to PC Hardware

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CPU
The CPU (Central Processing Unit) is where all the calculations happen and is essentially the heart of your PC. Intel and AMD battle it out for your attention in this space and your quest for hardware knowledge starts here.

Motherboard and GPUs
This is where everything comes together. The motherboard is that one product onto which your components come together to form your personal computer. The chapter also looks at discrete graphics cards.

RAM
Before data is can be computed upon it must be obtained, and this data is obtained from the RAM. The RAM is like the PC’s short-term memory. In this chapter you’ll get to know the various types and the terminologies associated with it.
Hard Disc Drive
The internal hard drive is something we’ve all known about whether we have a PC or not. It is the main source of storage space with the ability to store any type of data of varying sizes.

Displays, chassis and Audio Cards
Now that most internals of the PC have been covered we’ll move on to the case in which you house your components and the screen on which you’ll see your PC come to life. We also cover Audio cards for the discerning few who want to indulge more than a few senses and Power supplies to power your creation.

IO Devices
Keyboards, Mice and other peripherals complete your PC requirements. But there’s a lot more to these ancillary components than meets the eye.

Networking
Great now that you know everything about what goes into a PC, how do you make it connect to the outside world? After all a lonely PC is a sad PC.
Now you can be a computer guy too!

Everybody has a “computer guy” to rely on when things don’t work out the way they want with their gadgets. You go to this person when your OS conks off or if you get a BSOD. Maybe the router has the persistent connection dropping problem or you are simply not confident about your next purchase (never listen to that sales person!). At times like these this magician of sorts comes about and solves all your problems and leaves you wondering how he/she did it. This month we aim to make you into a “Computer Guy/Gal” or at least put you on the path to becoming one. Shuffle through the following pages and read up on the different components that come together to make your PC the mean (or puny) machine it is. Obviously these 96 pages don’t contain every bit of information on each component, we can write dedicated books on each component but that would have bored you to the end of the earth, instead these are baby steps that you are about to take into the marvellous world of computer hardware.

We’ve kept the jargon to a minimum but all the important topics have been covered. If something doesn’t make sense initially, read a little further into the book and you’ll find what you need. You don’t need an engineering degree to understand the basics of computer hardware though one would help in understanding the minute details. We’ve also put a few points at the end of each section which should help you make a more informed decision on what to buy and what to avoid, however, before purchasing any computer hardware a bit of due diligence is always necessary. Somewhere along the way things will become more lucid and then you’ll be pretty much on your own. Soon enough you’ll start following the tech news as we do and understanding what’s new and what matters and what doesn’t. So start reading and join the ranks of the computer guys.
CPU

The CPU (Central Processing Unit) is where all the calculations happen and is essentially the heart of your PC. Intel and AMD battle it out for your attention in this space.

Intel
Intel's current lineup consists of the “Core i” series. Under that we have three brackets dividing the processors based on usage scenarios. The Core-i3 is the entry level bracket, then comes the mid-range Core i5 series and finally the Core i7 series for enthusiasts. Along with the above mentioned series exist certain other lineups which are equally popular - Atom, Pentium and Celeron. While the Celeron is nowhere to be seen nowadays the other two are well and alive. Pentium is geared towards the lower spectrum of the mid-range and the Atom processors are ultra low power processors used in netbooks.

AMD
AMD on the other hand has the Phenom II Series, Athlon II Series and more recently the Fusion and Bulldozer series. All these series have processors for all three market brackets. What is new is that when AMD bought ATI it gained access to good GPU technology, naturally they combined their CPU technology with the other to create the Fusion processors. As a result, the Fusion series has a much powerful on-chip graphics processor.
Technology

1. Core

The word core means different things for both processor manufacturers. Intel has a few actual cores and then you have HyperThreading which emulates two threads (think of a thread as a processing queue) per core. So the operating system sees two cores per core ... confusing isn’t it? Basically just multiply the number of cores by 2 if you see the HT (HyperThreading) tag on the model. This, however, doesn’t mean that there are actually that many physical cores. AMD has a similar architecture where the processor is divided into certain modules and each module though physically single is capable of performing the same as 2 cores. So the word core has lost a bit of significance given the hoopla generated by either company.

