booting up, which is short for bootstrapping.

BIOS can also be said to be a coded program embedded on a chip that recognizes and controls various devices that make up x86 personal computers. Among other classes of computers, the generic terms boot monitor, boot loader or boot ROM were commonly used. Some Sun and Macintosh PowerPC computers used Open Firmware for this purpose. There are a few proposed alternatives for Legacy BIOS in the x86 world: Extensible Firmware Interface, Open Firmware (used on the OLPC XO-1) and coreboot.

The term first appeared in the CP/M operating system, describing the part of CP/M loaded during boot time that interfaced directly with the hardware (CP/M machines usually had a simple boot loader in ROM, and nothing else). Most versions of DOS have a file called "IBMBIO.COM" or "IO.SYS" that is analogous to the CP/M disk BIOS.

The BIOS Chip and BIOS Recovery

Before 1990 or so BIOSes were held on ROM chips that could not be altered. As its complexity and need for updates grew, BIOS firmware was subsequently stored on EEPROM or flash memory devices. The first flash chips attached to the ISA bus. Starting in 1998, the BIOS flash moved to the LPC bus, a functional replacement for ISA, following a new standard implementation known as "firmware hub" (FWH). In 2006, the first systems supporting a Serial Peripheral Interface (SPI) appeared, and the BIOS flash moved again.

EEPROM chips are advantageous because they can be easily updated by the user; hardware manufacturers frequently issue BIOS updates to upgrade their products, improve compatibility and remove bugs. However, this advantage had the risk that an improperly executed or aborted BIOS update could render the computer or device unusable. To avoid these situations, more recent BIOSes use a "boot block"; a portion of the BIOS which runs first and can not be altered by updates. This code verifies if the rest of the BIOS is intact (using hash checksums or other methods), before transferring control to it. If the boot block detects any corruption in the main BIOS, it will typically warn the user that a recovery process must be initiated by booting from removable media (floppy, CD or USB memory) so the user can try flashing the BIOS again. Some motherboards have a backup BIOS (sometimes referred to as DualBIOS boards) to recover from BIOS corruptions. In 2007, Gigabyte began offering motherboards with a QuadBIOS recovery feature.

Due to the limitation on the number of times flash memory media can be flashed, a flash-based BIOS is vulnerable to "flash-burn" viruses that repeatedly write to the flash, permanently corrupting chip content. Such attacks can be prevented by some form of write-protection, the ultimate protection being the replacement of the flash memory with a true ROM.

The size of the BIOS, and the capacities of the ROM, EEPROM and other media it may be stored on, has increased over time as new features have been added to the code; BIOS versions now exist with sizes up to 8 megabytes.

The BIOS business

The vast majority of PC motherboard suppliers license a BIOS "core" and toolkit from a commercial third-party, known as an "independent BIOS vendor" or IBV. The motherboard manufacturer then customizes this BIOS to suit its own hardware. For this reason, updated BIOSes are normally obtained directly from the motherboard manufacturer.

Major BIOS vendors include American Megatrends (AMI), General Software, Insyde Software, and Phoenix Technologies (which bought Award Software International in 1998).

CMOS

CMOS (Complimentary Metal Oxide Semiconductor) is a special memory area with battery backup used to store system configuration and set up settings that the PC refers to every time it's turned on.

- You can write new information to CMOS.
- You can configure/store information about physical memory and new drives, etc. (usually automatically detected during POST).
- CMOS still has power when PSU is off due to the on-motherboard battery.
- If you remove the CMOS battery, the system goes back to system defaults.
- Settings stored in CMOS are:
  - Password-2 types:
    - System (User) password-allows user to access system
    - Set-up (Supervisor)-restricts access to CMOS set-up, can also set a User password and set User Setup to "View Only"
  - Drive order (boot sequence)-checked by POST
  - Memory-how much RAM is installed
  - Drive types and size
  - Display or monitor type
  - Hard Drive Space
  - Date/Time
  - Port settings

ROM BIOS

- Acts as an interface between hardware (CPU and chips) and the OS (DOS, Windows 95, etc.)
- Its function is to boot up the system
- ROM BIOS upgrade- in the past-replace chip; now-Flash ROM is re-programmed (need update for MMX-enabled CPU)
- Top reasons to upgrade BIOS:
  - Hardware problems,
  - Video card upgrade
- Boot Block-uneraseable part of flash ROM BIOS.

POST (Power On Self Test)

Detects interrupts, I/O address, or base memory address conflicts. The Power On Self Test will test the following areas of a computer in the indicated order.

1) Processor-if test fails, system halts w/o message.
2) BIOS ROM-check sum series are computed-if they don't match up, then system halts.
3) DMA Controller-system halts if failure.
4) Interrupt Controller-if fails-long beep and then short beep, system halts.
5) System Timing-if fails, system halts.
6) BASIC ROMs (if present).
7) Video card-if fail, long beep and then 2 short beeps, if successful then ROM BIOS are copied into RAM.
8) Expansion board initialization-if necessary, the exp. Board's ROM gets copied into upper memory.
9) RAM-counts and tests RAM by writing a bit to each memory bit.
10) Keyboard-presence of keyboard and any stuck keys.
11) Floppy drives-signal is sent to adapter to activate floppy drive motor.
12) Ports-parallel and serial ports are queried, system looks for an OS to load.
13) **System Software:** DOS, Windows 2000, Windows NT.
14) **Program Software:** Windows 95 (works on top of DOS).
15) **Application software:** Microsoft Works, Excel, games, e-mail, graphics, etc. Software allows you to do something.
16) **Driver Software:** Software that drives peripherals (CD-ROM drives, printer device drives).
17) **Firmware:** software that is stored in the ROM memory chips even when the power is off. Firmware is read into memory from the hard drive and instructs computer how to load OS.

Undocumented FDISK:

FDISK is a very powerful program. In DOS 5 and later, including Windows 9x/ME, Windows NT, and Windows 2000, it gained some additional abilities. Unfortunately, these capabilities were never documented in any of the Microsoft documentation for Windows or DOS. The most important parameter in FDISK is the **/MBR** (Master Boot Record) parameter, which causes FDISK to rewrite the Master Boot Record code area, leaving the partition table area intact.

The **/MBR** parameter is tailor-made for eliminating boot-sector virus programs that infect the Master Boot Record (cylinder 0, head 0, sector 1) of a hard disk. To use this feature, enter the following:

FDISK /MBR

FDISK then rewrites the boot record code, leaving the partition tables intact. This should not cause any problems on a normally functioning system, but just in case, you should back up the partition table information to floppy disk using a third-party product such as Norton Utilities.

Boot Sequence:

The BOOT process is a cycle that runs from the moment the power switch is turned on to the moment the DOS command prompt (C:\>) or the Windows Desktop appears. In order for this process to be a success, all hardware must be working. Below is a list of events the computer runs through during the BOOT process:

1) Power is turned on or the computer is restarted,
2) A surge of electricity wakes up the Central Processing Unit (CPU),
3) The CPU runs the Power On Self Test (POST) from the Basic Input Output System (BIOS),

4) POST then checks to see if the major hardware components are working. Once completed, you should hear one beep. If POST detected a problem, then it would give off a series of long and short beeps followed by an error message displayed on the screen (if the screen is working),
5) Next, the BIOS loads the operating system from an active partition or disk. During this step, the Operating System (OS) is loaded onto the computer.

6a). The loading of Disk Operating System (DOS) can be broken down into the following steps:

a) Scan drive A, then drive C to find the ready drive.
b) If drive C is selected, the Master Boot Record (MBR) is loaded. If drive A is selected, skip to step d).
c) The program in the MBR is executed and the bootable partition is located.
d) The DOS Boot Record (DBR) is loaded from the first sector of the DOS partition or from the first sector of the DOS bootable floppy.
e) Control is passed to the DBR.
f) DBR loads the hidden files (IO.SYS and MSDOS.SYS).
g) The first hidden file, IO.SYS, loads all other hidden files.
h) The first hidden file, IO.SYS, loads and interprets CONFIG.SYS, including device drivers.
i) The COMMAND.COM file is then loaded.
j) Finally, COMMAND.COM loads and executes the AUTOEXEC.BAT file.

6b). The loading of Windows 9x can be broken down into the following steps:

a) Power initialization – The motherboard chipset keeps the CPU off until the power supply stabilizes.
b) BIOS startup – The processor reads the jump address and starts the BIOS program.
c) POST (Power-On Self Test) – The BIOS checks the hardware system – any errors are signaled with error beep codes.
d) Video and peripheral BIOS – The video card and any other device BIOS execute.
e) System check – After displaying its startup screen, BIOS checks memory, storage drives, ports, and other devices – any errors are signaled with error messages on the screen.
f) Plug and Play (PnP) check – If BIOS supports this standard, it detects and configures any Plug and Play devices.
g) Summary screen – The BIOS displays a summary of the PC's configuration. On some systems, it displays long enough to read, but on many others it usually flashes by very quickly and is unreadable.
h) Boot device – The BIOS scans for the active boot device in the specified order as set in CMOS and looks for the master boot record (MBR) on drive c: or the volume boot sector (VBS) on any other defined device.
i) OpSys running – Control passes to the boot sector code and the operating system.
j) DOS Boot Record (DBR) loads the hidden files (IO.SYS and MSDOS.SYS).
k) The first hidden file, IO.SYS, loads all other hidden files.
l) The first hidden file, IO.SYS, loads and interprets CONFIG.SYS, including device drivers.
m) The COMMAND.COM file is then loaded.
n) Finally, COMMAND.COM loads and executes the AUTOEXEC.BAT file.
o) After the Autoexec.bat file executes, COMMAND.COM executes windows.

For more information, see the Wikipedia page at **http://en.wikipedia.org/wiki/BIOS**

Bus Structure

In computer architecture, a bus (bidirectional universal switch) is a subsystem that transfers data or power between computer components inside a computer or between computers, and a bus typically is controlled by device driver software. Unlike a point-to-point connection, a bus can logically connect several peripherals over the same set of wires. Each bus defines its set of connectors to physically plug devices, cards or cables together.

Early computer buses were literally parallel electrical buses with multiple connections, but the term is now used for any physical arrangement that provides the same logical function as a parallel electrical bus. Modern computer buses can use both parallel and bit-serial connections, and can be wired in either a multidrop (electrical parallel) or daisy chain topology, or connected by switched hubs, as in the case of USB.

First generation

Early computer buses were bundles of wire that attached memory and peripherals. They were named after electrical buses, or busbars. Almost always, there was one bus for memory, and another for peripherals, and these were accessed by separate instructions, with completely different timings and protocols.

One of the first complications was the use of interrupts. Early computers performed I/O by waiting in a loop for the peripheral to become ready. This was a waste of time for programs that had other tasks to do. Also, if the program attempted to perform those other tasks, it might take too long for the program to check again, resulting in loss of data. Engineers thus arranged for the peripherals to interrupt the CPU. The interrupts had to be prioritized, because the CPU can only execute code for one peripheral at a time, and some devices are more time-critical than others.

Second generation

"Second generation" bus systems like NuBus addressed some of these problems. They separated the computer into two "worlds", the CPU and memory on one side, and the various devices on the other, with a bus controller in between. This allowed the CPU to increase in speed without affecting the bus. This also moved much of the burden for moving the data out of the CPU and into the cards and controller, so devices on the bus could talk to each other with no CPU intervention. This led to much better "real world" performance, but also required the cards to be much more complex. These buses also often addressed speed issues by being "bigger" in terms of the size of the data path, moving from 8-bit parallel buses in the first generation, to 16 or 32-bit in the second, as well as adding software setup (now standardized as Plug-n-play) to supplant or replace the jumpers.

Third generation

"Third generation" buses are now in the process of coming to market, including HyperTransport and InfiniBand. They also tend to be very flexible in terms of their physical connections, allowing them to be used both as internal buses, as well as connecting different machines together. This can lead to complex problems when trying to service different requests, so much of the work on these systems concerns software design, as opposed to the hardware itself. In general, these third generation buses tend to look more like a network than the original concept of a bus, with a higher protocol overhead needed than early systems, while also allowing multiple devices to use the bus at once.

Buses such as Wishbone have been developed by the open source hardware movement in an attempt to

further remove legal/patenting constraints from computer design.

Expansion buses or Slots

Interacting w/ the host system - a device gains the attention of the host CPU and then transfers data.

Techniques of interacting

1. **Interrupts** - signals CPU that the adapter card, system hardware, or application software needs attention There are 3 types of interrupts:
   a) Hardware interrupt-system hardware (keyboard, system clock) and from adapter cards. Each adapter has its own IRQ (Interrupt ReQuest) number.
   b) Exception interrupt-used mainly by CPU itself to handle error conditions
   c) Software interrupts-sent by application that is running on PC
2. **I/O addresses** - after interrupt is established, the adapter communicates with host by I/O addresses (Base I/O address, I/O port). Each adapter has its own non-overlapping I/O address which is a range of conventional memory from 4-32 bits.
3. **Base Memory Addresses** - memory address of any memory on an adapter card. Ranges from 640KB-1MB in the upper memory bank (UMB) on the host computer. Each adapter card must have a unique BMA and operate in the same mode (8 bit or 16 bit) (can't have an 8 bit sound card and a 16 bit video card together).
4. **Direct Memory Access (DMA)** - DMA controller is on a chip set and relieves the CPU of responsibility of transferring data between adapter and system memory. Each adapter needs a unique DMA channel to communicate w/ the DMA controller.

