

How to Build an 8-Core Hyperthreaded Monster Computer on a Budget

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IEEE Computer Society

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My Uncle's Motto

If you are going to do a job
Do it right
Or don't do it at all

(Note: My uncle was a master die-maker)

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Introduction

- My Birthday gift
- 8 core hyper-threaded computer
 - Performs like 16 cores
- Designed for parallel processing of linear algebra (matrix manipulations) & mathematics
- Will use OpenSuse Linux for OS
- Not for gaming or server

Why Build Your Own?

- Opportunity to learn
- Can be rewarding
- Have special purpose or need
- Can save money
- Challenge
- I built mine because:
 - Enjoyed doing it, feel accomplishment
 - Reliability
 - Cost
 - Performance (specific application)

Advantages

- Build it the way that you want it
- Ability to add when new things are available
- Repair it yourself when needed
- Reliability (use best quality components)
- Price (watch for sales and rebates)
- Performance (a specific task) & features
- Pride
- Opportunity to learn

Disadvantages

- Can not blame someone else
- Can not just pickup whole thing and bring in for service
- Have to learn, gain skills
- Hard work
- Have to keep it away from know-it-alls
- Need to have time and patience, willingness to research and study, fail until succeed

Where to Start

- Decide if this is a task that you would like to do
- Make specification list of what you want it to do (this is most important, do not just say that you want a killer machine)
 - Gaming
 - Mathematics (like me)
 - Graphics and/or video
 - Impress people (e.g. RGB lighting?)
 - Which programs are main ones used
- Decide on budget
 - Money
 - Time
 - Space (room to build it and to put it when completed)

Design Comes First

- What do you want it to do?
- What do you need it to do?
- What will you use it for?
- How long will you use it before replacing it?
- How many hours per day will it be on
- What functions will your most important programs use?

Considerations

- Think of the programs that you will be using
 - Will they utilize multiple cores?
 - Will they utilize GPGPU?
- Will it be a server or workstation?
- What Operating System?
- Virtual Machines? How many?
- How much memory will you need?
 - Can no longer just add down the road

Necessity of a Plan

- Must have a blueprint before building



My Needs

- Mathematics and Linear Algebra
 - Intelligent decision making
 - Large memory for matrices
 - Ability to use GPGPU
- Multicore for multiprocessing
 - Intel Fortran, Octave, NumPy, Maxima, etc
 - SIMD and MIMD
- Room to add
- No gaming
- Reliable
- Fit a budget

SISD, SIMD, & MIMD

Flynn's Taxonomy

- Single Instruction, Single Data stream
 - 1 process on 1 item
 - Ex: 1 towel and 1 washing machine
- Single Instruction, Multiple Data streams
 - 1 process on many items
 - Ex: many loads of laundry with washing machines
- Multiple Instruction, Multiple Data streams
 - Many processes on many items
 - Ex: many loads of laundry for wash, dry, & iron

Hyperthreading

- Think of fast clerk
 - Sitting at two windows
 - While waiting for forms from person at window #1 he is processing papers from window #2
- Appears like two clerks
 - Really only one person
 - Not wasted time waiting
- Hyperthreaded CPU appears to be twice as many cores by working while waiting
 - Data coming from memory or hard drive is much slower

Importance of Multiprocessing

- Program can execute in less time
- A neural network can be programmed in matrices
- Allows for different functions to be simultaneously run and can fit together like pieces of a puzzle
- My example of speedup
 - 1500 x 1500 matrix complex-8 on 6 core CPU
 - 64 seconds on 1 core, 11 seconds using 6 cores
 - This machine (no GPGPU) 2.964 seconds
 - Windows machine >5 minutes

Material List

- Case
- Motherboard
- CPU and Cooler (and thermal compound)
- Power supply (PSU)
- Memory (speed, quality, and how much)
- Graphics card (sometimes built into motherboard)
- Electromagnetic (hard) and solid state drive(s)
- Optical drives
- Other things (cables, hardware, cable ties, etc)

Reality Check

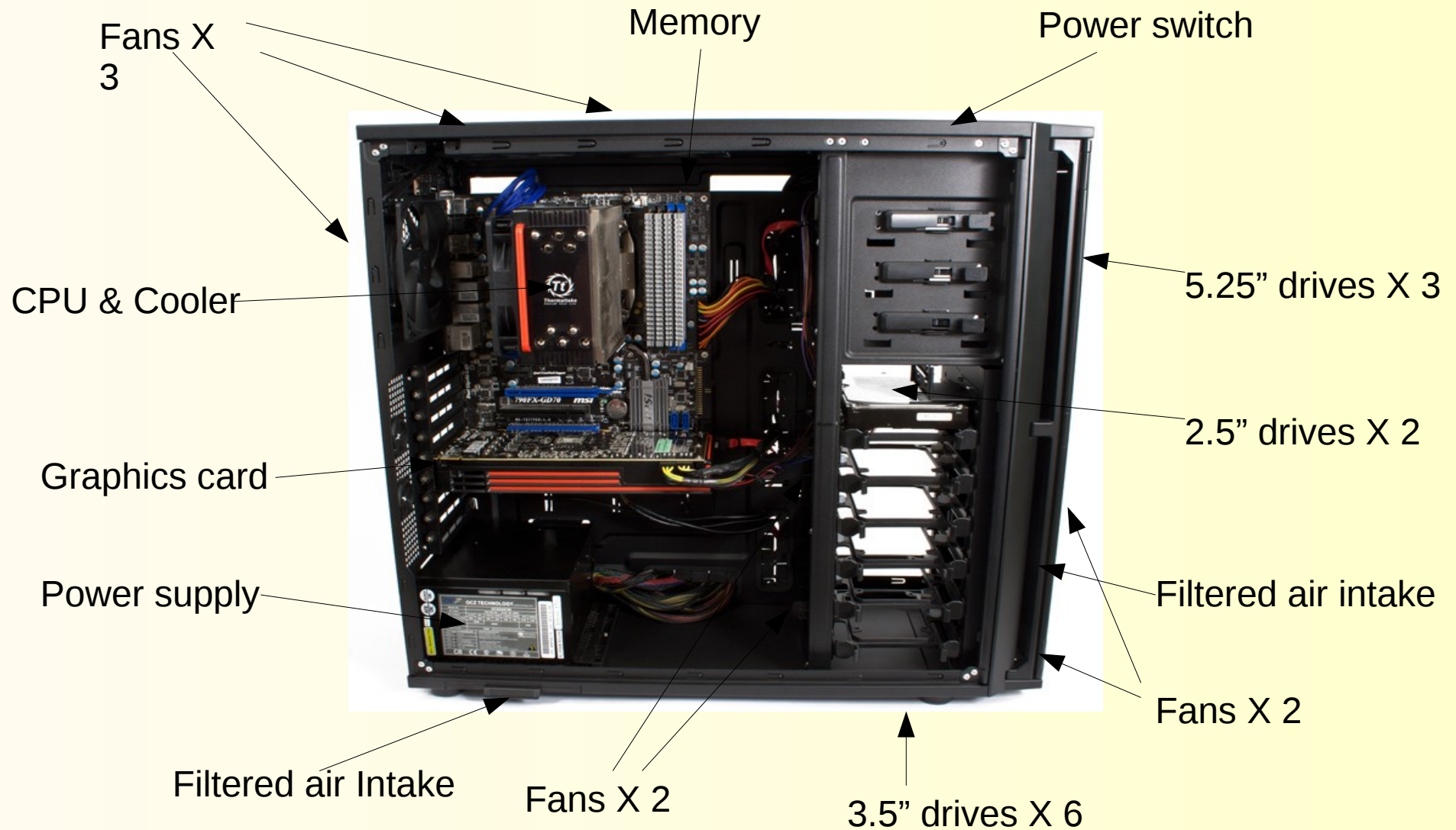
- There is always better and faster
- Know the difference between need and like
- Know that it will be replaced with better in a day
- Know when to stop
- Draw the line
- My experience:
 - I just got this up and running and now AMD releases the 3000 series 2nd generation