A common misconception is that if the processor is rated at say 2 GHz then a quad core processor is equal to 8 GHz, this is definitely not how it works. Performance does not scale in a linear fashion. What matters even more is the way programs are coded, they need to be programmed in a certain way in order to utilise the power of more than one core so don’t expect any program to speed up miraculously when you get more cores.

Another concern is how many cores a user needs. Most programs released after Windows 7 emerged are optimised for multiple cores, however, when benchmarked it was observed that at most 2 cores were utilised. Video games share a similar fate, few games are programmed to handle 4 cores while the majority work fine with 2 cores. Multimedia Design software on the other hand use as many cores as it can get its hands on. So for gaming 4 cores without hyperthreading is the best choice, video editing and 3D modelling do well with the enthusiast processors and casual home / office users need no more than 1 / 2 core(s).

2. Sockets

We’ve covered sockets in good detail in the next section on motherboards, so we’ll just have an overview here. Each processor generation came with it’s own socket, sometimes manufacturers like to use the same socket as the previous generation but of late what we have seen is a change in socket types every other year.
3. Chipsets
The chipsets (Platform Controller Hub) and the processor go hand in hand. Certain features of the processor like overclocking and video encoding are only available when a certain chipset is used, so you need to get the combination right or else you are basically throwing money away. So which chipset should you get? Simply Google the model number of your processor and it’s respective product page will mention all it’s features and list the compatible chipsets. Local vendors will sell a CPU and a motherboard as a unit to avoid compatibility issues so you needn’t worry about not getting it right, however, we always advise caution.

4. Overclocking
The process of getting more performance out of your processor is called as overclocking. You do this either by increasing the base clock frequency of by increasing the multiplier. The speed that you see when you buy a processor is the base frequency times the multiplier. So a 3.2 GHz processor may have a base clock of 100 MHz and a multiplier set at 32. Now more processors have their multiplier locked to a very narrow range (+/- 2), when the need for extra power arises this multiplier is raised automatically. Manufacturers have named this technology as Turbo boost, though different manufacturers have different names they essentially do the same thing.

High end processors tend to have an unlocked multiplier, i.e. the multiplier range is wider now, you can scale it up by 16 levels. However, high processing speeds demand a lot more power and that too well regulated power. Also the heat released is tremendous, so the processors are rarely stable at such high speeds. You need to make use of liquid nitrogen and liquid helium to keep temperatures low and ensure a stable performance.

However, the increments obtained are in steps when only the multiplier is fiddled with, getting the teeny bit extra now comes down to the base frequency. A mere 1 MHz increment scales linearly and adds up depending on the current multiplier level. So 1 Mhz base clock increment translates to 32 MHz when the multiplier is 32. Enthusiast overclockers have to achieve the balance between the multiplier and base clock to achieve the maximum possible from your processor. Even then there are external factors like the batch of manufacturing which affects how much a processor can scale.
5. Naming conventions

Intel

When buying a processor, the model number often says quite a lot about the processor. According to the current naming schema the processor name is as follows:

The i7 signifies the brand (among i3, i5 and i7), then there are 4 digits of which the first digit signifies the generation and the remaining three numbers signify the position of the processor in that generation. Naturally processors with higher numbers are better performing ones in that particular brand. The numbers are followed by a few suffixes which signify the line of processors. Here are some suffixes and what they mean:

M - Mobile   MQ - Mobile Quad core
MX - Mobile Extreme   T - Power optimised
S - Performance optimised   K - Unlocked multiplier

AMD

AMD doesn't follow the same naming convention throughout their processor line. Unlike Intel, AMD has 2 main line of processors. The FX series and the APU series.

The FX series has multiple conventions under it. For example the FX-6100 is from the FX series, has 6 cores(3 integer clusters) and the number 100 signifies its position in the 6 core line-up. At the same time we have the FX-8300 and the FX-9370. Going by the earlier convention the FX-8300 should be an 8-core processor and the FX-9370 should be a 9-core processor but they are both 8-core processors. The APU lineup has the same issues with the naming convention. The only way to be absolutely sure is to Google its model number.

6. SKUs

So how do so many models creep up? Why not just stick to 3 models for each performance bracket? This is where marketing comes in as having many SKUs results in more sales. The way SKUs are decided is by binning the processors. Essentially each new architecture results is 1-2 actual processor designs. And as with any manufacturing process there are defects
that creep into certain processors. These processors are later tested and a stable frequency is achieved. The processor is then locked onto this frequency and a new SKU is born. All features that are not supposed to be part of that SKU are burned out with a laser. Naturally, the high end processors were the best performing from a particular bunch, that is why they tested well and subsequently got binned into a higher category. Enthusiasts also like to bin processors, this helps figure out which batch had the best scaling processors and then that particular batch sells like hot-cakes.