Interface - place on PC where other devices (disk drives, modems, keyboard, mouse, etc.) are connected. 2 types: 1. Built in, or 2. Interface card (adapter card)-card that is inserted into a slot that connects to CPU.

Buses - collection of wires that make the connection and the rules that describe how data should flow through the wires.

- Buses specify the placement of connections, the electric signals that are allowable on each computer, and what those signals mean.
- Configured with
  1. jumpers,
  2. switches,
  3. software (setup software communicates w/ special circuitry on the adapter card via pulsed signals. After settings are configured (IRQ, DMA), they are stored in EEPROM on the card), or
  4. PnP - configure set up by OS's. BIOS need to support PnP in order to use PnP. PnP OS's – Windows 95, 98, and NT(sort of), Win2k, WinXP, Windows Vista.

- 8-bit bus - Not many (if any) left. Will only support single slot cards using an 8-bit data bus, 8 interrupts, and 4 DMA channels. **Should not be on the exam!** Presented here just to be complete.

ISA (Industry Standard Architecture) – operates at 8 Mhz, 16-bit data bus, uses a double slot connector (has 1 notch). The additional connector added 8 more IRQ lines and 4 more DMA lines. Cards using the slots usually used jumpers or DIP switches to set things like IRQ, memory I/O ranges, and DMA numbers. ISA also separated the bus clock from the CPU clock to allow the slower data bus to operate at its own speed. ISA slots are found on anything from 286 systems up through and including some of the earlier Pentium systems. ISA buses communicate w/ the host

system in 2 steps: 1. They signal that they are @ ready to transfer data and then 2. They transfer data 1 byte at a time. The process is repeated until all data is sent. ISA is not a good choice for a server. It has limited transfer rate and memory limits.

EISA (Extended Industry Standard Architecture) – 32-bit bus but operates at only 8-*10* MHz to be backward compatible with the 16-bit ISA bus that it also uses. More notches than ISA. Offers 3 additional modes of transfer: 1. Burst mode - uses 1 signal for transfer of more than 1 byte of data, 2. Streaming mode - transfers a block of data at up to 40 Mbps, and 3. Multiplexed streaming mode - transfer data up to 64 Mbps.

- EISA is more suitable for servers than clients PC. Configurations are saved in CMOS on a (SCI-System Configuration Information File) and also in on-board ROM.

- EISA allows for bus mastering-1 adapter takes control and bypasses the CPU (if an expansion card has its own built-in processor, it can operate independently from the CPU. A bus-mastering board can control the bus and act as if it were the entire system, which allows for very fast throughput).

MCA (Micro Channel Architecture) – introduced with the IBM PS/2, it was the first 32-bit option and featured bus mastering and a 10 MHz bus clock for expansion cards. Uses an asynchronous bus-does not depend on the system timing.

VLB (VESA or Video Local Bus) – first used on 486 systems and used to place a port directly on the system bus or a processor direct slot. The only difference between this and EISA is the fact that it is directly on the system bus and can run at the speed of the CPU. They are mostly proprietary and support only expansion cards from the PC's manufacturer. Tied to the 486 chip set, limited to an actual speed of about 33 MHz, and very sensitive to electrical fluctuations. Usually limited to a maximum of three per motherboard. VESA = Video Electronics Standards Association.

PCI (Peripheral Component Interconnect) – introduced with the Pentium processor, it supports either a 32 or 64-bit bus, which allows it to be used with both 486 and Pentium processors. *Creates a high speed data path between the peripheral and the CPU.*

AGP (Advanced Graphics Port/Processor) – Similar to the PCI slot but it is located on the system RAM bus and is designed specifically for video cards only. There will only be one per system. *Speeds up 3-D graphics.*

USB (Universal Serial Bus) – *newest.* Designed to provide PnP capability to peripherals from outside the case. New peripherals can be "hot-swapped" without installing interface cards or even turning off the system. Can chain up to 127 serial peripherals to one central hub. Carries power supply as well. Cables should be 5 meters or less in length, supports up to 127 devices.

Firewire – Will replace SCSI technology because devices do not have to be terminated or assigned ID numbers. Can chain up to 63 devices and uses a 6 prong connector. *Firewire has an internal (backplane bus) with speeds of 12.5, 25, and 50 Mbps, external speeds of 100, 200, and 400 Mbps. See Hard drive Interfaces.

Local buses are PCI, ISA, EISA, VL.

PCMCIA (Personal Computer Memory Card Industry Association) – designed to give laptop and notebook computers an expansion capability. Currently only 4 standard types:

Type I – 3.3 mm (RAM), thin card used for memory
Type II – 5 mm (I/O cards such as modems), thicker card used for interface adapters
Type III – 10.5 mm (hard drives), thickest card used for hard drives
Type IV – greater than 10.5 mm (not yet standardized as of 1998)

Bus	Bus (bits)	Speed (MHz)	Configured	*# of IRQ's*	*# of DMA channels*
8-bit	8	8	Jumpers or Switches	*8*	*4*
ISA	16	8	Jumpers or Switches, *newer ISA's use software*	*16*	*8*
EISA	32	8-*10*	Software		
MCA	16/32	10 *(book says 20)*	Software		
VLB	32	Up to 50 *(really 33)*	Jumpers or Switches *or software*		
PCI	32/64	CPU	Plug and Play		
AGP (1.0)	32	66, 133	Plug and Play		
AGP (2.0)	32	266	Plug and Play		
USB 1.0	1 *(4 pins)*	12 Mbps	Plug and Play		
USB 2.0	1 (4 pins)	480 Mbps	Plug and Play		
Firewire	1 *(6 pins)*	* 400 Mbps	Plug and Play		
PCMCIA	16/32	33	Plug and Play		

ISA – Industry Standard Architecture. VESA – Video Electronics Standards Association.

For more information, see the Wikipedia page at **http://en.wikipedia.org/wiki/Bus_(computing)**

Interrupts

IRQ	BIN	Hex	Device	Address	DMA	POST	Recommended
0			System Timer	0040-0043			
0	0000	0					
1			Keyboard	0060-0064		3XX	
1	0001	1					
2			Cascade from 9	00A0-00A1			
2	0010	2	Video Card			5XX	
3			Com 2 *(primary)*	02F8-02FF			Modem
3	0011	3	Com 4 *(secondary)*	02E8-02EF			
4			Com 1 *(primary)*	03F8-03FF			Serial Mouse
4	0100	4	Com 3 *(secondary)*	03E8-03EF			
5			Sound Card	0220-022F	0/1/5		Sound Card
5	0101	5	LPT 2	0278-027F			
6			Floppy Drive	03F0-03F7	2	6XX	FDD Controller
6	0110	6					
7			LPT 1	0378-037F	3 (ECP Mode)	14XX	LPT1
7	0111	7					
8			RTC	0070-0071			
8	1000	8					
9			Redirect IRQ 2				NIC
9	1001	9	NIC	0300-030F			
10							USB
10	1010	A					
11							SCSI Host
11	1011	B					
12			PS/2 Mouse	0238-023F		86XX	Mouse
12	1100	C					
13			Math Coprocessor	00F0-00FF			
13	1101	D					
14			Primary IDE	01F0-01F7		17XX	
14	1110	E					
15			Secondary IDE	0170-0177			
15	1111	F					

1XX-system board
2XX-main memory
-Anything that is on IRQ's 8-15 is on IRQ 2.
-The lower the IRQ #, the higher the priority it is.
-I/O ports use address range 0-255 (hex-0h-FFh)
-All other devices use address range 9256-65,535 (hex-100h-FFFFh)

Some INTEL Microprocessor Characteristics:

Year to Year	CPU	Chip Package	Speed (MHz)	Internal Data Bus	Address Bus (bits)	Memory (MB) RAM	Multi CPUs	Cache (K)	Socket/ Slot Type Used
1978	8086	DIP	*4.77*-8	16	20	1	No	0	
1982	80286*(intro. of real and protected mode)*	PGA	8 to 20	16	24	16	No	0	
1985	386DX	PGA	40	32	32	4096 or *4 GB*	No	0	
1988	386SX	PGA	25	16	24	16	No	0	
1989	486DX *(intro of heat sink, L1 cache on die CPU, burst mode, and math coprocessor)*	PGA	25 to 50	32	32	4096	No	8	
1991	486SX	PGA-*169 pin*	16 to 50	32	32	4096	No	8	Socket 1
1992	486DX2	PGA	40 to 80	32	32	4096	No	8	
1993	P5 - Pentium (586)- *two 486's*	SPGA-273 or 296 pin	60 to 66	64	32	4096	2	16*K*	Socket 4
1994	486DX4	PGA	75 to 120	32	32	4096	No	16	
1994 1995	P54	PGA - 296 or 321 pin	75 to 120	64	32	4096	2	16	Socket 7
1995	Pentium Pro *(intro. of L2 cache)*	SPGA-387 pin	150 to 200	64	64/36	65536 or *64 GB*	4	16*L1* + 256 to 1M*L2*	Socket 8
1997	Pentium MMX	PGA - 296 or 321 pin	133 to 300	64	64/32	4096	2	32*K L1*	Socket 7
1997	Pentium II	SEC	233 to 450	64	64/36	65536	2	*32 L1* + 512 *L2*	Slot 1
1998	Celeron	PPGA/SECC	333 to 700	64	64/36	65536	No	*32 L1* + 128*L2*	Slot 1, Socket 370
1999	Pentium III	PPGA/SECC	450 to 1400	64	64/36	65536	2	32*K L1* + 512*L2*	Slot 1
1999	P III Xeon *L2 cache on die*	SECC	550 to 1000	64	64/36	65536	8	32*L1* + 256K to 2MB*L2*	Slot 2
2000	P3 Celeron	FC-PGA	533 to 3600					32 L1 + 128 L2	Socket 370
2000 2008	P4	PGA423, PGA478	1300 to 3800					*256 - 512L2*	Socket 423, 478
2003 2008	Pentium 4- M	Micro-FCBGA	900 to 2260					64L1 + 1000L2	Socket 479
1998 Current	Celeron M		266 to 3600					64L1 + 512L2	Slot 1, Socket M
2006 Current	Dual-Core		1400 to 2600						LGA 775, Socket M

Notes:

- 80186 - Unsuccessful due to numerous compatibility problems but they combined 15 to 20 system components that were used in the 8086 series CPUs, so paved the way for the 80286 CPUs.
- Pentium is basically two 486 chips in the same package that creates the possibility of onboard parallel processing.
- Pentium and Pentium Pro added parallel processing.
- Pentium II/III Xeon processors have more L2 cache (512KB, 1 MB, or 2 MB) and run at full core speed .

CPU's are either:
1. CISC (Complex Instruction Set Computer)-instructions are not a fixed length, or
2. RISC (Reduced Instruction Set Computer)-instructions are a fixed length. There is also SIMD (Single Instruction Multiple Data) with Pentium MMX.

CPU packages are either:
1. Slot based, or
2. Socketed (100 lbs. of force to install-socket 1; Zero Insertion Force-sockets 2-8) Socket 6 was never used.

DIP - Dual Inline Package. Socketed.

PGA - Pin Grid Array, the 486 uses a 169-pin package; the Pentium mounts in either a 273-pin or 296-pin socket; and the Pentium Pro uses a 387-pin socket. This changes the physical size of the chip. There is a CPGA (ceramic), a PPGA (plastic), or a FCPGA (flip chip). Socketed.

SPGA - Staggered Pin Grid Array. Socketed.

SECC - Single Edge Contact Cartridge, the processor mounts as a single module into a special slot on the motherboard.

Cache- area of memory reserved for storing data that the CPU determines it will be using frequently.

Math Co-processor - In the table above the first CPU to incorporate an onboard MPU was the 486DX.

MMX (Multimedia Extensions) - added 57 new instructions to improve video, audio, and graphics capability; added SIMD (Single Instruction Multiple Data) technology, in which one instruction can control several data items; and Cache was doubled to 32K.

Chipset - a set of microchips that work as a unit to set or control the amount of memory and the type of RAM chips that can be used, and provide support for certain types of peripherals. Chipset is commonly used to mean the basic functions of a motherboard. If the chipset doesn't support an upgrade you will be required to change the motherboard.

Thermal grease - a compound used to conduct heat from the CPU to the cooling fins of a heat sink. It is mercury-based so you should avoid getting any on your skin.

Intro to the Console Internals (Lab)

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Memory Systems

Computer data storage, often called storage or memory, refers to computer components, devices, and recording media that retain digital data used for computing for some interval of time. Computer data storage provides one of the core functions of the modern computer, that of information retention. It is one of the fundamental components of all modern computers, and coupled with a central processing unit (CPU, a processor), implements the basic computer model used since the 1940s.

In contemporary usage, **memory** usually refers to a form of semiconductor storage known as random access memory (RAM) and sometimes other forms of fast but temporary storage. Similarly, **storage** today more commonly refers to mass storage - optical discs, forms of magnetic storage like hard disks, and other types slower than RAM, but of a more permanent nature. Historically, memory and storage were respectively called primary storage and secondary storage.

