Design and Build a Personal Computer

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### Build it yourself vs. Buy?
(Ask yourself if you agree to the following advice from PC Magazine)

<table>
<thead>
<tr>
<th>Build</th>
<th>Buy</th>
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<tr>
<td>If <strong>average-performing</strong> PC, you can maybe save money since everyday prices competitive with what PC manufacturers pay</td>
<td>If <strong>high-performance</strong> PC, manufacturers (e.g., Dell), who <em>mostly</em> assemble <strong>OEM</strong> parts, probably do it cheaper since they buy parts in bulk at prices not available to everyone yet</td>
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<td>You can ensure <strong>industry standard Original Equipment Manufacturer’s (OEM)</strong> parts (unlike Dell who <em>might</em> use their own proprietary parts)</td>
<td>Learning <strong>curve</strong> not as steep</td>
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<td>Learning is fun</td>
<td>More comprehensive warranty and service (e.g., you don’t have to <strong>diagnose</strong> problem, <strong>or fix</strong> it)</td>
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<td><strong>You control design</strong> (both initial, and any required fix or upgrade)</td>
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PC Design Steps
(Note that steps 1 and 2 should be done at the same time),
And you may want to do step 3 first

1. Pick **CPU** (and number of cores and chip set)
2. Pick **RAM** “main memory” and **Motherboard**
3. Pick **Graphics Board and Monitor**
4. Pick **Drives**
5. Pick **other specialty boards**
6. **Power**
   - **Clean** (a concern for networks and factory settings)
   - **Sufficient Supply**
   - **Cooling**

Think about **FUTURE PC’s**
PC Design Steps (Pick CPU)

- Choose by CPU clock speed
  - CPU fastest thing on motherboard
- Choose Intel or AMD (Advanced Micro Devices) brand (same family!)
- Much more $ for “bleeding-edge” (better to buy hottest from six months ago)
- 64-bit processing now common (for both data and addresses)
  - big chunks of data (e.g., multimedia)
  - large address space (bigger than physical RAM -- i.e., virtual)
- Dual-core, (two CPU chips in package), Quad-core, or Dual Dual-core options
  - Don’t assume speed-up proportional, yet!
- Cache(s) common “on-chip” (sometimes just in same package, but can be on same chip -- i.e., same piece of silicon)
  - Typically L1 cache now integrated into CPU
  - Typically L2 cache connected to CPU via “Back-Side-Bus” (in same chip-package!)
- Consider cooling requirements (e.g., heat-sink, dedicated-fan, heat-pipe, liquid)
PC Design Steps (Pick RAM “main memory”)

- Pick motherboard at same time (i.e., to match bus speed)
- RAM (Random Access Memory) used as “Main Memory” in PC
- Dual In-line Memory Modules (DIMM’s) plug into sockets on motherboard
- This “Main Memory” is DRAM
  - (i.e., Dynamic -- volatile and needs to be refreshed)
- Many variations of DRAM; some more recent:
  - DDR (Double Data Rate) uses both positive and negative clock edges
  - DPRAM (Dual-ported RAM) allows multiple reads or writes at nearly the same time
- Also, motherboard may have Dual-Channel capability to allow two banks of RAM to work concurrently

- Caches use SRAM
  - (Static -- although volatile, does not need to be refreshed, also faster, but less dense and more expensive)
PC Design Steps (Pick Motherboard)

- Match speed of CPU, RAM, and Motherboard Front-Side-Bus (FSB) which connects CPU and RAM
- Make sure it has socket to plug in your CPU (i.e. Intel or AMD)
- Make sure it has correct chip-set to handle your CPU, RAM, Graphics Card, and other I/O needs

**Northbridge** for RAM and video card control,

and restricts overclocking

**Southbridge** for power, clock, and other I/O control

Images from:
https://en.wikipedia.org/wiki/Northbridge_(computing)
PC Design Steps (Pick Motherboard)

- May want **Dual-Channel** capability (can handle two banks of RAM concurrently)
- Make sure Motherboard can **handle your Graphics Card** (NVIDIA, CrossFireX, etc)
- Expansion Slots for boards to plug into.
  - **AGP** ("Accelerated Graphics Port")
  - **PCI** (maximize speed and number of slots)
  - **ISA** (almost obsolete)

OR **PCIexpress** (not a bus protocol)