7. Manufacturing process
Processors are made up of billions of transistors and they are connected by thin wiring, it is the width of the wiring which denotes the manufacturing process. The smaller the manufacturing process the more transistors that can be squeezed into a small area and thus better performance can be achieved. Both AMD and Intel outsource their manufacturing to the same company and they share similar trends when shifting between manufacturing processes. Intel calls its trend as Tick-Tock. The Tick refers to a reduction in manufacturing process (smaller transistor size) while the Tock refers to a new architecture revision. They occur in an alternate fashion.

8. Cache
Cache is the shared memory between processors. There are different levels of cache depending upon the processor architecture. Each core has its own L1 and L2 cache. All the cores are then linked to each other via the L3 cache. Since the L1 is the closest to any core, not much memory is needed (data is stored and retrieved really fast) but as we move further away and get to the L3 cache we need a lot more. The basic idea is that more is better.

9. TDP
Thermal Design Process refers to the net wattage that a processor will consume. Greater the TDP the more heat it will dissipate and thus you need a better heatsink. Better performing processors naturally have more TDP but we are seeing a gradual reduction in TDP each processor generation since the manufacturing process is getting smaller and smaller. There are certain variants of high-end processors that come on low TDP SKUs. These
generally have some suffix attached to the model number, they also perform a bit below their normal TDP counterparts.

TDP also raises the question of custom coolers. Normally the stock cooler that comes with your computer is more than sufficient for everyday operations. But if you live in an area with relatively higher temperatures then your processor can heat up pretty quickly, at such times it is wise to invest in a better cooler and a better thermal paste.

10. 32-bit vs 64-bit
This discussion is a thing of the past since all processors released nowadays are 64-bit processors. The difference between them is that 64-bit processors can support more memory since it can address $2^{64}$ bits of memory. In order to make use of this capability one has to install a 64-bit operating system and use 64-bit programs and drivers.

Onboard Graphics solutions
Processors with Integrated Graphics capabilities have been out for quite a few years, while early on they were barely worth a mention things have changed for the better now. Processor graphics were never meant to replace discrete graphics cards so no matter what generation you look at the discrete graphics card will always be ahead. Simply because they are both different in their architecture based on the type of calculations that need to be done. Processor calculations are varied and require the usage of a lot of different instructions, however, graphics calculations are pretty much simple in comparison but the sheer volume of calculations is overwhelming. The main purpose for integrated graphics is that really high resolutions (4K resolution) can be run natively without the need for a separate graphics card and some moderate gaming can be done. If you have a current generation processor then you should be able to play games that were released 2 years back at 1920x1080 resolution and medium settings without any problems.

Intel
Intel has the HD series of integrated graphics, the current lineup of third generation and fourth generation processors are pretty much at par with most entry level graphics cards. The fourth generation HD4600 boasts of an increment of nearly 300% in graphics performance compared to the third generation HD4000. Real world benchmarks peg it at much lower than discrete graphics.
AMD
AMD's APU is slightly better when compared to Intel since AMD uses technology from its graphics division. This way they have tried and tested technology to rely on which means less R&D is needed. The current HD8670D which is present in the A10-6800K APU outshines all current generation AMD APUs and Intel HD graphics.

What to buy
While shopping for a processor keep the following points in mind
1. Figure out your needs and your usage scenario. This means all the types of applications that you are going to be using. Certain applications need all the processing power that a quad core processor with hyper-threading can provide.
2. The motherboard and CPU go hand in hand, gone are the days when one could just upgrade either, nowadays sockets and processors are phased out so fast that if you wish to upgrade one then the other is absolutely necessary.
3. Chipsets determine the capabilities of a processor that can be used, higher end chipsets support overclocking and are part of much expensive boards.
4. If you are going to overclock your processor then remember to get a better cooler and thermal paste. If you are an enthusiast then you know what needs to be done.
5. Integrated graphics are only good for old games, so don’t rely on a high-end processor to deliver stunning graphics. You need a discrete graphics card for that.
6. For scenarios where a lot of parallel processing needs to be done, look at graphics cards and software optimised to use CUDA / stream processors.
MOTHERBOARD AND GPUs

This is where everything comes together. The motherboard is that one product onto which your components come together to form your personal computer. There are scores of motherboards available for you to choose from, each manufacturer takes their design for a unique spin.