The contemporary distinctions are helpful, because they are also fundamental to the architecture of computers in general. As well, they reflect an important and significant technical difference between memory and mass storage devices, which has been blurred by the historical usage of the term storage.

Characteristics of storage

Storage technologies at all levels of the storage hierarchy can be differentiated by evaluating certain core characteristics as well as measuring characteristics specific to a particular implementation. These core characteristics are volatility, mutability, accessibility, and addressability. For any particular implementation of any storage technology, the characteristics worth measuring are capacity and performance.

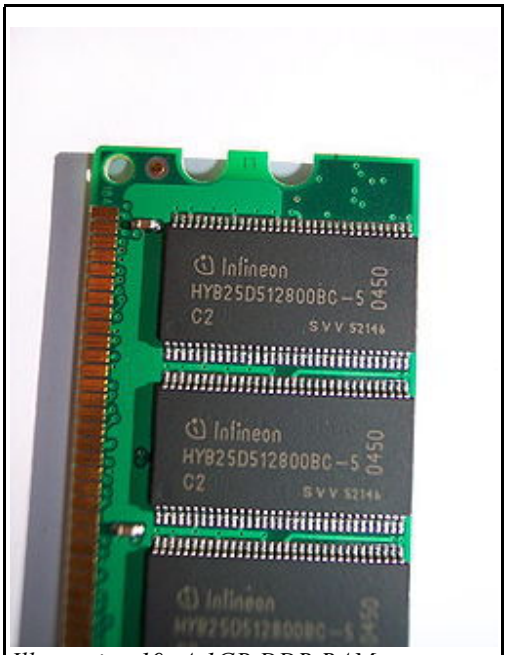

Illustration 19: A 1GB DDR RAM memory module

Volatility

- Non-volatile memory - Will retain the stored information even if it is not constantly supplied with electric power. It is suitable for long-term storage of information. Nowadays used for most of secondary, tertiary, and off-line storage. In 1950s and 1960s, it was also used for primary storage, in the form of magnetic core memory.
- Volatile memory - Requires constant power to maintain the stored information. The fastest memory technologies of today are volatile ones (not a universal rule). Since primary storage is required to be very fast, it predominantly uses volatile memory.

Differentation

- Dynamic memory - A form of volatile memory which also requires the stored information to be periodically re-read and re-written, or refreshed, otherwise it would vanish.
- Static memory - A form of volatile memory similar to DRAM with the exception that it does not refresh on occasion.
- Side note: most modern PC system developers have gone with DRAM as the standard with SDRAM and SRAM being slowly phased out of the common marketplace as new motherboards are not being built to support these styles of chips.

Mutability

- Read/write storage or mutable storage - Allows information to be overwritten at any time. A computer without some amount of read/write storage for primary storage purposes would be useless for many tasks. Modern computers typically use read/write storage also for secondary storage.
- Read only storage - Retains the information stored at the time of manufacture, and write once read many (WORM) storage allows the information to be written only once at some point after manufacture. These are called immutable storage. Immutable storage is used for tertiary and off-line storage. Examples include CD-ROM and CD-R.
- Slow write, fast read storage - Read/write storage which allows information to be overwritten multiple times, but with the write operation being much slower than the read operation. Examples include CD-RW.

Accessibility

- Random access - Any location in storage can be accessed at any moment in approximately the same amount of time. Such characteristic is well suited for primary and secondary storage.
- Sequential access - The accessing of pieces of information will be in a serial order, one after the other; therefore the time to access a particular piece of information depends upon which piece of information was last accessed. Such characteristic is typical of off-line storage.

Addressability

- Location-addressable - Each individually accessible unit of information in storage is selected with its numerical memory address. In modern computers, location-addressable storage usually limits to primary storage, accessed internally by computer programs, since location-addressability is very efficient, but burdensome for humans.
- File addressable - Information is divided into files of variable length, and a particular file is selected with human-readable directory and file names. The underlying device is still location-addressable, but the operating system of a computer provides the file system abstraction to make the operation more understandable. In modern computers, secondary, tertiary and off-line storage use file systems.
- Content-addressable - Each individually accessible unit of information is selected with a hash value, or a short identifier with a number pertaining to the memory address where the information is stored. Content-addressable storage can be implemented using software (computer program) or hardware (computer device), with hardware being a faster but more expensive option.

Capacity

- Raw capacity - The total amount of stored information that a storage device or medium can hold. It is expressed as a quantity of bits or bytes (e.g. 10.4 megabytes).
- Density - The compactness of stored information. It is the storage capacity of a medium divided with a unit of length, area or volume (e.g. 1.2 megabytes per square inch).

Performance

- Latency - The time it takes to access a particular location in storage. The relevant unit of measurement is typically nanosecond for primary storage, millisecond for secondary storage, and second for tertiary storage. It may make sense to separate read latency and write latency, and in case of sequential access storage, minimum, maximum and average latency.
- Throughput - The rate at which information can be read from or written to the storage. In computer data storage, throughput is usually expressed in terms of megabytes per second or MB/s, though bit rate may also be used. As with latency, read rate and write rate may need to be differentiated. Also accessing media sequentially, as opposed to randomly, typically yields maximum throughput.

Common DRAM modules

Common DRAM packages as illustrated to the right, from top to bottom:

1. **DIP** 16-pin (Dual Inline Package)
2. **SIPP** (Single Inline Pin Package)
3. **SIMM 30-pin** (Single Inline Memory Module)
4. **SIMM 72-pin** (so-called "PS/2 SIMM", usually EDO RAM)
5. **DIMM 168-pin** (SDRAM, Dual Inline Memory Module)
6. **DIMM 184-pin** (DDR SDRAM)
7. **RIMM 184-pin** (Rambus Dynamic RAM Memory)
8. **DIMM 240-pin** (DDR2 SDRAM/DDR3 SDRAM)

Illustration 20: Common DRAM modules

Memory:

- internal storage areas in the computer.
- memory chips are made of up millions of transistors, which conduct electricity (1) or do not conduct electricity. (0).

Non-Volatile

- **ROM** (Read Only Memory)-special permanent memory used to store programs that boot the PC and perform diagnostics. It can be re-written.
- **PROM** (Programmable ROM)-programmed only once by applying high voltages that alter circuits and store desired program.
- **EPROM** *(*Erasable PROM) is erased by exposure to ultraviolet light.
- **EEPROM/Flash** (Electrically Erasable PROM)-erased electronically-1 bit at a time-used in printers. Most new BIOS are flashable.

Illustration 21: RAMBUS memory with integrated heatsink

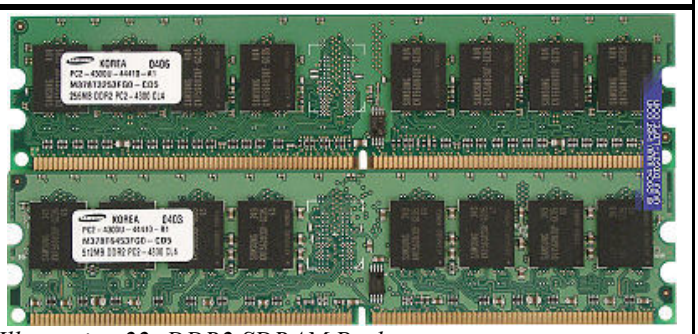

Illustration 22: DDR2 SDRAM Packages

Firmware is stored in ROM.

Volatile

- **RAM** (Random Access Memory)-main memory. Can be read or written over. Needs constant source of electricity
- **DRAM** (Dynamic RAM) – Most common type of RAM, uses 1 transistor and one capacitor, refreshed every 16 milliseconds.
- **SRAM** (Static RAM) – Very fast RAM, Used in L1 and L2 Cache, CMOS, etc. Uses 6 transistors, not refreshed, charged from system board memory.
- **SDRAM** (Synchronous DRAM) – Faster than DRAM, may operate at the speed of the CPU. On a

video card, has a clock that is coordinated with the system clock.

- **RDRAM** (Rambus Dynamic RAM) – new memory to support speeds up to 800MHz. Needs to be refreshed. Has a 0 wait state.
- **EDO RAM** (Extended Data Output RAM) – will not discharge unless written to, faster than other memory.
- **VRAM** (Video RAM) – two access paths to a single memory location enabling simultaneous read and write.
- **WRAM** (Window RAM) – optimized for display adapters, specifically as a video graphics accelerator for Windows 3.x. Same structure as VRAM.

DRAM, EDO RAM, WRAM, SDRAM, DDR SDRAM, and SGRAM are also types of video RAM.

Parity Checking

- 9th bit that verifies the integrity of previous byte. It verifies 1 byte at a time w/ no corrections.
- Odd parity-parity bit is 0 and there is an odd number of 1's; data is valid and the p-bit is removed and data is sent.
- Even parity-parity bit is 1 and there is an even number of 1's; data is invalid and a parity error is generated.

Error Correct Code (ECC)

- type of memory that checks parity of segments of code and corrects 1 bit errors. Used in high-end servers.

Types of RAM packages

- **DIP** (Dual Inline Package) – a family of rectangular, integrated-circuit flat packages that have leads on the two longer sides. Either plastic or ceramic, DIP memory chips hold 16KB to 1024KB (1MB).

- **SIPP** (Single Inline Pin Package) – a small circuit board with pins across the bottom. No longer manufactured.

- **SIMM** (Single Inline Memory Module) – a group of DRAM memory chips on a small Printed Circuit (PC) board with a single row of input/output contacts. Only one side of the module makes contact with the computer. They must be installed in pairs. All SIMM's run at the speed of the slowest SIMM.
  - **30-pin** – about 9 DIP chips, 256KB to 16MB.
  - **72-pin** – about 36 DIP chips, 4MB to 64MB.
  - SIMM's transfer data at 32 bits at a time

  DIMM (Dual Inline Memory Module) – an array of memory chips on both sides of a small PC board with two rows of input/output contacts. The contacts are located on both sides of the module board. They have 168 pins and range in size from 8MB to 256MB. Transfer data 64 bits at a time with a 64 bit or wider memory bus.

- **RIMM** (Rambus Inline Memory Module) – a 184-pin, 2.5 volt, 600 or 800 MHz, 16-bit and 18-bit memory module for Direct Rambus Dynamic Random Access Memory (Direct RDRAM). ID numbers and up to 63 devices can be chained. Uses a 6-prong power connector.

- If memory module is divisible by 8 it's non-parity; if divisible by 9 it includes parity bit (Parity checking is set up in CMOS).

For more information, see the Wikipedia page at
http://en.wikipedia.org/wiki/Computer_data_storage

and **http://en.wikipedia.org/wiki/DDR2_SDRAM**

Storage Systems

Illustration 23: A hard disk drive with protective cover removed.

Secondary storage, or Storage in popular usage, differs from primary storage in that it is not directly accessible by the CPU. The computer usually uses its input/output channels to access secondary storage and transfers desired data using intermediate area in primary storage. Secondary storage does not lose the data when the device is powered down - it is non-volatile. Per unit, it is typically also an order of magnitude less expensive than primary storage. Consequently, modern computer systems typically have an order of magnitude more secondary storage than primary storage and data is kept for a longer time there.

In modern computers, hard disks are usually used as secondary storage. The time taken to access a given byte of information stored on a hard disk is typically a few thousandths of a second, or milliseconds. By contrast, the time taken to access a given byte of information stored in random access memory is measured in thousand-millionths of a second, or nanoseconds. This illustrates the very significant access-time difference which distinguishes solid-state memory from rotating magnetic storage devices: hard disks are typically about a million times slower than memory. Rotating optical storage devices, such as CD and DVD drives, have even longer access times.

Some other examples of secondary storage technologies are: flash memory (e.g. USB sticks or keys), floppy disks, magnetic tape, paper tape, punch cards, standalone RAM disks, and Zip drives.
The secondary storage is often formatted according to a file system format, which provides the abstraction necessary to organize data into files and directories, providing also additional information (called metadata) describing the owner of a certain file, the access time, the access permissions, and other information.

Most computer operating systems use the concept of virtual memory, allowing utilization of more primary storage capacity than is physically available in the system. As the primary memory fills up, the system moves the least-used chunks (pages) to secondary storage devices (to a swap file or page file), retrieving them later when they are needed. As more of these retrievals from slower secondary storage are necessary, the more the overall system performance is degraded.

Characteristics of storage

The characteristics of storage for Primary Storage also apply to Secondary Storage.

Magnetic storage media

Magnetic storage uses different patterns of magnetization on a magnetically coated surface to store information. Magnetic storage is non-volatile. The information is accessed using one or more read/write heads which may contain one or more recording transducers. A read/write head only covers a part of the surface so that the head or medium or both must be moved relative to another in order to access data. In modern computers, magnetic storage will take these forms:

- Magnetic disk
    - Floppy disk, used for off-line storage
    - Hard disk, used for secondary storage
- Magnetic tape data storage, used for tertiary and off-line storage

In early computers, magnetic storage was also used for primary storage in a form of magnetic drum, or core memory, core rope memory, thin film memory, twistor memory or bubble memory. Also unlike today, magnetic tape was often used for secondary storage.