Product Specifications: Case

- The bigger cases are easier to work with, less cut hands, more room to grow
- Big cases take up more room at desk
- Big cases usually cost more
- Number of cooling fans
- What size motherboard
- How many drives and what kind(s)
- Sound deadening

My Computer Case

Antec P-280



My Case

Wiring Side

- Wiring on this side, hardware on other side
- Not only makes it neater, but gives airflow
- Need longer cables
- Only few cases have wiring side separate



Product Specifications: Motherboard

- Brand reputation and tech support
- Read reviews
 - Read between the lines
 - Not all products of a manufacturer are the same quality
- Which CPU – AMD or Intel (many differences)
- Which socket
- How much Memory, what speed
- Specs for YOUR needs
- How many and what kind slots
- Drive ports (IDE, ATA, SATA, M2)
- I/O ports
- What kind of fans does it support (LP4, 4 pin, 3 pin, PWM)

My Board

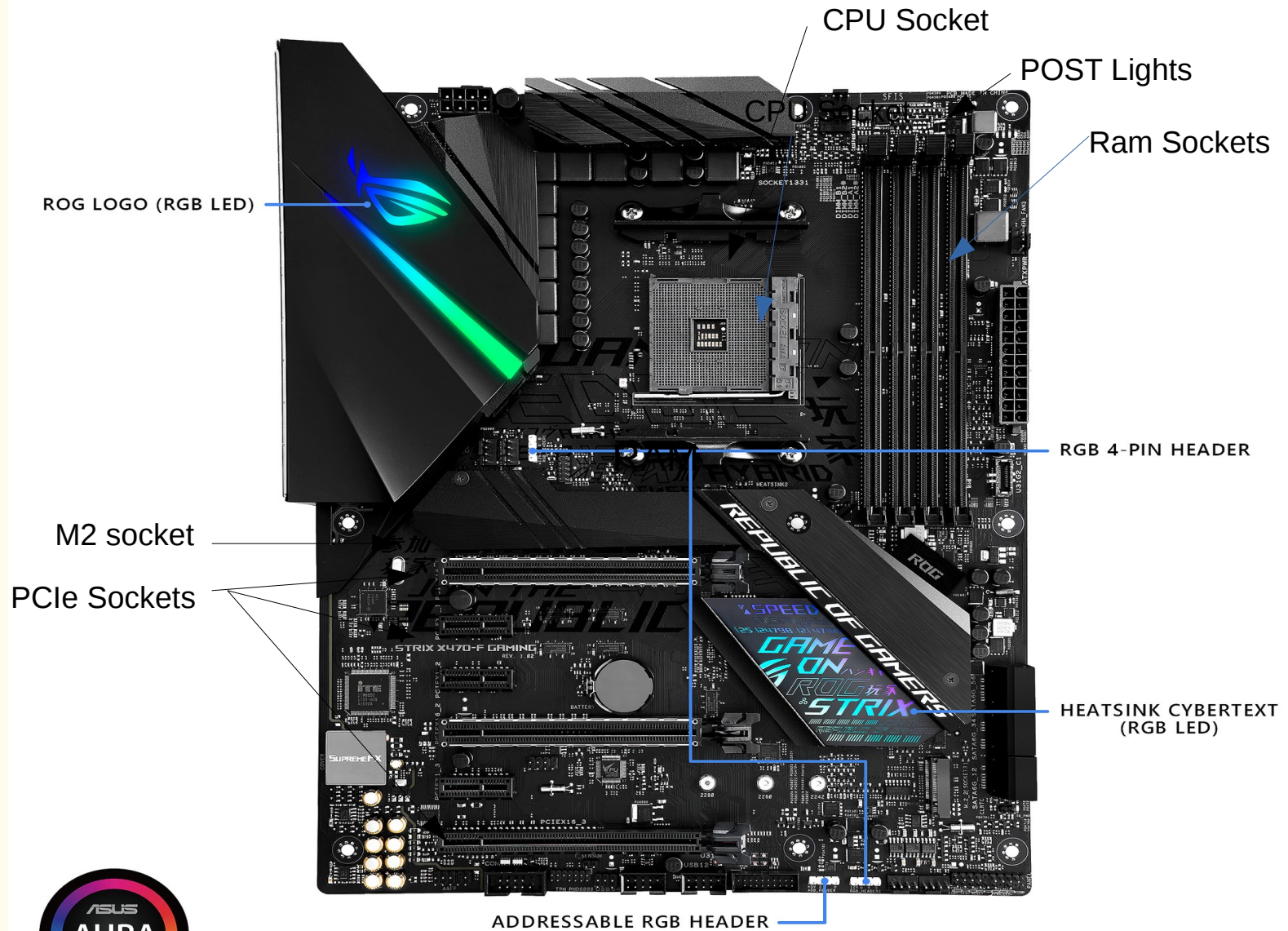
Asus ROG STRIX X-470-F

- Features – Reliability- Warranty
- 470 chip set
- USB 3.1 and USB 2.0
- 6 SATA ports
- 2 M2 sockets
- AMD AM4+ socket
- Max 64 GB RAM
- PWM fans
- 3 year warranty
- Intelligent processors
- Power control