Motherboard

Form factor

The first and foremost thing that one notices about a motherboard is its shape and size. Laptop motherboards have stopped following convention, in the race to create more compact designs the motherboard has been broken down into multiple PCBs but the scenario in the desktop market has remained unchanged for quite some time. There are a fixed number of form factors that one can choose from to build a computer, they can be either the palm sized PC/104 or the biggest of them all - the WTX. The image on the next page has covered quite a few of them with their dimensions in mm.
The problem is that manufacturers often make minor modifications to fit in a few extra features and thus end up creating a new form factor, there are over 40 form factors in existence to this day. Smaller form factors are geared towards embedded design while the really big ones are for workstations and servers that use more than one processor and fit in around 128 GB of RAM. We are looking at desktop motherboards which would happen to be one of the following - EATX, ATX, MicroATX, MiniATX and NanoATX. It is obvious that a bigger form factor has more real estate to have a lot more features, even then you will find exceptions where a big motherboard has the most basic of all configurations.

Manufacturers have to bring out a motherboard for all price points. There are entry level motherboards which just bring together a basic PC with a keyboard and mouse. Then there are the enthusiast motherboards which feature all sorts of bells and whistles that can make an enthusiast cry in joy. Let’s have a look at the various components that form the motherboard.

**Components**

The motherboard design has gone through some changes as is common with technology. However, the common parts are
1. CPU Socket
2. Ram Sockets
3. BIOS
4. North Bridge (Older generation motherboards)
5. South Bridge (Newer generation motherboards have a single PCH instead of a NB and SB)
6. Expansion slots
7. Peripheral slots
8. Headers for peripherals
9. Power Management
10. Backplate I/O ports

1. CPU socket

There are two main manufacturers for desktop processors - Intel and AMD. Each have hundreds of processors up for sale. Every six months or so either manufacturer will release 6-20 new processors. Intel follows a certain pattern called the Tick-Tock cycle where the Ticks and Tocks refer to changes in the processor architecture or manufacturing process. Earlier the Tick and Tocks were years apart. Now they happen every 8-12 months. AMD has a similar product cycle where it comes up with a new architecture and after that improves upon the same architecture for a year or so.

So every six-months we have a lot of new processors entering the market and every year or so the socket pin count changes. Sometimes it is all for just 1 pin like the LGA 1156 and the LGA 1155 which are differentiated by just one pin. The wiring of the pin does change internally so don’t go about putting a LGA 1155 processor onto a LGA 1156 socket. Basically Intel will have three sockets which distinguish the type of processors that the motherboard supports. There is the entry level socket, mid-range and then comes the enthusiast level. AMD on the other hand has been keen on using the same socket for a couple of generations. Maybe it has more to do with how far apart the iterations in their product life cycle are. So in the long term getting an AMD motherboard would ensure that you could upgrade your processor though a few architecture revisions while an Intel based board would be best for just about 2 years.

Current sockets are by design either LGA (Land Grid Array) or ZIF (Zero Insertion Force) sockets. LGA sockets have an array of bent metal pins in the socket which makes contact with the pads underneath a processor, this way the processor is more durable because of their pinless design. ZIF sockets
are designed the other way around with the pins being on the processor and holes being present on the socket. Both Intel and AMD make use of both sockets for their processors, Intel uses LGA for their desktop processors and AMD uses ZIF for their desktop processors. The current socket lineup for Intel consists of - LGA 1155 / LGA 1150 / LGA 2011. And for AMD - AM3+ / FM1 / FM2. Sockets are not always backwards compatible. One query we’ve received is if the biggest socket (LGA 2011) supports all lower socket processors. The answer is a strong resounding NO! Never put a processor in any socket other than the one it was made for.

2. RAM sockets

RAM sockets are placed as close as possible to the CPU socket since the latency of communicating with the RAM affects CPU processor. Usually one finds 2 or 4 RAM slots on a motherboard. This is due to the support for dual channel and quad channel memory configurations. In the previous generation of processors we even had triple channel configurations so those motherboards featured 3 or 6 slots. With each improvement in RAM technology, the density of RAM modules increases and the capacity that each slot can support (this is decided by the CPU architecture and BIOS) also increases. Currently we have RAM modules that have a capacity for 8 GB, though 16 GB DIMMs have been announced for DDR4 modules starting early next year. Also RAM frequency support varies with motherboards.