Optical storage media

Optical storage, the typical Optical disc, stores information in deformities on the surface of a circular disc and reads this information by illuminating the surface with a laser diode and observing the reflection. Optical disc storage is non-volatile. The deformities may be permanent (read only media), formed once (write once media) or reversible (recordable or read/write media). The following forms are currently in common use:

- CD, CD-ROM, DVD, BD-ROM: Read only storage, used for mass distribution of digital information (music, video, computer programs)
- CD-R, DVD-R, DVD+R BD-R: Write once storage, used for tertiary and off-line storage
- CD-RW, DVD-RW, DVD+RW, DVD-RAM, BD-RE (Blu-Ray Disc Rewritable): Slow write, fast read storage, used for tertiary and off-line storage
- Ultra Density Optical or UDO is similar in capacity to BD-R or BD-RE and is slow write, fast read storage used for tertiary and off-line storage.

Magneto-optical disc storage is optical disc storage where the magnetic state on a ferromagnetic surface stores information. The information is read optically and written by combining magnetic and optical methods. Magneto-optical disc storage is non-volatile, sequential access, slow write, fast read storage used for tertiary and off-line storage.

3D optical data storage has also been proposed.

Hard Drives

- have 2 motors
  - To turn the platters, and
  - Stepper motor to stop. Also has a voice coil (similar to an audio speaker) which allows data to be written close together.
- Physical Characteristics
  - form factor- 8, 5 ¼, and 3 ½ inch disks;
  - height- full, ½ or 1" height drives.
- Configuring Hard Drives
  - set jumpers. 1st drive is the master, 2nd drive is the slave,
  - hook up cables [power (molex) and control (40 pin cable)].
- Setting up Hard Drives
  - low level format sets up hard drive to accept data,
  - high level format sets up segments (smallest unit of storage). Uses a File Allocation Table (FAT).

Hard Drive Interfaces

ST-506/ST-412 – One of the oldest legacy drive interfaces still in use. One drive per controller used two drive cables, a 34-pin data cable and a 20-pin control cable.

ESDI (Enhanced Small Device Interface) – Similar to the ST-506 but allowed two drives per controller card. A termination resistor required for the last drive in the chain.

SCSI (Small Computer System Interface) Standards

- SCSI has a logical and an electrical interface.
- Connects either on system board or SCSI adapter card is added into PCI slot.
- Connection made by 50 pin ribbon connector (internal SCSI), or 50 pin Centronics or 68 pin HD D connector or 25 pin connector(external connections).
- One SCSI controller (which is really an adapter called the host bus adapter) can control up to 7 devices on 1 cable.
  - The host bus adapter connects data from the system bus to the SCSI bus and vice versa.
  - Each SCSI device has its own ID# from 0-7 (0-15 on SCSI-III).
  - Either 0 or 7 is the ID# used by the host bus adapter.
  - LUN (Logical Unit Numbers)-a sub-device of SCSI which allows you to have up to 7 sub-devices per each SCSI ID#.
- SCSI can be either 8, 16, or 32 bit versions.
- SCSI must be terminated and can only be attached to SCSI controller.
- SCSI does not use BIOS, so drive is not configured in BIOS.
  - You can boot from a SCSI drive without using BIOS. SCSI has its own BIOS chip.

Single-ended device – one wire per data bit. Noise a problem, 6 Meters max.

HVD (High Voltage Differential) – two wires per data bit, could damage Single-ended devices if put on the same chain, 25 Meters max.

LVD (Low Voltage Differential) – two wires per data bit, can be used with single-ended devices, 12 Meters max.

Description /Standard	Bus Width	Transfer rate	Max. # Devices	Cable Type	Max Cable Length
SCSI-1	8-bits	5MBps	8	25-pin	6 Meters
SCSI-2	8-bits	5MBps	8	50-pin	6 Meters
Fast SCS-3	8-bits	10MBps	8	50-pin	3 Meters
Wide SCSI-2	16-bits	10MBps	16	68-pin	3 Meters
Ultra	8-bits	20MBps	8	50-pin	1.5 Meters
Fast Wide	16-bits	20MBps	16	68-pin	3 Meters
Ultra-2	8-bits	40MBps	8	50-pin	3 Meters
Ultra Wide	16-bits	40MBps	16	68-pin	3 Meters
Wide Ultra-2	16-bits	80MBps	16	68-pin	3 Meters

IDE (Integrated Drive Electronics) – also known as the ATA interface, two hard drives max (one master and one slave), no other devices accepted, 504 MB maximum drive size. (the boot drive should be on IDE1).

- IDE needs to go through the CPU and chipset.
- IDE connections are made with 40 pin ribbon cable; Max. Cable length is 2 ft.

LBA (Logical Block Addressing/WD) or **ECHS** (Extended Cylinder Head Sector/Seagate) – procedure used to bypass the 504MB limitation of IDE drives. Maximum size is 8.4GB. It uses a method of sector translation that gives the BIOS incorrect information about the devices addresses.

Int13 (Interrupt 13/Phoenix) – New BIOS commands allow hard drive sizes to 137GB.

EIDE (Enhanced IDE) or (ATA-2 or Fast ATA/WD) – Allows up to 8GB drives, it has 2 connectors, each w/ dual host interface controllers (allows up to 4 devices, and CD-ROM and tape drives are an option). Not limited to just hard drives.

- EIDE needs to go through the CPU and chipset.
- EIDE connections are made with 40 pin ribbon cable; Max. Cable length is 2 ft.

PIO Mode - programmed Input Output Mode

- Set in the BIOS when IDE/EIDE drives are installed.

Standard	PIO Mode	Transfer Rate
ATA	0	3.3 Mbps
ATA	1	5.2 Mbps
ATA	2	8.3 Mbps
ATA-2	3	11.1 Mbps
ATA-2	4	16.6 Mbps

Ultra DMA (UDMA)

- configuring and troubleshooting p.217-219 Core text
- supported by BIOS
- drive protocol for hard drive data on IDE/EIDE drives
- UDMA plugged into IDE/EIDE is limited to 16.6 Mbps.
- BIOS and drivers need to be upgraded to maximize speed
- UDMA connector is blue
- UDMA/33 has 40 wires/40 pin cables(7 pins for grounding)
- UDMA/66 and UDMA/100 has 80 wires/40 pin cables(40 extra wires are to assist with grounding and to keep signal noise and crosstalk down.
- UDMA can go directly to memory, but you need certain chipsets to be UDMA compatible.

Standard	Year	Transfer Rate
DMA/33	1996	33.3 Mbps
DMA/66	1998	66 Mbps
DMA/100	2000	100 Mbps

Firewire – Will eventually replace SCSI technology because devices do not have to be terminated or assigned.

Hard drive error messages

Non-system disk or disk error-occurs when non-system boot up disk is in floppy drive during boot process
Invalid Media Type-occurs when drive is partitioned, but not formatted
Invalid drive specification-occurs when drive has not been partitioned at all
Invalid Configuration-press F1 to continue-BIOS settings in CMOS do not match the hardware
Fixed disk error-improper BIOS setting for the drive or bad cable

Changing hard drives

... from one PC to another PC

1) If drive was slave on PC1 and going to be master on PC2
   a) Jumpers need to be reconfigured before installation
   b) CMOS- you must let PC know which type of hard drive you want to use as the master
   c) You must format the hard drive with OS (it was not the boot drive in PC1)
2) If drive was master in PC1 and will be master in PC2
   a) Jumpers should stay the same.
   b) CMOS-you might need to check.
   c) Drive already has OS installed.
3) If drive was master and now it's going to be the slave drive.
   a) Jumpers should be reconfigured.
   b) CMOS should auto-detect the slave drive.
   c) You can leave the OS, but it will decrease memory on slave drive.

Ways to designate a hard drive as a master or slave

1) Set master jumper to on (master) or off (slave).
2) On newer hard drives, plug a Cable Select cable into either the master or slave connector (missing pin 28) on the back of the hard drive.

Working with Disks

A floppy disk has been the standard of storage for personal computers since 1971 when an 8-inch disk held 79KB of data. The standard, reached in 1987 for a 3½" Floppy disk was 1.44 MB. Though storage up to 200 MB was reached by 1999, the Floppy disk has slowly been replaced by solid-state electronic devices currently capable of storing over 8 GB in a device potentially much smaller than a Pink Pearl Eraser!

Illustration 24: Pink Pearl Eraser

Think of a mechanical computer storage device as an onion cut across the rings. You can see how the tracks (A) in the image to the right appear to be different layers in an onion. A geometrical sector (B) is then formed by two lines from the center to the outer edge. A track sector (C), or simply a Sector, is where a Track and a geometrical sector intersect. This is the smallest unit of storage on a Floppy Disk. A Cluster (D) is the smallest logical amount of disk space that can be allocated to hold a file.

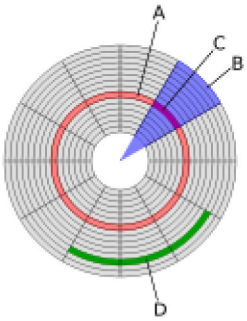

Illustration 25: Disk Structure

For a 1.44MB Floppy disk, the Cluster is equivalent to a Sector and is 512 Bytes. 512 Bytes is approximately ½ of an 8½" x 11" sheet of single spaced typed paper, and there are 2,847 Sectors on a 3½" Floppy Disk. It can hold an equivalent to over 1423 typed pages in ASCII (American Standard Code for Information Interchange) format! That would be one BIG book!

A standard Floppy Disk is shown in cut-away form to the right. The components are as follows:

1) Write-protect tab
2) Hub
3) Shutter
4) Plastic housing
5) Paper ring
6) Magnetic disk
7) Disk Sector

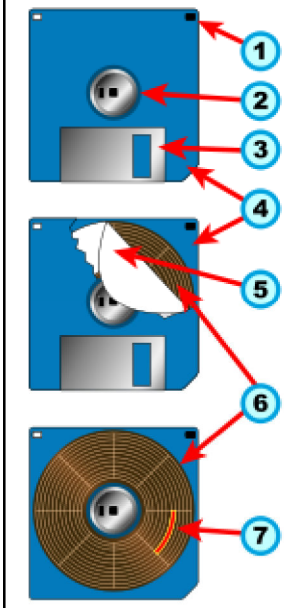

Illustration 26: Floppy Disk Structure

Illustration 27: September 1956 5MB IBM Harddrive

To give you some reference of advancements in technology, look at this harddrive from 1956 and compare that to our modern equivalents.

I/O Ports

how data is transmitted.

Serial transmission - data is sent and received 1 bit at a time over a single wire. Each bit is transmitted as a voltage. Sent at a rate of 115,000bps. Serial cable can be up to 50 ft.

Parallel Transmission - 1 byte at a time is sent over 8 wires. Max. distance for cables 10-15 ft. (for the test 10 ft.). to keep crosstalk down. Anything over 10 ft, you need good quality cables.

PS/2 port or 6 pin mini DIN - keyboard (IRQ1) and mouse (IRQ12) connections on ATX board; 5 pin DIN on AT boards. Output voltage is +/- 5 volts DC. On older ports mice were on serial ports.

There is also a **MIDI** (Musical Instrument Device Interface) port and a SCSI (Small Computer System Interface) port.

Serial Ports - most common device is the modem (enables 2 computers to communicate over a phone line).

- In order for 2 computers to communicate, they must use the same settings for: 1 bps (data rate-how much data is transferred in 1 sec), 2. Data bits, 3. Parity, 4. Stop bus, and 5. flow control.
- data rate vs. baud rate-baud rate is the number of signal changes on a data transmission line in 1 sec.
- Synchronization - receiver must know how frequently to read the data line. If receiving device is not in synch with signal, then the signal will be misread.

2 types of Synchronization:

1. **Synchronous transmission** - receiver's clock and transmitter's clock must be in synch.
2. **Asynchronous transmission** - transmitter adds a start, parity, and stop bit to the data line, which is called a data frame. This process is called framing. Asynch. Transmission also involves flow control (uses handshaking- rec. sends a signal using a separate wire to let the transmitter know it's ready to receive).

Serial port standards

- RS232 Standard-standard way to connect computer to modems. It describes: 1.mechanical characteristics (wiring, connection pin arrangements, and cable connections, i.e. DB25 male or DB9 male), 2. Signaling techniques, 3. Function of support circuits, and 4. Procedures used to communicate over RS232 lines (handshaking).
- Connectors - most common DB9 male connector.

Parallel Ports - most common device is the printer (uses Centronics standard (36 pins connector to the printer and a DB25 pin connector to the computer).

- connectors:-most common DB25 female connector.
- SPP-standard parallel port. Originally data only flowed to the printer (unidirectional) or other devices
- EPP-Enhanced Parallel Port) was bi-directional. (Needed for CD-ROM's and network adapters). ECP-Enhanced Capabilities Port-10x faster, defined by IEEE 1284 Standard-which defines 3 types of connectors:
  1) Type A-DB 25 pin connector,
  2) Type B- 36 pin conductor, 0.085 centerline clamp with bale locks, and
  3) Type C-36 pin conductor, 0.050 centerline mini connector with clip latches.