Motherboard Layout

Unmatched Personalization



Product Specifications: CPU & Cooler

- Must match motherboard
- Socket type must match
- Best to buy CPU without fan and buy good heat stove
- Cooler fan must have same type connector as motherboard.
 - Newest have PWM (some have two PWM sockets)
- Silver heat sink compound
- Watch for sales, rebates, and price-match

My CPU & Cooler: Ryzen 7-2700 & N-212 Coolermaster

- I do math, need more cores
- AMD has most bang for \$
- Will your software use threads
- Cooler is heat stove
 - Cheap insurance
- Use good compound
 - Arctic silver
- Read about Ryzen
 - ANN for prefetch
 - Hyperthread works well
 - Most CPU for the money



What Size Power Supply

Add up the watts

1) CPU	65 W
2) Motherboard	50 W
3) Graphics card	100 W
4) 5 drives	80 W
5) 3 DVD drives	75 W
6) 7 fans	84W
7) <u>Safety Margin</u>	<u>100 W</u>
8) <u>Total</u>	<u>554 W</u>

- I have:
 - 3 hard drives
 - 1 SSD
 - 1 M2
 - 1030 Graphics card
 - 7 fans & CPU cooler
- Antec 750 Gold Plus
 - On sale
 - Rebate
- This is what I have and why

Product Specifications: Power Supply 750 Gold Plus

- Good brand reputation
 - Design by Antec in CA
 - Built by Seasonic
- Read reviews
- Add up watts needed
- Have enough current?
- Get a little bigger for when you add
 - Look at power output not input
- Get high efficiency (Gold Plus)
 - Less heat
 - Lower electric bills
 - 80 plus gold certified
- Modular cables



This one is 92% efficient

Product Specifications: Memory

- Must match motherboard
 - Must be on QVL
- Brand reputation
- Heat sinks needed?
- Know how much you will need
- Look for sales and/or rebate
- Speed to match CPU and motherboard
- Put in all that you will ever need
 - Can NOT add memory later
 - Without replacing it all



Product Specifications

Graphics Card

- Will you be using GPGPU? (specialized math)
 - Nvidia supports math, free software & info
- Are you a gamer?
- Nvidia vs ATI vs AMD APU series
- Amount of memory vs programs in use
- Must have right kind of slot(s) on motherboard
- Power consumption
 - Some require extra cables from power supply
- Watch for sales with rebates

My Graphics Card

EVGA Geforce GT1030

- 384 cores
- Big heat sink, no fan needed
- Nvidia chip
- 2 GB DDR5 memory
- Good brand
- Good warranty
- Affordable with rebate



Product Specifications: Hard Drive(s)

- SSD is fast, but only so many writes before it fails.
Good for OS – Many reads, few writes
- M2 uses PCI ports (max 4) so can be faster
 - Adapters available for \$10 to \$15
- Price pressure on hard drives reduced quality
- Look at warranty and MTBF
- How many hours on per day
 - Affects MTBF
- Mount size for case (3.5” or 2.5”)
- I like enterprise drives for reliability and performance
- Look for one day sales

Enterprise VS Regular HDD

- 5 year warranty
- 2,000,000 h MTBF
- Two bearings
- Big (128-256) MB Buffer
- SATA or SAS
- 24/7 usage
- 1E-15 error
- All of mine still work
- 1 year warranty
- Less hours per day
- One bearing
- 16 to 64 MB buffer
- SATA
- Many are 8 X 5 use
- 1E-14 error
- My newer ones all died

Product Specifications

Optical Drive(s)

- CD/DVD/Blue ray
- ROM or R/W
- Number of slots in case
- Interface type ATA or SATA
- Brand reputation and reviews
- I like Asus and Pioneer
- LG and Samsung pretty good
- Watch for sales and/or rebates
- Read Reviews!



Product Specification: M2 Drive

- A handy form of SSD
- M2 socket uses 4 PCI channels
- Good for reads but limited number of writes
- Called NVMe drive
- Buffered drive available
 - Patriot Scorch 1700 MB/S read, 1500 MB/S write
 - Samsung is 6900 MBS sustained read
- Great for OS and programs, not R/W
- Mine failed upon installing new OS, too many writes

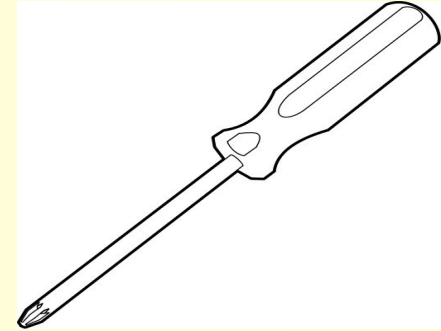


Getting the Parts

- I am not trying to plug any company, this is just what I have done
- I get daily sale emails from Fry's and Newegg
- Must have patience
- Also must buy misc cables on sale
- Good to also have screw kit
- Know which motherboard, get compatible parts
- Buy motherboard last but know which one
- Keep your design plan in mind

Tools That You Will Need

- Phillips Screwdrivers
 - Size #0, #1, and #2
 - Magnetic tips preferred
- Small needle-nose pliers
- Flashlight
 - Headlamp makes life easier
- Sometimes a 6mm nutdriver
- Magnifying glass
- Lots of patience



Read Instructions First!!

- First means before anything else
- Read multiple times
 - May need magnifying glass (small print)
 - Get pdf on line and use that
- Understand what goes where
- Read it again!
- I speak from experience
- Put a big towel on the table where you will work