**ISA, PCI, and AGP** use memory-mapped I/O using Bus protocol,
**PCIexpress uses a packetizing SERIAL protocol** like that used for Ethernet TCP/IP

Image from: [http://ist94.wikispaces.com/motherboards](http://ist94.wikispaces.com/motherboards)
Image from: [https://lenovopress.com/tips0456](https://lenovopress.com/tips0456)
DATAGRAM (i.e., a “Packet”) for TCP/IP (Transmission Control Protocol/Internet Protocol)

From TCP tutorial (http://www.ssfnet.org/Exchange/tcp/tcpTutorialNotes.html):

TCP HEADER
TCP data is encapsulated in an IP datagram. The figure shows the format of the TCP header. Its normal size is 20 bytes unless options are present:
SrcPort and DstPort fields identify source and destination ports. These plus source and destination IP addresses combine to identify each TCP connection.

Sequence number identifies byte in data stream from sending TCP to receiving TCP that the first byte of data in this segment represents.

Acknowledgement number is next sequence number that sender of acknowledgement expects to receive. i.e., sequence number plus 1 of last successfully received byte of data. This field is valid only if ACK flag is on. Once a connection is established Ack flag is always on.

Acknowledgement, SequenceNum, and AdvertisedWindow involved in TCP's sliding window algorithm. The Acknowledgement and AdvertisedWindow field carry info about flow of data going in other direction. In TCP's sliding window algorithm receiver advertises a window size to sender using the AdvertisedWindow field. The sender is then limited to having no more than a value of AdvertisedWindow bytes of unacknowledged data at any given time. The receiver sets a suitable value for the AdvertisedWindow based on the amount of memory allocated to the connection for the purpose of buffering data.

Header length (in 32-bit words) Required because length of options field is variable.

6-bit Flags field used to relay control info between TCP peers. SYN and Fin flags for establishing and terminating a TCP connection, ACK flag is set any time Acknowledgement field is valid, implying that the receiver should pay attention to it. URG flag signifies this segment contains urgent data. When set, UrgPtr indicates where non-urgent data in this segment begins. PUSH flag signifies sender invoked push operation, which indicates to receiving side of TCP that it should notify the receiving process of this. RESET flag signifies receiver has become confused and so wants to abort connection.

Checksum (FOR ERROR DETECTION) is a mandatory field calculated by sender, then verified by receiver.

Option field is maximum segment size option, called MSS. Each end of connection normally specifies this option on first segment exchanged. It specifies maximum sized segment sender wants to receive.

Data portion of TCP segment (optional, but it’s the actual data you are most likely trying to send!) i.e., everything else is communication overhead!!
PC Design Steps (Pick Motherboard) cont.

- **On-board Connectors**
  - **Jumpers** are connectors for electrical pins sticking up from motherboard
  - To set: (1) CPU frequency; (2) Front Side Bus frequency; (3) CPU voltage
  - Now many motherboards have auto-detection to do this for you
- **Disc Drive Connectors**
  - **IDE** pins sticking up from motherboard ("parallel" ATA)
  - **SERIAL ATA** (newest), flat red cable from motherboard
  - **RAID** (Redundant Array of Independent Disks) (redundant drives for fault-tolerance)
- **ATX Power Connector** from power supply for 3.3 volts, 5 volts, and 12volts DC
  - 3.3 and 5 volts for digital logic circuits (e.g., CPU, RAM, chip set, etc.)
  - 12 volts for fan, disk drives, motors, etc.
  - May need special power for sophisticated cooling systems
- **USB (Universal Serial Bus)**
  - Replacing all Parallel and Serial
    - Like DIN-5 PS/2 and AT Keyboard jacks
  - >100 peripherals simultaneously
  - Hot insertion and removal
- **eSATA** for external storage
- **SCSI (Small Computer System Interface)**
  - Connect multiple Hard drives
- **FireWire** for cameras and portable storage
- **Network** Ethernet jack “Rj-45”
- **Dial-up** phone jack (modem) “Rj-11”
- **VGA (Video Graphics Array)**
- **DVI (Digital Visual Interface)**
- **Audio** jacks
- **HDMI (High-Definition Multimedia Interface)**
  - Audio and Video
PC Design Steps (Pick Motherboard) cont.