USB (Universal Serial Bus) Ports - used to connect common I/O devices. Can connect up to 127 devices to 1 USB port by using USB hubs.

- Has a 4 pin socket on the PC. There are 2 types of USB plugs: 1. Type A-rectangle, which connects to the host or hub and 2. Type B-D-shaped which connects to the peripheral.
- USB runs at 12Mbps.
- USB is PnP compatible.

Advantages of USB:

1. No new expansion cards need to be installed,
2. Devices can be hot-swapped, no installation of new drivers is needed, or no configuring IRQ and DMA addresses.

- This is because OS software supports and manages USB host controller and USB hub controller, which then manages the USB ports.
- The host controller is: 1. on the system board or 2. a PCI slot card can be added to the system The CPU is totally out of the picture.
- USB has 2 main modules: 1. (SIE-Serial Interface Engine)-responsible for the bus protocol and 2. The root hub-used to expand the # of USB ports.
- USB cable can be no longer than 5 meters between devices.
- Troubleshooting is done through the BIOS (for Win95-you need Win95 OEM service release 2.1 and 2.5 CD's).

Firewire Ports - IEEE 1394 specification. Faster than USB and SCSI.

- hot-swappable.
- It has 2 levels of interface: 1. Internal (backplane) bus and2. External bus.
- Firewire runs internally at 12.5, 25, or 50 Mbps and externally at 100, 200, or 400 Mbps.
- IEEE 1394b-speeds up to 800 Mbps, 1.6 Gbps, or higher.
- Advantages of Firewire over SCSI:
  1. It automatically assigns addresses
  2. It doesn't require termination
  3. It is hot swappable
  4. It is PnP because there are no addresses or DMA channels to assign.

Firewire is a viable solution for digital cameras, video cameras, printers, TVs, network cards, and mass storage devices.

- Cable can only be up to 4.5 meters between devices.
- Firewire uses a 6 conductor cable (2 pair of wires for transporting data and 1 pair for power).

Expansion Boards

Video Cards

- controller - convert digital signal to analog (DAC)
- used in VGA
- usually only one connector on the back of the card

Video Display Components

1. Adapter that goes in the expansion bus slot
2. Monitor or Display

Components determine the capability of the computer including

1. Display mode
2. Number of characters that can be displayed
3. Resolution (number of graphic dots on display or pixels).
4. Number of colors on display
5. Scan rate-how frequent the display image is refreshed.

Standards

1. MDA (Monochrome Display Adapter)
2. CGA-(Color Graphics Adapter) - 16 colors in text and graphics mode
3. EGA (Enhanced Graphic Array) - higher resolution
4. VGA (Video Graphics Array) - up to 256 colors at high resolution (800x600). Original VGA 640x480, 16 colors.
5. SVGA (Super VGA) and UVGA (Ultimate VGA) - even higher resolutions

Monitors

1. TTL - transistor to transistor logic (MDA)
2. RGB - red, green, blue (CGA)
3. Enhanced Color Display monitor (EGA)
4. VGA monitor (VGA) - Connectors:-DB15 pin connector, 3 rows
5. Number of monitors per CPU, Win98 = 9, Win 2000 = 10

To look at type of video card

1. At MSDOS prompt type
   - debug
   - dc000:00
   - dc000:70
   - quit (to return to DOS prompt)

Sound Cards (IRQ 5) - Convert digital signal to sound waves, Soundblaster is the standard.
Connections

- Mic-in - receive signal from external microphone
- Speaker out - sends signal to speaker/headphone
- Line-in - receives signal from output of an external sound device
- Line-out - sends signal from soundcard to external sound device
- CD-Audio - Receives digital signal audio from audio source
- IDE port - connects an IDE CD ROM drive to sound card
- Game port - Usually a DB-15 is used to connect sound/game/joystick/and MIDI devices.

Modem Cards

- allows 2 computers to communicate over phone lines
- use a D to A Converter (DAC) and an A to D Converter (ADC)

Types

1. Asynchronous - most common
   - uses serial transmission
   - more prone to errors and therefore uses a parity bit
2. Synchronous - less errors

Standards

V.42- error checking standard; V.42bis- compression standard; V.34-28K modem; x2, 56 flex, and V.90 – 56 Kbps modem standards
-MNP standards-defines class 1-5
-Each class differs in levels of error correction and detection and data compression

Attention (AT) Commands

- AT - attention used at start of modem command lines
- DT - dial using a touch tone
- H - hang-up
- *70 - disables call waiting
- many others available

Configuring Modems

1. Start\Settings\Control Panel\Modem Utilities,
2. Select UART (Universal Asynchronous Receiver Transmitter) to set receiver and transmitter buffers.

Removable Media and Disk Drives

Floppy Disk Drives

- 8", 5 ¼", and 3 ½"
- FDD can be set up in CMOS
- 5 ¼" high density-1.2 MB of memory; low density-360 KB of memory
- 3 ½" high density-1.44MB of memory; low density-720KB of memory

Cables

Connects - A drive after twist, B drive before twist; set both to B drive (twist reverses setting to A) the other connector goes to motherboard.

CD-ROM Drives

- Basically use SCSI attached to EIDE drive
- Standard CD-ROM holds 700 MB; after formatted it holds approximately 533MB (direct CD)
- CD-R - read only
- CD-RW - read/write
- Direct CD will only work in CD-RW
- Internal CD-ROM-device is connected to EIDE drive
- External CD-ROM-device is connected to parallel or SCSI port (SCSI is better and faster)
- ASPI (Advanced SCSI Programming Interface) enables use of a singular ASPI device driver for multiple SCSI devices
- Power connector for CD-ROM drive is a molex because of current required by laser

ATAPI (attachment package interface)

- Extension to EIDE that enables support for CD-ROM drives (including CD-R and CD-RW) and tape drives on an IDE controller
- Installed as if it were another EIDE drive
- Doesn't need to be configured in CMOS, it configures automatically.
- ATAPI can be set up as a master or slave on primary or secondary drive controllers
- DVD's also require MPEG (Movie Picture Experts Group) decoder to decode MPEG files
- MPEG standards
  - MPEG1-video resolution of 352X240 at 30 frames/sec
  - MPEG2-video resolution of 720X480 or 1280X720 at 60 frames/sec.

Other Removable Drives

Zip drive

- slightly larger and 2x as thick as 3 ½ " disk
- can only read zip disks
- memory of 100MB-250MB
- initially they were connected to parallel ports; now parallel, SCSI, USB, ATAPI, or network

Syquest Drives

1. SparQ-1GB memory cartridge for PC's w/ parallel port or EIDE interface. Speed is equivalent to the hard drive
2. SyJet-1.5 GB cartridge for PC and MAC interface choices include parallel, SCSI, EIDE
3. Average transfer rate is 3.8 MBps
4. EzFlyer-230MB cartridge for PC and MAC. Interface at parallel or SCSI ports (MAC's only SCSI)

5. Transfer rate of 2.4 MBps
6. Jaz Drives-1-2GB memory. Comes in Ultra SCSI PCI, SCSI ISA, SCSI to parallel, and SCSI to PCMCIA. Transfer rate is same as hard drive
7. SuperDisk Drives-120 MB per disk. Can also read regular 3 ½" 1.44 MB disks. Available w/ parallel, SCSI, internal, and PCMCIA connections

Back up Systems

Types

1. **Quarter Inch Cartridge** (QIC) technology-oldest, most standardized, and most reliable
   - available in 60, 150, 250, 525 MB and larger
   - detractions cost and speed
   - mm DAT (Digital Audio Tape)-offers higher storage capacities at a lower cost
   - memory capacities range from 1-4 GB and more
   - detractions are less reliable than QIC and vulnerable to heat and moisture

2. **8mm** (Exabyte)
   - storage capacity of 2.2-10 GB per cartridge
   - tapes are only slightly larger than 4mmDAT tapes and are more reliable
   - detractions are expense
   - popular w/ UNIX

3. **DLT** (Digital Linear Tape)- ½" cartridge w/ a single hub
   - 128-208 linear tracks holding 10-35 GB of data
   - Also a Super DLT that holds up to 50 GB
   - DLT transfer rates are in the 1.25-5 MBps

4. **CD-ROM**
   - 700 MB of storage
   - Better than tape drives because tapes have a tendency to lose data over time.

Tape Drives are usually connected through SCSI adapter.

Backup Policy

1. Considerations in choosing Backup method:
2. Appropriate hardware for your environment
3. Who is responsible for backup administering
4. Determining minimal backup frequency
5. Choosing the appropriate backup type
6. Determine the number of tapes or other media (backup set) required to complete a backup
7. Determining when to perform backup
8. Labeling backup media and storing safely (data identification)
9. Occasionally testing backup data
10. Determining hardware and media maintenance (or replacement)
11. Laying out a recovery operation plan for complete recovery of data
12. Structuring how to backup media are rotated in and out of schedule (backup method) - Weekly, monthly, yearly

Rotation method

1. Grandfather method
   - Backup every day (Mon-Thurs)- next week re-use daily backup tapes
   - Friday backup entire week- next month re-use weekly backup tapes
   - At the end of every month the month is backed up-next year re-use the monthly backup tapes
2. Tower of Hanoi method

- Use 5 media sets
  1) Set A-every other day,
  2) Set B-every 4 days,
  3) Set C-every 8 days,
  4) Set D-every 16 days, and
  5) Set E-alternated w/ Set D

Backup Types

1. **Full** - all information is backed up regardless of whether it was backed up before. Resets archive bit.
2. **Incremental -** new files and files created/modified since last full or incremental back up are backed up. Resets archive bit.
3. **Differential** - All files that were created/modified since the last full backup are backed up. Doesn't reset the archive bit.

Backup Type	Relative Time Necessary to Perform a Full Backup	Relative Time Necessary to Perform a Full Restore
Full back up only	Longest	Shortest
Incremental back up with full back up	Shortest	Longest
Differential back up with full back up	Time increases each day; shorter than full, longer than an incremental	Shorter than incremental, but longer than full back up

Storage

1. Move at least 1 full back up set per week offsite.

Peripheral Devices

Primary Input Devices

Keyboards (FRU)

- IRQ 1
- usually plugs into PS/2 keyboard port
- manufacturing techniques
  1. coiled metal springs
  2. rubber/plastic membrane

Settings

- Sticky keys - can only press one key at a time
- Filter keys - ignores common keyboard errors
- Toggle keys - gives an audible signal when keys are pressed while Caps, Num, and Scroll Locks are set

Preventative Maintenance

- Use mild glass cleaner or isopropyl alcohol
- Do not spray cleaner onto keyboard

Mouse (FRU)

- IRQ 12
- usually plugs into PS/2 mouse port
- how motion is detected-motion detecting rollers are connected to small disks that have evenly spaced slots cut in them. As these disks spin, the slots repeatedly break a light beam going from an LED to a photo-detector. The number of times the beam is broken is proportional to the distance the mouse travels. The rate that the light beams is broken tells the computer how fast the mouse is going.

Preventative Maintenance

- wash ball in warm, soapy water;
- shake any loose dirt from inside mouse;
- remove any dirt or lint from axles,
- keep mouse pad clean.

Alternatives

1. Bus mouse w/ interface card,
2. USB mouse,
3. Trackball,
4. Joystick,
5. Touch pad,
6. Mouth control mouse substitute,
7. Light pens, and
8. gloves to full body suits

Primary Output Devices

CRT-based Monitors (Cathode Ray Tube)

- display images using phosphorous dots with a scanned electron beam
- monitors have 3 guns shooting independent streams of electrons at tiny colored phosphors on the screen that produce Red,Green, or Blue dots

- pixel - smallest discrete element on a video display.
- Dot pitch- the distance between 2 RGB groups on the screen. The lower the dot pitch, the better the picture quality.
- Color info. for each pixel is stored in video memory.
- RAMDAC on the video card reads the bytes of video data in the card's memory and converts digital data in memory to continuous analog signals that tell the monitor what to display.
- Vertical Scan Rate - how fast it takes to fill up the entire screen (75 Hz = 75 cycles/sec)
- Horizontal Refresh Rate - how many lines can be painted per sec. (75 KHz = 75,000 cycles/sec)
- Persistence-how long the phosphor glows after the electron passes it.
  - You need the persistence to be low and the scan rate to be high.
- Refresh rates for Multiscan and Multisync monitors
  1. Interlaced - refresh every other line in each vertical pass down the screen
  2. Non-interlaced - refresh every line on the screen every time
- Screen ratio of width:height should be 4:3 (aspect ratio) 320X200=8:5; 1600X1200=4:3.
- Monitor specifications - DB 15 high density VGA connector is the most common connector for PC monitors (it has 3 rows).
- Color Depth - how many different colors you can display at once. It is a function of dot pitch and resolution
- Color Memory - comes in .5, 1, 2, 4, or 8 MB. Modern cards have as much as 256 MB or more.
  - Calculated by multiplying the # of pixels displayed by the # of bytes used to represent the color of each pixel.