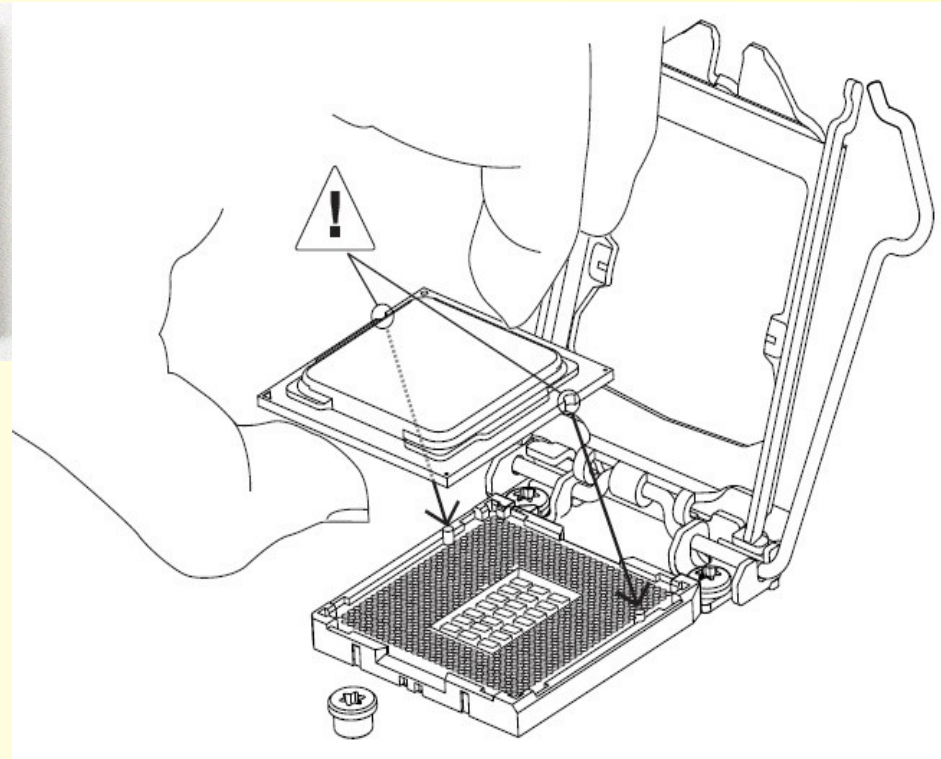
Install CPU & Cooler

- When buying, make sure has same type fan as motherboard requires (3 wire, 4 wire, PWM)
- Be very careful with pins, do not force or bend
- Use silver heat sink compound
 - Start in middle
 - Follow instructions with cooler & compound
- Put in CPU, then cooler (do not touch pins)
- Plug in fan

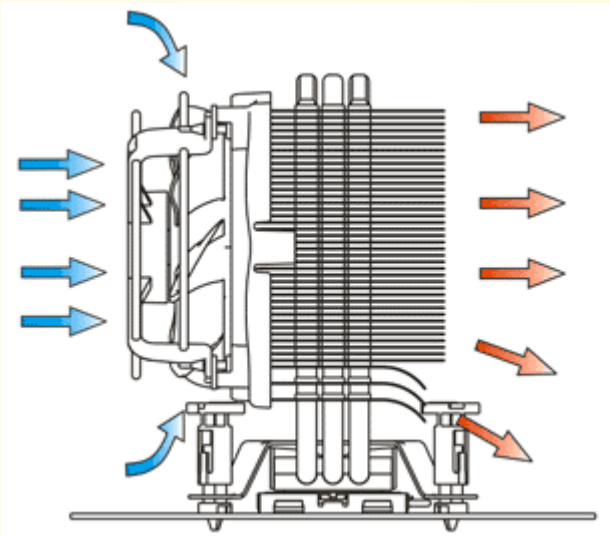
Install CPU & Cooler



Do not touch pins!!!



Hold by edges



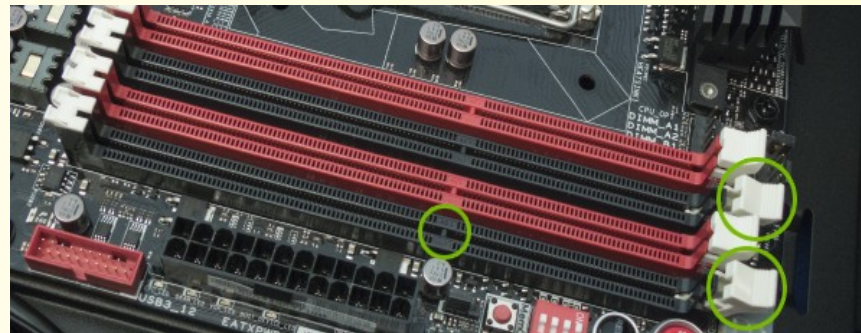
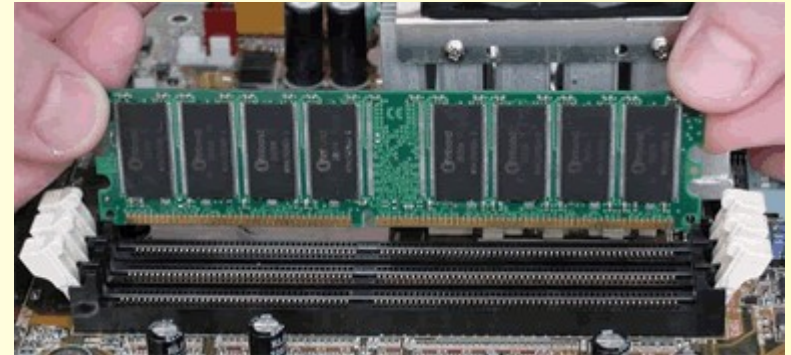
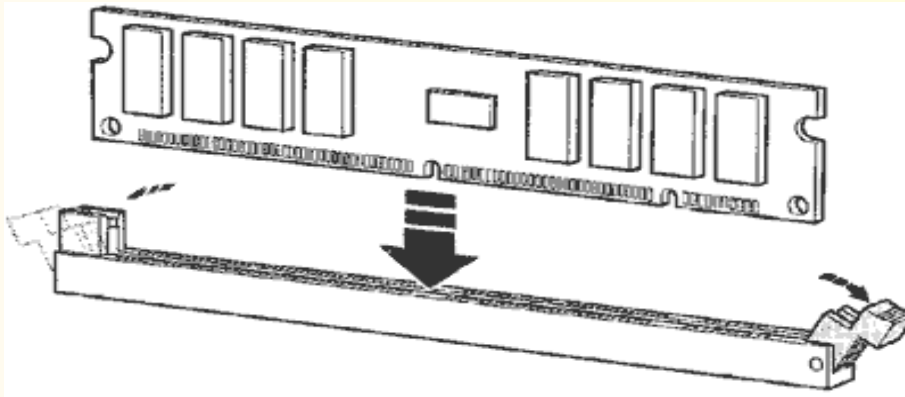
Heat stove cooler

Blows in direction with rest of case

Install Memory

- All memory is the same brand, model, & batch
- Must be on QVL for motherboard
- Follow instructions with motherboard manual
- Watch which bank to install
- Make sure in right direction (watch notch)
- Make sure pushed in all the way
- Do not touch pins