- Optical Audio “Toslink”
- USB A
- Firewire 4 pin iLink
- Firewire 400 1394a
- Firewire 800/3200 1394b/c
- Ethernet 8P8C common RJ-45
- Modem RJ-11
- Apple Desktop Bus – AD8
- Mac Serial
- PS/2
- USB A 3.0 (2008)
- DE–9F
- DB-25 Serial/Com Port
- DE-9 Serial RS232
- E-SATA

SEE ALSO USB C
PC Design Steps
(Pick Motherboard) cont.

- Centronics Parallel 36pin
- Centronics SCSI 50pin
- AT Keyboard
- 50 pin SCSI 2
- Surround sound
- Stereo/headphones, Line In, Mic
- Digital Audio RCA plug style
- AAUI
- Composite Audio / Video
- S-Video
- Component Video
- F-Connector RF/COAX

**SUMMARY** of Audio and video interfaces and connectors
PC Design Steps (Pick Motherboard) cont.

- Parallel Port/ **SCSI 1** /DB-25F
- Mac Video/MIDI/ gameport /AUI/DA-15
- Mini DisplayPort
- Mini-DVI
- Mini-VGA
- Apple Hi-Density Video HDI-45
- Apple Display Connector –ADC
- LFH60 (Dual DVI-0)
- DMS59 (Dual DVI-D)
- HDMI
- Micro-DVI
- DisplayPort
- DVI Video
- DE-15/HD/15 VGA/SVGA
ROM BIOS CHIP (Basic Input/Output System)
- ROM (Read Only Memory) is now actually writable since it is in a flash memory accessible through your “CMOS” setup during boot-up
- On system power-up, BIOS does:
  
  A) POST (Power On Self Test) to:
  1. Verify integrity of BIOS code
  2. Determine reason POST executed
  3. Find, size, and verify system main memory
  4. Discover, initialize, and catalog buses and devices
  5. Provide a user interface for systems configuration
  6. Identify, organize, and select which devices available for booting
  7. Construct system environment required by target OS

  (from wikipedia)

B) Load Operating System from disk into RAM, then start it executing
PC Design Steps (Pick Motherboard) cont.
Some other info on motherboards (not typically design considerations)

- **Clocks**
  - Quartz crystal contained in an oblong can, oscillates at a precise fixed frequency when an electrical current is applied to it
  - Crystal made by grinding a slice of Quartz to a precise thickness to yield a fixed frequency pulse when electrically stimulated
  - All clock frequencies derived from this (e.g., CPU, RAM, FSB, PCI, AGP, PCIe, ISA, USB, etc)
  - Overclocking CPU possible by setting “Multiplier” in CMOS setup or by adjusting jumpers (e.g., 1GHz main clock and Multiplier=4 yields 4GHz CPU speed) -- a good way to burn-up your CPU if you don’t change cooling too

- **DMA** (Direct Memory Access) to allow direct link between RAM and I/O
  - Frees-up CPU

- **Battery** so date and time maintained when power off
Sample Motherboard, Can you guess how recent?

Image From: http://www.computerhope.com/jargon/m/mothboar.htm
Sample Motherboard, Can you guess how recent?
Sample Motherboard, Can you guess how recent?
Sample Motherboard, Can you guess how recent?

Image From: http://www.computerhope.com/jargon/m/motherboard.htm
PC Design Steps (Pick Graphics Board and Monitor)

- We will have an entire lecture on this
PC Design Steps (Pick Drives) cont.

- We will have an entire lecture on this
PC Design Steps (Pick other specialty boards)

- We will have an entire lecture on this
Providing Clean Power

A concern for networks and factory settings

- We will have an entire lecture on this
Basic Principal: As the number of transistors that fit on a chip increases, the number of chips on board goes down. Good because:
- Less soldering problems
- Less chance of stray capacitance or inductance of conducting pathways on Printed Circuit Board (PCB)
- Less distance between components (therefore faster communication speeds and less chance of signal degradation)
- Cheaper

On the horizon, or already happening now:
- 3-D silicon circuits with all caches, RAM, chip-set, DMA, graphics capabilities, communications, etc. on single chip (or wafer or cube)
- Super cool the whole thing
- Neural Network circuits
- Network type CPU multi-core architectures that actually speed up with more cores
- Pack it all in a small box (maybe in the back of the monitor)
- One universal connector for everything (i.e. a super USB)
- Super small external portable storage
Maybe will will live inside the network or it will live inside us

- Virtual and Augmented Realities replacing real physical experiences?
- The Matrix?
- The Borg?
- Surrogates?