Resolution	Height x width (A)	# of colors	Bytes/pixel (B)	A x B	Video Memory needed
640X480	307,200	256	1	307200	0.5 MB
800X600	480,000	65,536 (High color)	2	960,000	2 MB
1,024X768	786,432	16 mill (True Color)	3	2,359,296	4 MB
1600X1200	1,920,000	16 mill (True Color)	3	5,760,000	8 MB

- 64 MB video memory is used for 3-D (several layers of 2-D. 4 layers of 2-d at 8MB requires 32 MB of video memory

Preventative Maintenance
- Turn off monitor
- Used gentle cleaner sprayed onto a lint free cloth

Alternatives
- LCD (liquid Crystal Device)-flat screen
  - disadvantages - not as bright as CRT's and must sit directly in front of them
  - advantages - uses less energy and do not emit electromagnetic radiations
- Virtual Reality games with special glasses as monitors
- Projectors

Printers

Problems can come from many different sources

1. Something physically wrong with the printer.

2. Printer driver may be faulty.
3. Printer settings in the Printer Control Panel may contain unwanted values
4. Page set up specifications in the application that is trying to print may not match the printer's capabilities
5. When upgrading-you need to install the software drivers

Types of Printers

1. Impact Daisy wheel
2. Dot Matrix - forms images out of dots that are created by a set of pins that strike an inked ribbon
   - heads contain 9 or 24 pins, initially 8 pins.
   - Repair-keep a well inked ribbon in the printer and keep mechanical parts free of dust and debris.
   - Print quality is Near Letter Quality.
   - usually limited to printheads.
3. Ink jet - aka bubble jet.
   - major appeal over laser printer. It can print in color for the same price as a B/W laser printer
   - ink is forced out of carefully aimed nozzles onto the paper
   - Methods of releasing ink:
     - thermal, or
     - piezoelectric
   - the higher the resolution, the smaller the drop of ink that is sprayed.
   - problem - if paper gets wet, color will run
   - solution - ink jet printers with wax cartridge
   - Repair - replace ink cartridge and use quality paper
4. Laser - print 1 page at a time using a combination of electrostatic charges, toner, and laser light.
   - It has several FRU's-toner cartridge, laser scanning assembly, high voltage power supply, DC power supply, paper transport assembly, transfer corona assembly, fusing assembly, and the formatter board.
   - use fully formed characters and print in letter quality (LQ)
   - Process the laser printer uses to produce the finished page:
     1) **Cleaning** - the Electrostatic Photographic (EP) drum is cleaned with a rubber blade.
     2) **Charging** or Conditioning- the EP drum is given a neg. charge (@-600 volts) by the primary corona wire.
     3) **Writing** - laser beam write to the EP drum causing portions of the drum to become almost positively charged (formed characters).
     4) **Developing** - toner is attracted to the areas of the drums that were hit by the laser light
     5) **Transferring** - transfer corona wire charges the paper with a positive charge. The EP drum turns as the paper runs beneath it and loses its toner to the paper.
     6) **Fusing** -The paper runs through the fusing assembly that is heated to 350 Degrees F. The fuser's high temperature and pressure fuses and melts the toner into the paper.

Connecting Printers

- Serial, parallel, USB, or infrared port, also via network.
- parallel port using parallel cable or USB port using USB cable.
- usually uses a 25 pin connector (DB25) to connect to the computer's parallel port and a Centronics connector to connect to printer.
- can use the RJ-45 connector on printers that have built-in Ethernet network interface connection.
- network connections need to have NIC on the computer appropriate for the topology of the network.
- data transfer rate for a parallel port is 150 KBps.

Other I/O devices

- **Scanner** - device that can convert printed images into a computer readable format. Takes a picture and stores it as a bmp file in the computer

  - types
    1. flatbed,
    2. hand held,
    3. sheet fed,
    4. film scanners,
    5. photo scanners

  - interfaces
    1. parallel (easy to use , but slow),
    2. serial
    3. SCSI port,
    4. and USB

- **Digital Cameras** - image is captured digitally and stored as a file on a floppy disk or removable memory card.

- **Still/Video Capture** - desktop digital cameras capture still or video images directly through the PC
  - 3D image-provides realistic 3D images through stereo viewing on systems ranging from PC screens to large screen projections.

- **DVD** (digital video device) - uses patterns of tiny pits on the disk's surface to represent data, which is then read by a laser beam.
  - Use a shorter wavelength than CD's so they can store more info.
  - PCI controller card decodes the information stored on the disc and separates it into sound and video data. It sends the sound data to be converted to an analog signal for the speakers, while sending the video data to the video controller card for the monitor.

- **CD-R** (recordable)/**CD-RW** (re-writeable)
  - CD-R's can play CD's as well as record them. CD's can only be recorded on once.
  - CD-RW's drives record on CD's that may be rewritten many times.

- **Microphones** - input to the sound card. Microphones change sound energy to electrical energy that sound card changes into digital info. Mic's are useless without a sound card.

- **Speakers** - output to the sound card.

- **Multi-function Machines** - combo. Scanner, printer, copier, and fax.

- **TV tuners** - converts TV signal into picture you can see on the computer's monitor.

Portable Computing

Portable Computers

- every one should have a PCMCIA slot.
- battery power is biggest limitation.

- **Types**
  - Desktop replacement,
  - Notebook, and
  - Sub-notebook.

- **Modes**
  - Quick start - power saving mode.
  - Deep sleep mode - drastically reduced power mode. Entered into after certain conditions (prolonged activity) have been met.
  - Speed step - technology that enables 2 different modes (maximum performance mode and Battery optimized mode.
  - Maximum mode - processor runs at its highest speed and normal internal voltage.
  - Battery optimized mode - the processor runs at a reduced speed and reduced internal voltage.

- **Storage systems** - portable hard drives capable of holding up to 25 GB of memory. Many hard drives are replaceable. Removable storage can be added to existing port, PCMCIA slot, or to floppy disk or CD-ROM drive.

- **Memory** - portables use either SIMM's or DIMM's (usually custom designed for each system)

- **Display** - portable use LCD (requires less power)
  1. Active Matrix - has 1 transistor for each pixel. Each transistor maintains the state of the pixel. Very clean image, better than CRT. Requires a lot of power.
  2. Passive Matrix - relies on persistence to maintain the state of the pixels between scans
     - has 2 groups of transistors (1 across the top of monitor and 1 across the left side of the monitor).
     - wires form a matrix that interconnect the rows and columns.
     - less expensive and less power hungry.
     - limited to 256 colors-Pointing Devices-trackball, trackpoint, trackpad.

- **Harddrives** - typically 2.5 inches.
- **Peripherals** - portables can't add expansion cards inside the computer.
- **Alternatives** - PC card, docking station, and ports.
- **Docking Station** (multi-port) - if full power, heavy duty peripherals are needed. The portable slides into docking station.
- **Port Replicator** - device that contains typical PC ports to enable user of portable to travel between multiple locations.

PDA's

- Personal Digital Assistants or palmtops.
- consist of a display/input area, a processor, and RAM.
- function as an electronic calendar, address book, calculator, maintain "to do" lists, send and receive e-mails, send and receive faxes, and take notes. Newer models are also cell phones and pagers. Other applications can be installed.
- used a pen based interface (stylus) or handwritten recognition.

PC cards

- credit card-sized devices connect to and draw power from the portable through a 68 pin male/female arrangement.
- can be hot-swapped.

- **Types of slots**
  - Type I - can hold 1 type I card.
  - Type II - can hold 1 type II card or 2 type I cards.
  - Type III - can hold 1 type III card or 2 type II's.

- **Cards**
  - Type I-3.3 mm thick, one row of sockets, used primarily to add to memory (RAM or ROM)
  - Type II-5 mm thick 2 rows of sockets, typically used for memory, i/o devices, NIC, LAN adapters, and SCSI connections. These usually have a pop out connection for an RJ-11c or RJ-45 connector.
  - Type III-10.5 mm thick, has 3 rows of sockets, most commonly used for hard drives or support adapters for external CD-ROM, DVD, and tape drives.
  - Extended cards also allow addition of components, which must remain outside the system (antennas, for wireless applications).

- Start up:
  - BIOS are permanent firmware. CMOS is controlled by a separate battery, RAM settings changed by BIOS need the battery to maintain settings.

Power Management

Batteries

1. NiCad (Nickel Cadmium)-lasts 3-4 hrs, up to 12 hrs to recharge, lasts 700-1000charge/recharge cycles. Memory effect.
2. NiMH (Nickel Metal Hydride)-environmentally friendly, 50% more power than NiCad, 400-500 charge/recharge cycles. No memory loss.
3. Li-Ion (Lithium Ion)-current industry standard.
4. Lithium Polymer-uses jelly like material as an electrolyte instead of liquid.
5. Zinc Air.

Power Management Systems

1. Advanced Power Management-provides several power saving options including
   - shutting off the display or hard drive,
   - suspending to RAM (Sleep mode or Instant mode). The system writes the data to memory and shuts everything down while keeping the data alive with a minute amount of power from the battery. Data could be lost if battery goes dead,
   - suspending to disk (hibernate) system writes data to disk and shuts off completely, no power is used, no data can be lost, turns on slower than suspend to RAM,
   - slowing the processor-system is on, but not involved in heavy duty calculations. Processor slows down, but can still handle user's needs.

2. ACPI (Advanced Configuration and Power Interface) - has 6 states. States S0-S5. S1-S4 are sleeping states.

S#	State	Power use	Software Resumption	Hardware Latency	System Context
S0	Fully operational	Full power	Not stopped	Not stopped	Not stopped
S1	Sleep	Slight reduction processor and bus clocks are off	Control restarts where left off	2 secs.	All retained
S2	Deeper sleep	Processor loses all power so data in its cache is lost	Starts from processor's restart vector	2 sec. or more	CPU context and system cache contents are lost
S3	Much deeper sleep	Processor and some system chips lose power	Starts from processor's restart vector	2 sec. or more	Only system memory is retained; CPU context, cache context, and chip set context are lost
S4	Hibernate	Power to all devices is turned off	Restarts from saved software file	Long, must power up everything	OS context; however, is maintained in a hibernate file
S5	Shut down	Power off	Must reboot	Long	None retained

Both APM and ACPI are BIOS based interfaces. They interact between OS and hardware

Lab Notes

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Networking

- server-computer on a network that manages resources for other computers on the network (ex. File server-stores files); Web server-sends out Web pages; e-mail server-organizes e-mail.
- Common hardware and software components of a network: server, client, media (physical means of communication between computer), resources, network adapter, network protocol, and network topology.

Types

1. LAN (Local Area Network) - usually cable based computers are directly linked together and housed in a clearly defined geographic area,
2. WAN (Wide Area Network) - usually satellite up link, fiber optic cable, routers, repeaters involved across the country or around the world (Internet is ultimate WAN),
3. MAN (Metropolitan Area Network) - confined to a single municipality,
4. SAN (Storage Area Network)-specialized LAN. Links several servers that are dedicated to storing large amounts of data in a central place,
5. VAN (Value Added Network) - provides both network access and additional proprietary services that are available only to its users,
6. EWN (Enterprise-Wide Network) - private network that connects all of an organization's computers no matter what the conditions.

Specialized network servers

- **network server**
- **print server** - manages network printers and print jobs.
- **communication server** - manages access to modems or other types of comm links.
- **database server** - stores large databases and runs database applications.
- **application servers** - any server that runs an application for access across the network.
- **mail server**
- **Internet or Web server** - both public Internet and private Intranet.

Network Licensing

- Either by seat (each person has a license) or by server (certain number of licenses per server) OS servers usually do not have client OS, but do have network OS.
- grouping by their capability to do more than 1 thing at a time.
- Multi-user - support 2 or more users at once.
- Multiprocessing - supports running a program on more than 1 CPU.
- Multitasking - supports more than 1 program running concurrently (time slicing).
- Multi-threading - supports different parts of a single program running concurrently.

Network Models

1. **Peer to Peer Architecture**
   a) can be set up in DOS, Win3.1, etc.
   b) limited to 10 computers or less.
   c) usually uses Net BIOS.
   d) one PC can transmit 1 bit of data at a time, which lowers throughput.
   e) allows for sharing of expensive peripherals, storage space, as well as having network security features.
   f) limitations: each computer needs to be available to support the needs of the other users, lots of

people are responsible for maintaining, controlling, and administering different parts of the network, security is not centralized.

2. **Client-Server Architecture**
   a) One centralized server manages resources and security for the other network users and computers.
   b) Everything that everyone uses is on the server.
   c) Uses network protocols instead of net BIOS (peer to peer).
   d) Word processing package is on the server (minimal files on individual PC's).
   e) Database files can go on the server.
   f) Important data should be on server, so it can be backed up by Admin Staff..
   g) It is possible to have multiple servers.
   h) Types of Client-server Servers:
      - PDS (Primary Domain Server)-keeps track of domains, passwords, usernames, and security.
      - Print server-controls the printer.
      - Application server-application is not stored in local workstation. Your workstations goes out to the server to get application and then loads it onto your PC.
3. **Combination Network Architecture** - hybrid of 1 and 2.
4. **Hierarchical Networks** - one or more central computers (mainframe) provides all the processing and resources to all other network nodes. Nodes can only perform specified sets of tasks (ATM machine).