Installing Memory



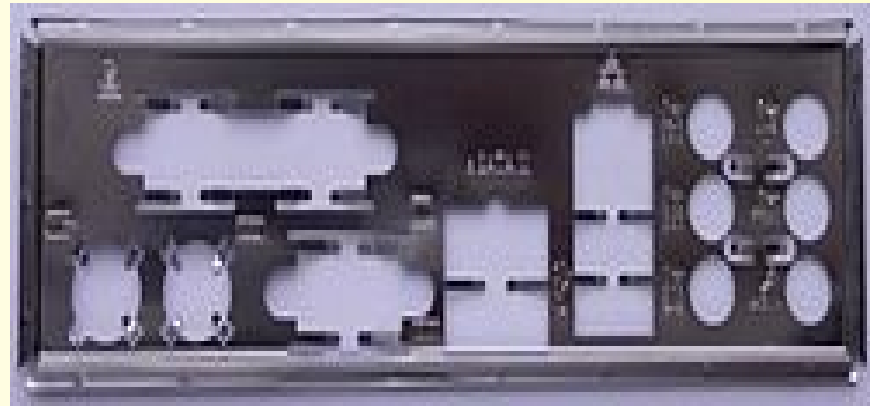
Put into Case

- Put I/O shield in for your motherboard
 - Comes with the motherboard
 - Be certain that it is properly snapped in
 - Some already installed on motherboard
- Put in correct standoffs for your motherboard
- Line up rear connectors and screw holes
 - This is a be careful and look and look task
- Do NOT tighten any screws until all in place

I/O Shield



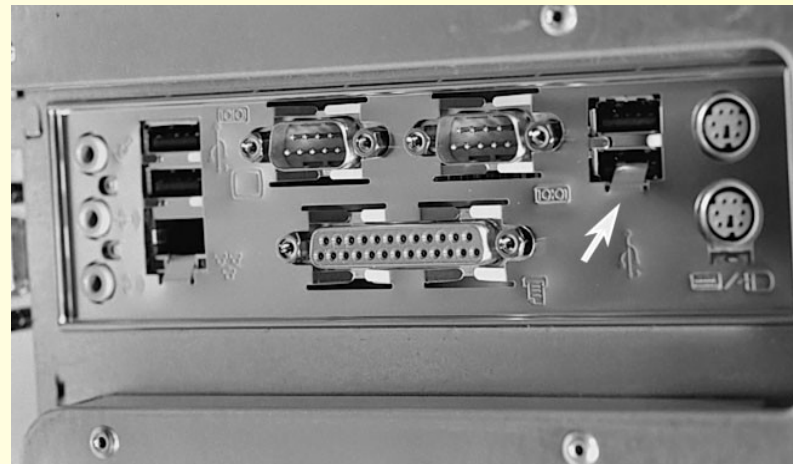
Where it goes



The I/O shield

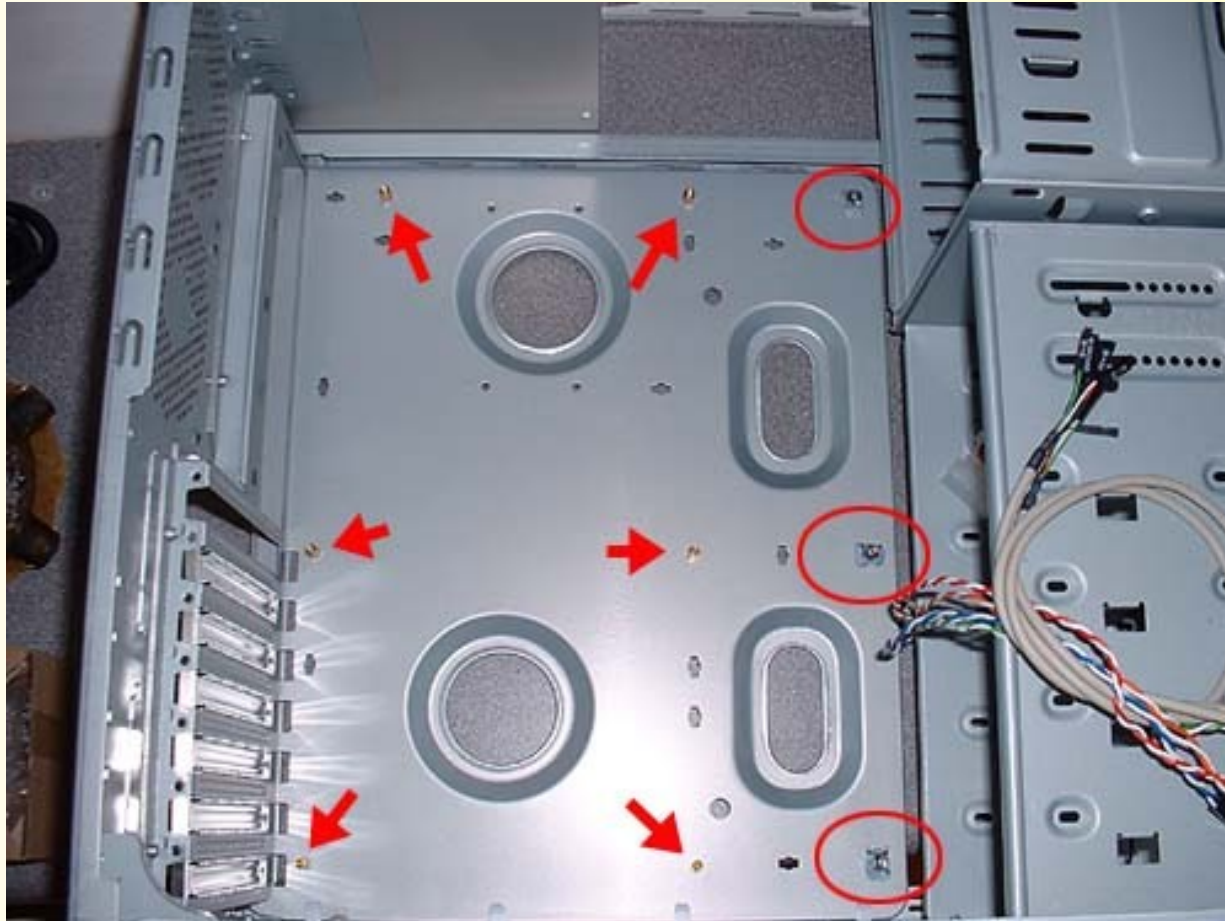


Installing the shield



Installed wrong

Install Standoffs



Usually 6mm, nutdriver works best, do not over-tighten!