Network Topologies

1. Point to point - computer to printer or computer to modem, etc.
2. Star topology - LAN
   - All nodes are individually connected to a central computer, multi-port repeater, concentrator, or hub.
   - Nodes can be added/removed easily; it will not affect the rest of the network.
   - If hub fails-the entire network fails.
3. Bus topology - LAN
   - Single main bus cable (backbone) transmits data to all nodes on the network.
   - Every node is directly connected to the main bus cable. Each segment of wire goes from NIC (Network Interface Card) on the computer to the bus cable.
   - Bus topology must be terminated on both ends (50 ohm resistor).
   - A break or faulty piece of cable anywhere can prevent all of the computers on the segment from being able to communicate.
4. Ring topology-LAN topology
   - All nodes are connected on a continuous loop w/ no end points and no terminators.
   - A packet called a token is passed from station to station. Only the machine w/ the token can transmit data over the network.
   - No other machine can send signals that will interfere with the signal from the machine with the token.
5. Mesh topology
   - Every node is connected to every other node in a point to point connection.
   - Redundant.
6. Hybrid topology-LAN topology that combines 2 or more or the other topologies.

Infrared Communications

- Technology that uses a beam of light to transmit data instead of cables,
- It uses a line of sight technology,
- Uses IrDA standards,
- Most commonly used to connect computers to printers,
- Data is transferred at a range of 4 Mbps (slow IrDA)- 9.6 Kbps (fast IrDA),
- Why bits? It is a serial transmission,
- Limited to 3-9 ft. between devices,
- An infrared connection must also be configured in Windows (2000, 98, and CE),
- Problems-object in the line of sight, devices are too far away from each other, bad or incompatible drivers.

Network Architecture Standards

- 802.XX-refers to network architecture (Ethernet)

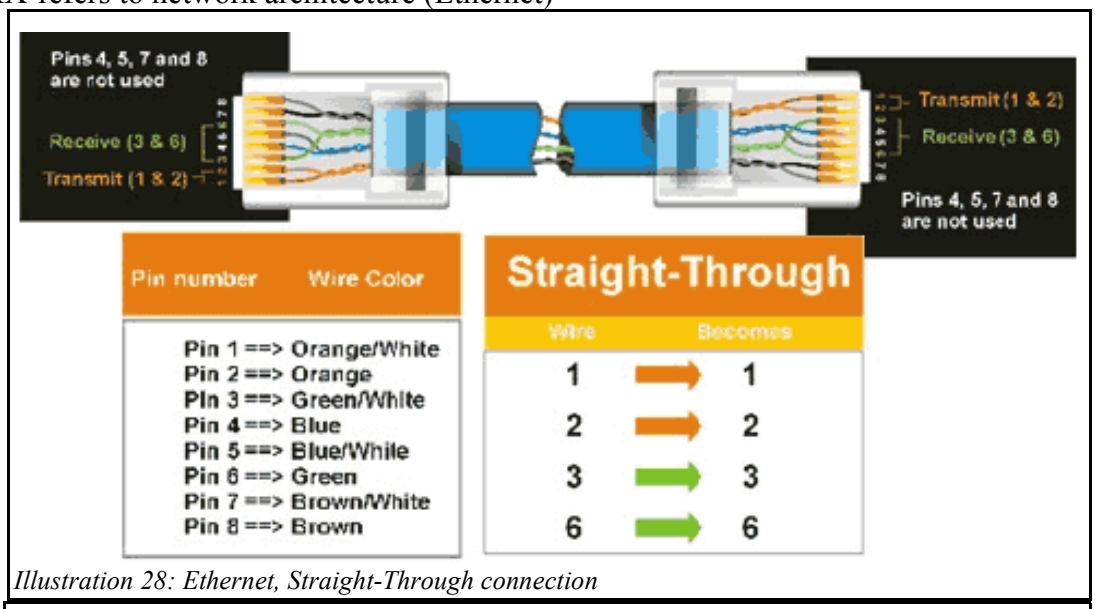

Illustration 28: Ethernet, Straight-Through connection

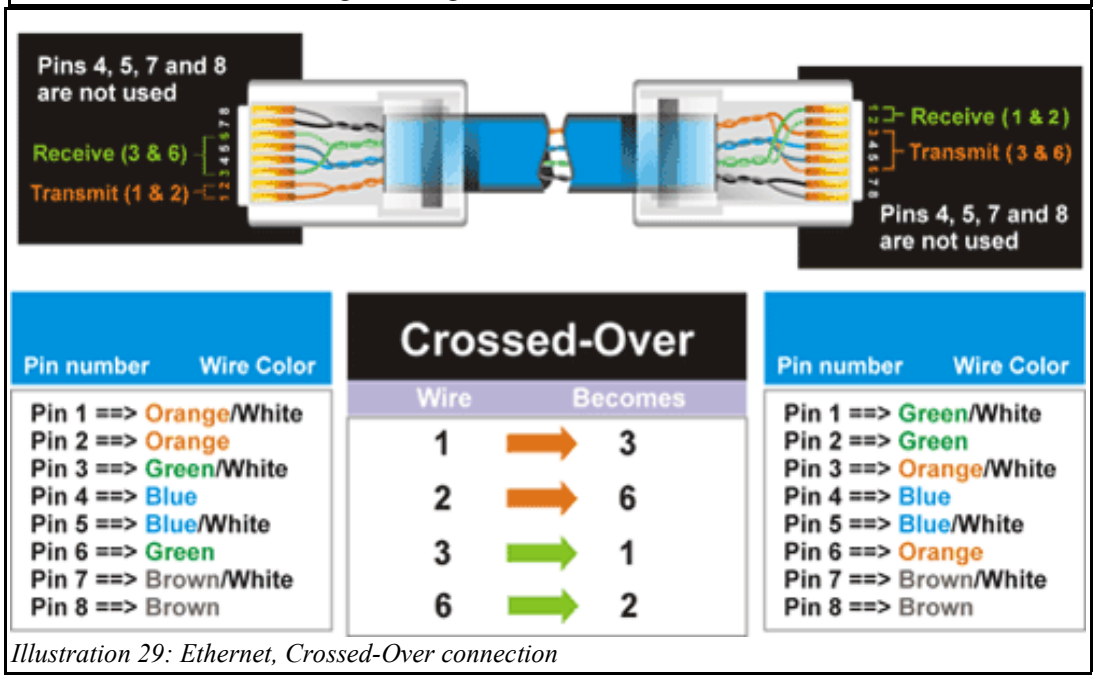

Illustration 29: Ethernet, Crossed-Over connection

Ethernet Description

- Is a LAN protocol that uses a bus or star topology.
- Most popular LAN technology in use today.
- Several standards in use:

Name	Max. data transfer speed	Max. length of cables	Other info.
10base5 (ThickNet)	10 Mbps	500 meters	Orig. standard, uses coax cable. 15 pin AUI conn.
10base2 (Thinnet)	10 Mbps	185 meters (607 ft)	Uses 50 ohm coaxial cable (RG –58 A/U). Also uses BNC connector, any unused connection must be terminated and needs to be terminated at the end and grounded at one end
10baseT (Twisted Pair Ethernet)	10 Mbps	100 meters	Also called twisted pair Ethernet, connects w/ RJ-45 connectors
Fast Ethernet (100baseT)	100 Mbps	Different lengths	Also have 100baseT4(2 pairs of twisted pair wires) and 100baseFL (fiber optic cables).RJ-45
Gigabit Ethernet	1000 Mbps (1Gbps)		

Ethernet Function

Three basic elements:

1. Physical medium (cables) used to carry signal
2. Set of media access control (MAC), which is a mechanism where rules are embedded in each Ethernet interface that allow multiple computers to fairly arbitrate access to the shared Ethernet channel.
   - Each MAC mechanism uses a system called CSMA/CD (Carrier Sense Multiple Access w/ Collision Detection).
   - Each Ethernet network interface card has a unique 48 bit address assigned to it by manufacturer (IEEE determines the 1st 24 bits and the company assigns the 2nd 24 bits). The 48 bit address is called the MAC address.
3. An Ethernet transmission consists of a standardized set of bits used to carry data over the system
   - 5-4-3 rule-guideline for limiting network size w/ multiple Ethernet segments.
   - Server and node should not be separated by more than 5 segments, 4 repeaters, and 3 populated segments.

Token Ring

- Type of computer network in which all the computers are connected in a continuous loop (ring topology).
- All stations on a Token Ring must transmit data at the same speed. If you want to upgrade a ring, you must update all network cards on the network.
- Token Ring uses MSAUs (Multi Station Access Units) (also MAUs) to connect network stations. They are similar to hubs w/ 8 port to connect stations and a Ring In and Ring Out port to daisy chain MSAUs.
- If Ring In or Ring Out ports fail, stations connected to that MSAU won't be able to communicate .

ARCNet

- Attached Resource Computer Network.
- One of the oldest, simplest, and least expensive LAN technologies.
- Can connect up to 255 nodes in a star topology using twisted pair or coaxial cabling.
- Originally could transmit at 2.5 Mbps; now ARCNet Plus transfers at 20 Mbps.
- Uses token technology.

AppleTalk
- LAN protocol.
- Currently transfer speeds are at 235 Kbps.

Network connectivity

The following connection devices fit into the OSI model at layers 1-3 (Network, Data Link, and Physical).

Hubs

Types:

1. **Passive hub** - (layer 1) simply forwards network messages. It does not process, modify, or regenerate signals at all.
2. **Active hub** (repeater or multi-port repeater-layers 1-2) - regenerates or amplifies in order that data bits maintain a strong signal that might otherwise deteriorate over a long distance. It allows computer on a network to be further apart.
3. **Intelligent hub** - provides intelligent functioning as well as forwarding signals. Provides bridging, routing, switching, and even more complex functions like network management and LAN.

Bridges (layers 1-2)
- Controls the flow of information between LAN segments or networks (even if they are different types of networks using different communication protocols).
- Allows a message to cross from one network to another if it is addressed to the other side.
- Local messages are not sent across the bridge, which makes traffic flow more efficient (switching-layers 1-2).
- Bridges build and maintain address tables of the nodes on the network to speed up the flow of data
- Bridges cannot determine the most efficient path.

Routers (layers 1-3)
- Determines the best path for the data packet to be sent from one network to the other.
- A router stores the electronic message, then reads the network destination address stored in the message, examines all possible paths to the destination address, chooses a path based on current traffic and # of other routers, and finally sends the message.
- Server with specific software that can function as a router.
- A router is smarter than a bridge. It takes more time to send message (slows down processing speed).

Brouters (layers 1-3)
- Functions as both a bridge and a router depending on which function is needed.
- Used on networks on which there is mixed protocol traffic and for networks that use protocols that do not support routing (NetBEUI).

Gateways (layers 1-4)
- Protocol converter that supports communication between networks that use different protocols.
- Gateways completely convert messages in one protocol to a message in a second protocol that is used by the destination network.
- Types of gateways:
  1) Protocol-connects networks that use different protocols.
  2) Format-connects networks that use different formats.
  3) Address-connects networks that use different file systems and directory structure.

CSU/DSU
(Channel Service Unit/Digital Service Unit)

- Service organization, either private or public, to assist with transmission media needs.
- You connect to their media to save yourself the installation and maintenance of your own.
- These organization sometimes require their customers to use CSU/DSU.
- CSU/DSUs are designed to shield network users from electric voltages and interference, and to ready data for transmission.
- CSU/DSU operates like a modem, but it's a digital-to-digital device (not digital-to-analog).
- Used with digital WAN links.
- Typically a CSU/DSU connects to a router or remote bridge.

Firewall

- Control network access both inbound and outbound.
- Used to prevent unauthorized access between Intranets and the Internet or an extra net.

OSI model

The Open System Interconnection has 7 layers with 7 sets of standards:

Layer	Name	Function
7	**Application**	Responsible for program to program communication.
6	**Presentation**	Manages data representation conversions of codes and formats
5	**Session**	Responsible for establishing and maintaining communication Channels
4	**Transport**	Responsible for end to end integrity of data transmission.
3	**Network**	Routes data from 1 node to another.
2	**Data Link**	Responsible for physically passing data from 1 node to another.
1	**Physical**	Manages putting data onto the network media and taking the data off. Provides the rules for transmission.

OSI Example

7 - Employees on the 7th floor convert input from a terminal or application program into a "message block", which includes the data (message contents) along with the sender's and receiver's addresses. When the block is complete, they pass it to the 6th floor. Application programs or terminals access the network only at this floor.		**7** – Workers here identify the receiving terminal or application program and display the message on the screen of the network user's microcomputer or pass it to the application program.
6 – Workers on the 6th floor convert code (EBCDIC to ASCII or vice versa), define the format of the data, and (when requested) encrypt the data and compress it before passing the message block to the 5th floor.		**6** – On the 6th floor employees convert code (ASCII to EBCDIC) and, if required, decompress and decrypt the message.
5 – Those on the 5th floor mark the beginning and ending of message blocks, set up a session connecting two terminals (log-in, passwords, user ID, etc.), end sessions, and determine whether the transmission will be half duplex or full duplex before passing the message blocks to the 4th floor.		**5** – 5th floor workers hold all message blocks until they have received the entire message, which they pass to those on the 6th floor.
4 – 4th floor employees divide very long message blocks into shorter message blocks for transmission, add a sequence number to each block, add a checksum for error detection, check for duplicate blocks, retransmit the blocks after an error or timeout, add security to message blocks, and pass the message blocks to the 3rd floor.		**4** – Those on the 4th floor recalculate checksums to confirm receipt of all message blocks and request retransmission of a block that appears damaged or is missing.
3 – 3rd floor employees resize the message blocks into packets (usually 128 characters) to meet specific network requirements, attach the addresses and sequence numbers to each packet, identify routes for packets through the network, and then pass the packets to the 2nd floor.		**3** – The 3rd floor workers recount incoming packets for error, security, and billing purposes, and reconvert the packets to message blocks.
2 – Workers here supervise the transmission. They insert the packet into a frame that becomes the envelope for carrying the packet during transmission, add a frame sequence number, confirm checksums for error detection, keep a copy of the frame to use for retransmission in case of error, and the pass the completed frame to the 1st floor for transmission.		**2** – On the 2nd floor they recalculate the checksum, request frame retransmission if there is an error, confirm arrival, and log-in the frame.
1 – The 1st floor is concerned with hardware, whereas the upper floors are concerned with software. The hardware on the 1st floor includes the RS-232 connector cables, modems, and circuits. What began on the 7th floor as a long message block is now sent over the circuits as a frame containing a packet in the form of a serial stream of bits.	Packet/Frame ► 1001010 ►	**1** – 1st floor employees reconvert the bits into frames.

This depicts the OSI model as a seven-story office building in which people handle messages instead of software programs doing the work. A message to be sent across the network enters the OSI software at the seventh floor, travels down to the first floor, goes out the front door, travels across the network, and reaches the other building, where it travels through the front door and up to the receiving terminal on the seventh floor of that building.

Network Media

Twisted pair

- Consists of 2 independently insulated 22-26 gauge wires twisted around one another.
- One wire carries the signal, the other is ground and absorbs signal interference.
- Least expensive.
- UTP (unshielded twisted pair)no shielding ; lower price, but higher electrical interference).
- STP (shielded twisted pair) wrapped in a metal sheath for extra protection from external interfering signals.
- TP is connected w/ RJ-45.
- 10baseT and 100baseT Ethernet standards are based on TP cables.
- Cat-5 (category-5)-network cabling that consists of 4 TPs of wire terminated by an RJ-45 connector.
- Used in Token Ring, 1000baseT, and 10baseT networking.

Coaxial

- Single conductor which is surrounded by insulation and a conductive shield, w/ heavy protective covering over the shield.
- More expensive, but can carry more data w/ less resistance.
- BNC connector are used to connect coaxial cables (like RG 58 A/U) into a network.
- 10base5 and 10base2 Ethernet standards use coaxial cable.

Fiber Optic (FDDI)

- Glass core w/ 2 layers of buffers.
- Carries a pulse of laser light (light waves) through bundles of glass or clear plastic threads which is encoded w/ a digital signal.
- Not affected by electrical interference and electromagnetic radiation.
- Differs from TP because TP carries electrical signals through metal wires which are subject to electrical interference and electromagnetic radiation.
- Fiber optics can carry much more data, faster, and over greater distances.
- Support data rate of up to 100Mbps and 1000 Mbps (1Gbps).
- More fragile and more expensive, difficult to maintain.
- Uses FDDI (Fiber Distributed Data Interface)-set of ANSI protocols for sending digital data over fiber optic cable.
- FDDI networks are typically the backbone for WANs.

Fixing faulty network cables

Tools needed:

1. Digital Volt Meter - measures AC and DC voltage, resistance, and current flow.
2. Time Domain Reflector - tests cable integrity by sending electrical signals into it and analyzing their reflections.
3. Oscilloscope - also used to test cable integrity. It provides a graphical output.

Wireless Communication

- Networks not connected by wires.
- Enabled by packet radio, spread spectrum, cellular technology, satellites, and microwave towers.
- Infrared is also considered wireless.
- CDPD (Cellular Digital Packet Data)-data transmission technology that uses unused cellular channels (in the 800-900 MHz range) to transmit data in packets.
- Offers transfer rates up to 19.2 Kbps, quicker call set up, plus better error correction than modems

and analog cellular channels.
- MMDS (Multichannel Multi-point Distribution Service or Microwave Multi-point Distribution Service).
- Sending and receiving stations must be in sight of each other, up to 30 miles apart.
- LMDS (Local Multi-point Distribution Service).
- Extremely fast wireless communication.
- Requires line of sight between transmitter and receiver antenna from 1-4 miles.

Network Adapters (NIC) (OSI layer 2)
- Connect directly to the cable carrying the electronic signal throughout the network.
- They are either built into the system boards circuitry or added into a slot on the system board.
- Can also connect through parallel port, or special PC card in portables.

Typical Ethernet NICs
- Fits into any ISA or PCI slot.
- Sends/receives data at 10 Mbps and/or 100Mbps.
- NICs have an integrated transceiver built into board that allows data to be sent/received over the network cable.
- NICs also have software to support MAC data link protocol built into firmware on the card.
- Every NIC has a permanent, unique Ethernet address burned into PROM on the card.
- The electronics on the card determine the type of media that the card will connect to.
- If it supports 10base5(thick Ethernet) - use a 15-pin AUI (Attachment Unit Interface) that connects to an external transceiver that connects with a ½" thick coaxial cable.
  - If it supports 10base2 (thin Ethernet) - use a BNC connector.
- If it supports 10baseT - use an RJ-45 connector that uses UTP cables.
- 100BaseTX - supports 100 Mbps through 2 pairs of wires in Cat-5 twisted cable.
- 100baseT4 supports 100 Mbps on 4 pair of wires in Cat-3, 4, or 5.
- If the card supports 10base FL or 10baseF-the card will have a socket to which the fiber optic cable is attached.
- Wireless cards go into slots on the system board and have an antenna built in.
- Other Ethernet adapters can communicate to the computer through the USB port and parallel ports.

Half and Full Duplex Communications
- Half Duplex-possible to transfer data in 2 directions, but only 1 at a time.
- Full Duplex-data can be sent and received over the same medium at the same time (typically uses CSMA/CD) to deal w/ data transmission collisions.

Network Communication Protocols
TCP/IP

(Transmission Control Protocol/Internet Protocol)

1. Uses binary.
2. Used to connect hosts on the Internet and is now the global standard for communication protocols.
3. Supported by all network OS's.
4. TCP/IP uses several protocols, including 2 transport protocols:
   a) TCP provides transport functions, which ensures that the complete message is received correctly at the other end.
   b) UDP (User Datagram Protocol)-alternate transport that does not guarantee delivery.

Used when a reliable delivery is not needed.

5. IP specifies the format of packets (datagrams) and the addressing scheme.
6. An IP address identifies a computer or device on a TCP/IP network.
7. The TCP/IP protocol routes messages based on the IP address of the destination node.
8. IP address is made up of 4 bytes (32 bits).(ex. 145. 231.76.139).

Classes of IP addresses:

Designated by using varying portions of the IP address to identify network (domain) and host (client).

1. Class A - 1st byte identifies network (domain) address; the other 3 bytes define host (client) address.
   - Supports only a small # of network (domain) addresses-254 (2 to the 8th-2); support a lot of host addresses-16,777,214 (2 to the 24th-2).
   - Example: 255.0.0.0
   - Range for 1st byte in decimals-1-127.

2. Class B - 1st 2 bytes are for network (domain) address; the other 2 are for host (client) addresses.
   - Supports medium # of network-65,534 (2 to the 16th-2) and host addresses (65536-2 to the16th)
   - Example: 255.255.0.0
   - Range for 1st byte in decimals 128-19.

3. Class C - 1st 3 bytes are for network (domain) address; the other 1 is for host (client) addresses
   - Supports a large amount of network addresses-16,777,214 (2 to the 24th-2) and small amount of host addresses - 254 (2 to the 8th-2).
   - Example: 255.255.255.0
   - Range for 1st byte in decimals-192-223.
4. There are Classes D and E, but not supported by Microsoft.

IP addresses for internal use only:

- Class A - 10
- Class C - 192.16.32.XX

Sub-Nets

- Network segments are called subnets if each network segment's address must be derived from a Single IP network address.
- Sub-netting (segmenting if not connected to Internet)- subdividing a single network address to allow for unique network addresses on each subnet (segment).
- Subnet mask-tells you which class network (domain) address you are in.

Reasons for sub-netting

1. Reduce traffic by dividing a large network into smaller segments by using a router.
2. Avoids physical limitations such as max. cable length or max. # of computers on a segment
3. Decreases CPU load.
4. Helping with troubleshooting by minimizing the impact of a subnet problem on other subnets.
5. Increasing security by limiting sensitive network traffic to one network.
6. Connecting different topologies such as Ethernet, Token Ring, and FDDI together via routers:
   - To be able to assign unique network addresses to each network-you need to use subnet masking.
   - Enables you to restructure how each IP address in your organization is divided between the network portion and the host portion

IPX/SPX

- IPX (Internetwork Packet Exchange)-works at layer 3 of OSI model.
- Routes datagrams from 1 node to another, and does not guarantee delivery of complete message.
- IPX packets contain the network addresses of the sending and destination nodes, so packets can be routed from 1 network to another.
- SPX (Sequenced Packet Exchange)-usual transport layer 4 protocol that works with IPX to guarantee that packets that were sent can be accurately assembled into the entire message by the destination node.

NetBEUI

(NetBIOS Enhanced User Interface):

- Works at layer 4 (transport layer) of OSI model.
- Not a routable protocol.

Common Network Problems

1. Reduced performance due to reduced bandwidth:
   a) Bandwidth is the max. amount of data that can be sent across the network cable per second.
   b) The higher the bandwidth, the higher the throughput.
   c) All devices share the available bandwidth and the max. cannot be exceeded.
   d) Reduced bandwidth is typically the result of too much traffic (either from increased user activity or malfunctioning device (bad NIC)) on the network cable.
   e) Transmissions may time-out, software may freeze, and users will notice a decrease in performance.
   f) Use network or protocol analyzers to identify where the loss is happening:
      - bad device - replace it.
   g) Heavy usage - you can increase the available bandwidth by changing the network's speed (need to replace NICs, hubs, and possibly cabling).
   h) Separate high traffic network segments from low traffic network segments and upgrade only the high traffic segments.
2. Loss of data occurs due to malfunctioning equipment (defective NICs, damaged cabling, non-working hubs, interference, missing terminators, and so on). Also could be due to packet collision:
   a) Use a network analyzer to identify problem and also check the collision lights on the hubs.
   b) Breaking up the network can reduce incidence of collisions.
3. Network slowdown means the network has suddenly become slow.
   a) Could be caused by excessive traffic on the network, but usually this slowdown would be gradual.
   b) Suspect a hardware problem if slowdown is sudden.

Sample System Resource Map

PC Make and Model: _____

Serial Number: _____

Date:

IRQ	IRQ Channels	I/O Addresses
0	Timer Circuits	040 - 04B
1	Keyboard/ Mouse Controller	060 - 064
2	2nd 8259 IRQ Controller	0A0 - 0A1
8	Real-time Clock/CMOS RAM	070 - 071
9		
10		
11		
12		
13	Math Coprocessor	0F0 - 0FF
14		
15		
3		
4		
5		
6		
7		
	Devices not using Interrupts	I/O Addresses
	Mono/EGA/VGA Standard Ports	3B0 - 3BB
	EGA/VGA Standard Ports	3C0 - 3CF
	CGA/EGA/VGA Standard Ports	3D0 - 3DF
DMA	DMA Channels	
0		
1		
2		
3		
4	DMA Channel 0 – 3 Cascade	
5		
6		
7		

Alphabetical Index

Illustration Index

Student Forum information sheet

Full Student Name:_____

Phone number:_____

Active Student Email account:_____

Student Email password:_____

Student Forum Username:_____

Student Forum Password:_____

Receipt for Pre-Tech Class books

At one time there was some question about whether or not a book had been ordered and paid for. In order to overcome any problem of this type in the future, I have decided to include a receipt here that can be filled out and signed by both the Student and the Instructor to record any transaction. I am not here to make money from book sales. If you would prefer to purchase your own books, you are free to do so. If you want me to purchase them for you, I will require cash in advance and this receipt must be filled in properly.

Please be advised that if the books are not in stock it may take as much as 7 business days before they are available. I will take orders the first week of class and will pick all books up at the same time. If you do not place an order but would like to get the books later, you may get them from Barnes and Noble Booksellers.

Student copy: Student Name:

Book Name	Retail Price	Tax	Total	Class cost	Amount given instructor (Both initial)
A+ Certification for Dummies	$34.99	$2.10	$37.09	$31.50	
Class Workbook			$10.00	$10.00	
Total			$47.09	$41.50	

Book(s) delivered to student:

Student signature:_____

Instructor Signature:_____

Cut here

Instructor copy: Student Name:

Book Name	Retail Price	Tax	Total	Class cost	Amount given instructor (Both initial)
A+ Certification for Dummies	$34.99	$2.10	$37.09	$31.50	
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