Install Motherboard

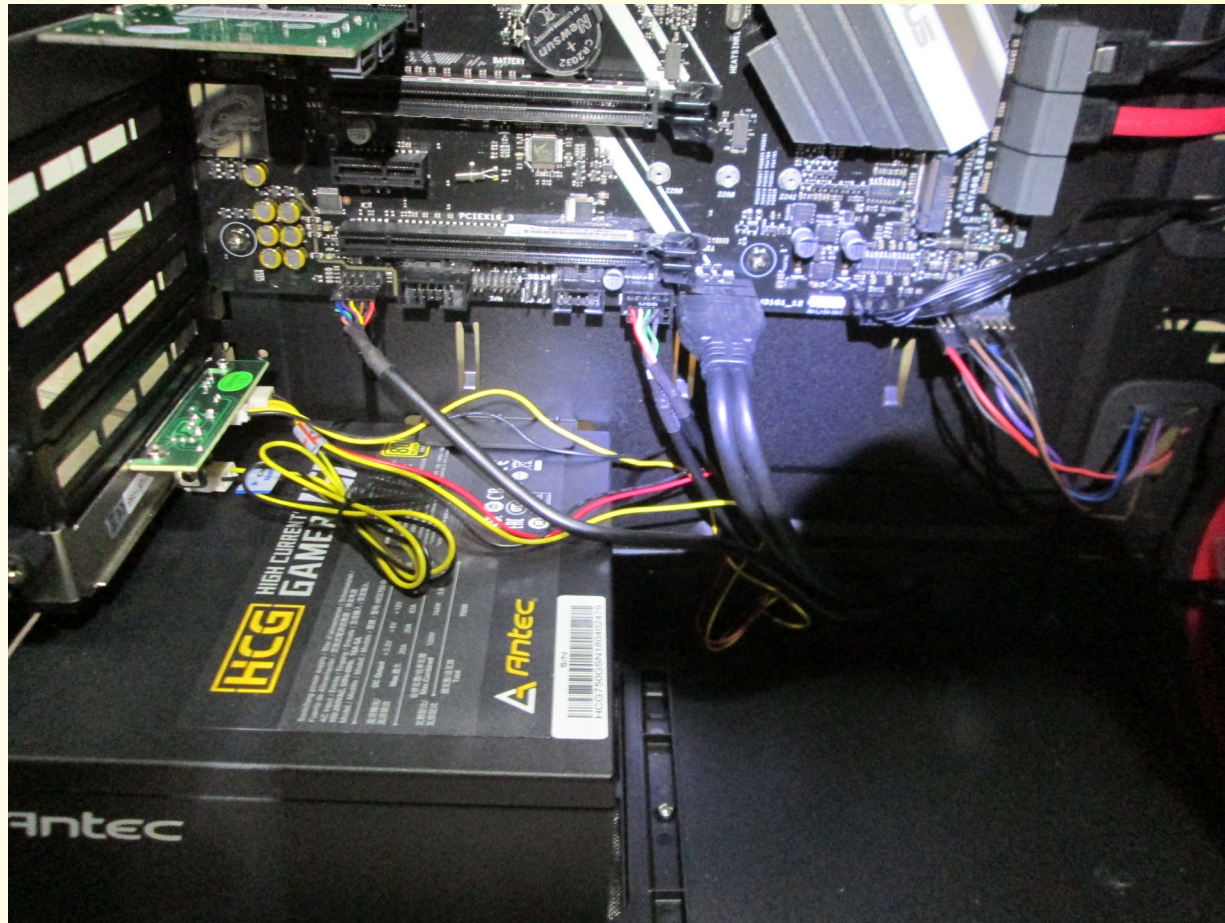


Make sure I/O lined up
Put in all screws but do not tighten until all are in and started
Look and make sure no stuck wires or such

Install Power Supply

- Fit PSU into place
 - Watch for air flow of fan
- Put in 4 screws
 - Do not tighten until all in place
- Attach cables
 - Fans
 - Motherboard
 - Drives
 - Sometimes extensions or adapters are needed
 - This is when having a selection on hand is nice
- Neatness counts

Mount PSU in Case



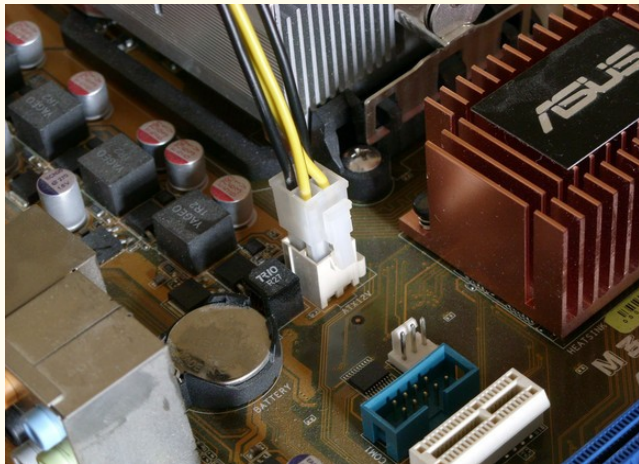
Fan is on bottom where air intake and filter is located

Attach Cables

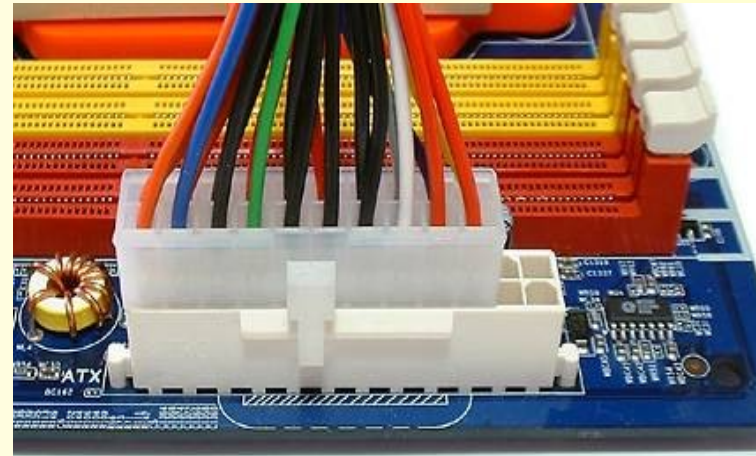
- Wires to case LEDs and switches
- Follow manual
- Read labels
- Watch polarity (black negative, red positive)



Motherboard Cables



This is for the CPU
Mine had 2 of these plugs
Next to each other, I used an
8 pin cable for this
I needed an extension as
cable was not long enough

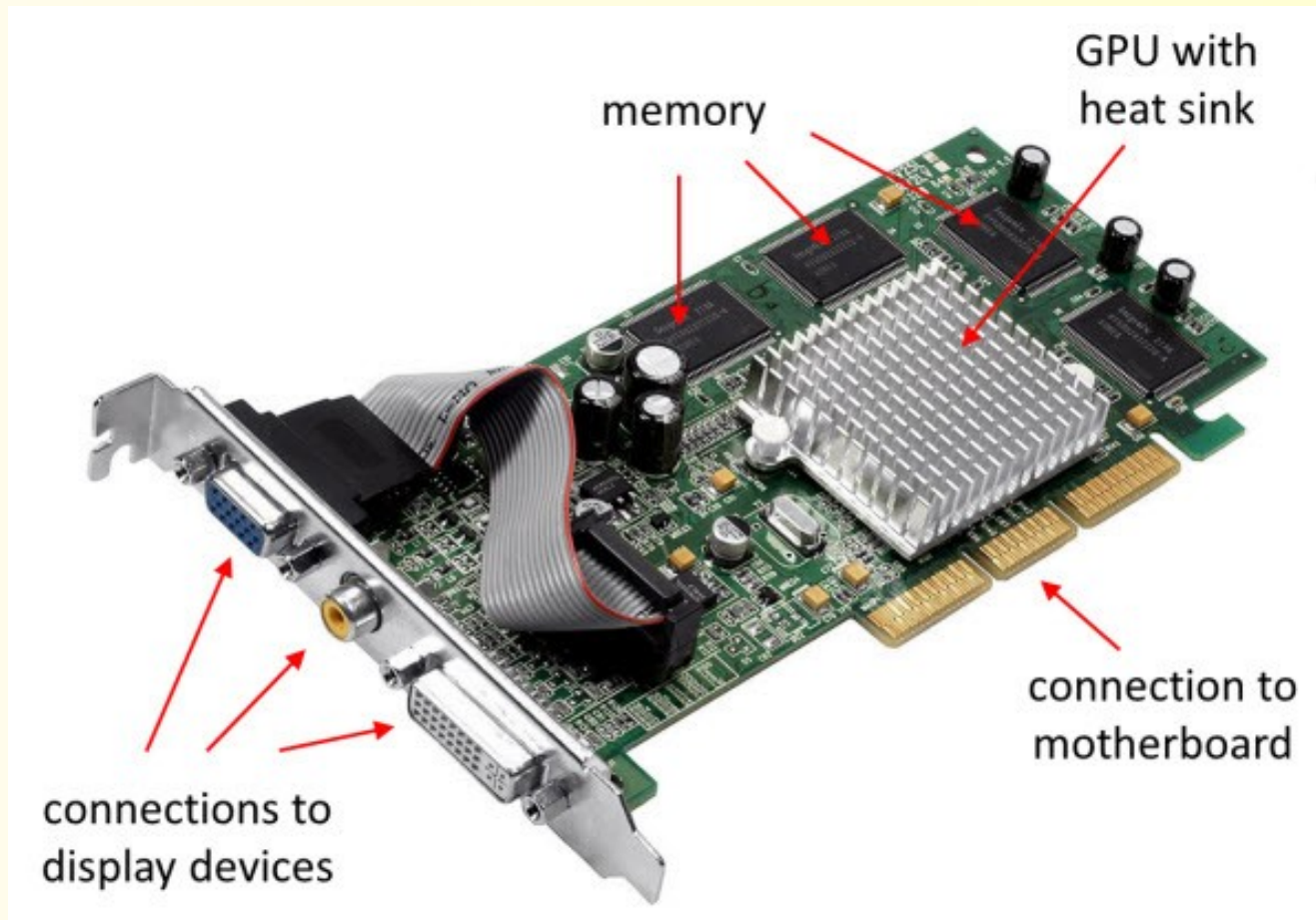


This is the main motherboard power
Notice that this is an old style 20 pin
When it really needs the 24 pin

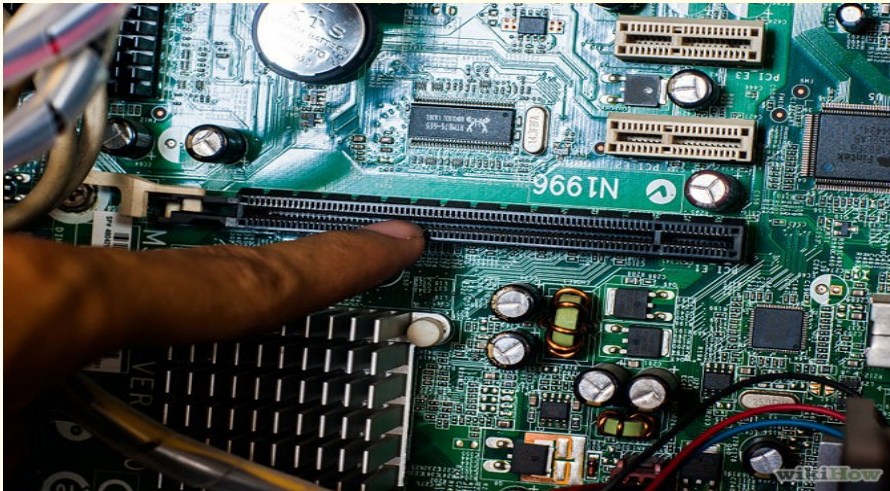
Install Graphics Card

- Find correct socket(s)
 - Usually PCI-X16 with extra tab at back
- Remove mounting screw
- Do not touch wires or contacts with hands
- Push into socket
- Put in mounting screw
- Some cards will need cable from power supply

Graphics Card



Install Graphics Card



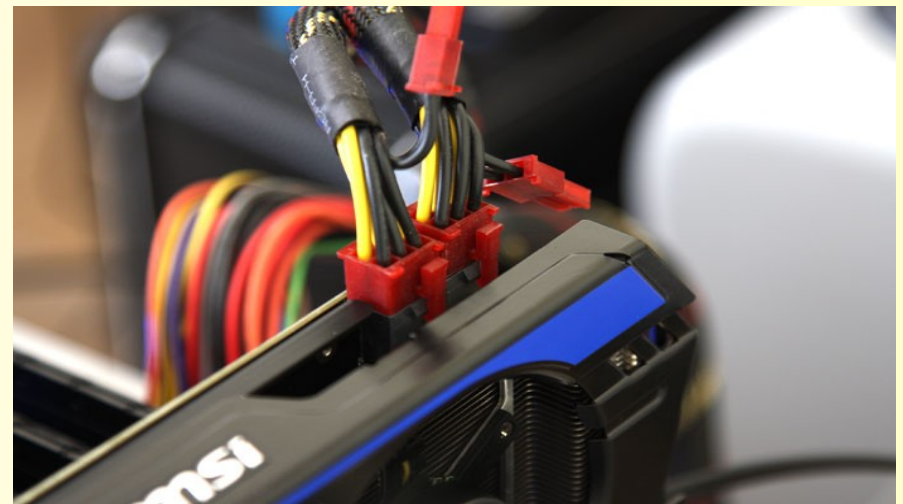
Single PCIE X4 slot



Dual PCIE X16 slots



Installing card

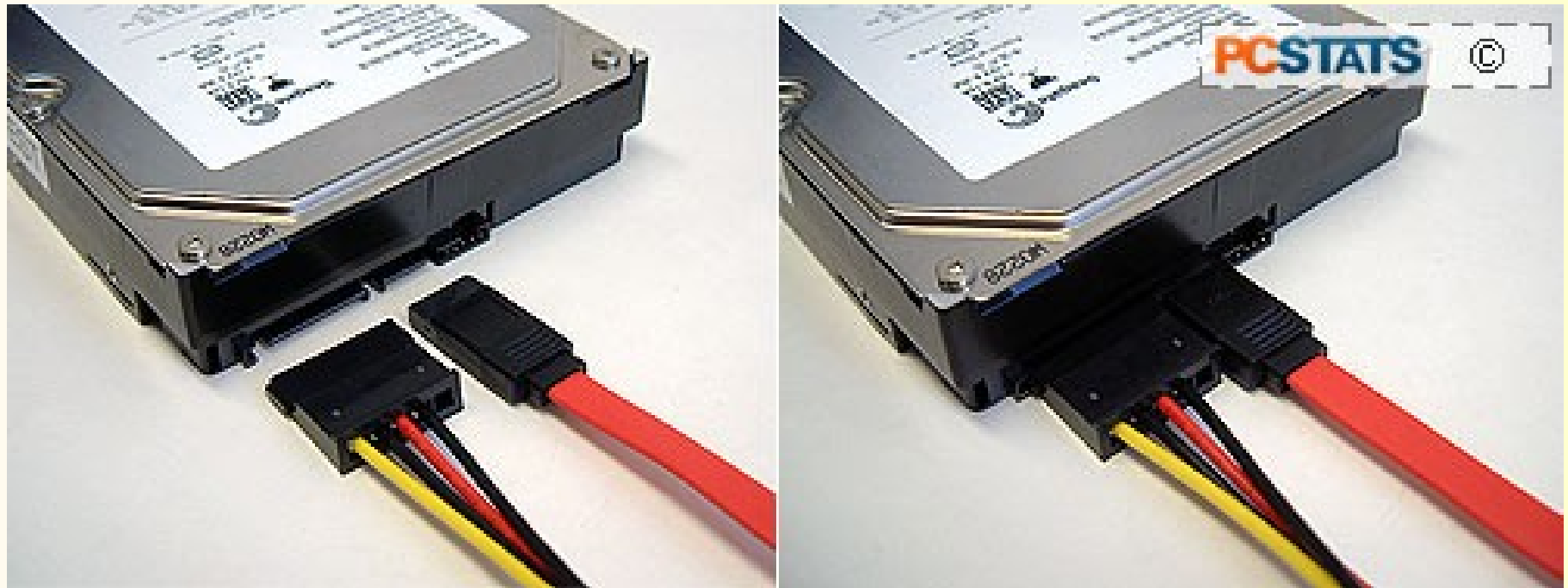


Plugging in Graphic card power

Install Drives

- Some cases do not require screws
- Better cases mount hard drives in soft bushings
 - Reduce vibrations
- Follow instructions
- Drives **MUST** be horizontal & label side up
- After all drives in place
- Attach cables (watch shape of connector)
- Route them neatly, no contortions on wires
- M2 drive – be careful with tiny screws

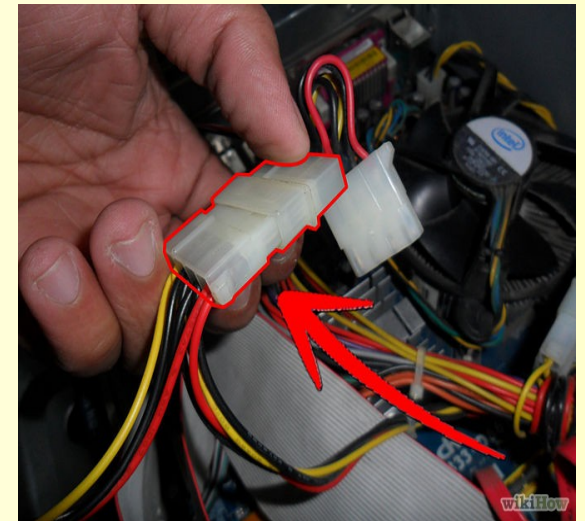
Attach Cables to Drives



Watch tabs to put plugs in correctly, not upside down

Power to Fans

- CPU cooler fan has special plug on board
 - Many BIOS will show this fan speed
- Many boards have special plug for chassis fans
 - Many BIOS will also show this fan speed
- Other fans plug in like this picture
- Fans plugged into motherboard are speed controlled
- Use correct kind of fan for each
 - PWM
 - 3 wire
 - 4 wire



Finish Assembly

- Listen carefully
 - Noises
 - Fans not running or running full speed
 - Things hitting
- Smells
- Feel heat
- Keep wires out of fan blades
- Neatness counts!

Installing the Operating System

- Newer hardware needs newer software
- Make sure that BIOS now set to boot first on DVD drive
 - Change later
- Put in the OS Install disk
- If using SSD/M2
 - Leave large portion unused
 - Put r/w files onto hard disk (e.g. var, tmp, opt, etc)
- Follow instructions
- Watch for any problems
 - Mark them down
 - Look them up and fix them
 - Most answers are on web

Problems

- Bad mobo (motherboard)
 - This drove me nuts, OS would stop at same place on install, tech support was worthless
- Bad fan
 - Might make noise (could fail later)
 - Might not spin and cause overheating
- Bad memory
 - Smart to run Memtest86 to test it
 - Free download
- Antec, Asus, & Gigabyte all have tech support (not always competent)

My Experience

- Opensuse 9.2 to 15.2 (over the years)
- Many programs
- Runs fast, uses all the cores
- Free including programs (nice to send donation)
- Have 8 desktops now
- Very happy

Mathematics Programming

- Are you interested in this?
- If you are, please let us know
- Then I can present this

Contacts

Listed Alphabetically

- Dr Brad Morantz
 - www.machine-cognition.com
- Antec.com
- Asus.com
- Frys.com
- Gigabyte.com
- leee.org
- Newegg.com

Questions

- Thank you for your attention and patience
- Any questions?