Certain motherboards in order to preserve compatibility come with 4 RAM slots out of which 2 support DDR2 and the other 2 support DDR3. RAM modules have notches on either side that help lock them onto the
motherboard socket. You will see markings like A, B, C, D, A1, A2, B1, B2 etc right beside each RAM slot. These help decipher the different memory configurations on your motherboard. In order for your memory to work in Dual channel or Quad channel (whichever is supported by your motherboard) you need to use certain slots and leave the others empty. This configurations are mentioned in your motherboard manual along with all the different memory modules that your computer was tested with.

3. North Bridge / South Bridge / Platform Controller Hub
The earlier motherboard architecture had a structure in which the functions and the control of the various motherboard components were divided amongst the SB (South Bridge) and the NB (North Bridge). The North Bridge primarily controlled the communication between the RAM + GPU with the CPU. All communication to the various peripherals was via the SB which was relayed to the CPU by the NB. However, ever since Sandy Bridge came out 2 years age and AMD’s APU came out around the same time, this approach has changed. This was primarily due to the fact that the functions performed by the North Bridge was incorporated onto the processor. This greatly reduced latency and allowed for faster communication.

The South Bridge was connected to the North Bridge and relayed to the processor whatever the various peripherals had to say. Since the migration of the North Bridge onto the processor, the South Bridge has been replaced by the PCH (Platform Controller Hub) which now connects directly to the processor. All USB ports, some SATA ports and other peripherals like FireWire, COM port, legacy ports etc are now controlled by the PCH. Now the PCH depends on the model of the CPU, there are multiple PCH chips with varying capabilities. Certain PCH allow overclocking, extra USB 2.0 / 3.0 ports, extra PCIE slots or maybe even some features like SSD caching. So it is advisable to figure out what features are important to you before buying a motherboard, everything else depends on it.

4. Power Management
Power Phases are components on your motherboard that take power from the SMPS and then regulate it before supplying your CPU and RAM. The phase circuitry is composed of VRMs and MOSFETs. A regulated power supply is very important for your CPU since that determines how much punishment your processor can take. Without a good power phase design
the CPU could suffer from surges or spikes which could either burn the pro-
cessor or shut it down temporarily. The simple rule is that the more phases
there are the better regulated your power supply is although anything above
12 phases is overkill for the majority of computer users. Overclocking is one
feature that heavily depends on a stable power supply. Power phase design
follows a simple notation where it is written as x + y +z or x + y. Example,
8+2 power phase denotes that 8 MOSFETs regulate the power for your CPU
and the remaining two is divided over your RAM and memory controller
/ Integrated graphics.

The reason for their existence is that CPUs require a lot of power and
having a single source of power results in a lot of heat being dissipated
by that one component, heat is bad for anything that has to do with elec-
tricity. So in order to keep temperatures lower you have multiple sources
of power, this way each phase remains on for a short duration / duty cycle
and then the next one turns on while the previous switches off. This way
you are ensured of a steady power supply that does not vary much. The
more phases there are the lesser amount of heat that each VRM component
has to dissipate. Naturally, high load operations like overclocking benefit
by a huge margin with a good power phase design. While the notation
used is not the absolute standard, the motherboard packaging should
mention the power phase design it has. Even graphics cards have
a VRM circuitry.

5. BIOS
The first thing that comes to life when you switch on your computer is
the BIOS (Basic Input/Output System). The primary objective is to get the
computer’s operating system started but before that happens the BIOS does
quite a lot of other things too, they are listed as follows -

- A POST (Power-On Self Test) where each essential component is tested
once to check if there are any faults. If any are found then a sequence of
beeps are issued to let you know about it. Newer motherboards have an
LED display which displays error codes. You can refer to your mother-
board manual to figure out which code means what.
- Switching on the BIOS on other peripherals. Every add-on card has
it's own BIOS, GPUs, Ethernet Cards etc have their own BIOS which is
switched on by the main BIOS.
- The initial management of input devices like keyboard and mice is done
by the BIOS prior to the OS booting up.
You can customise the various settings for each component, you can disable processor features or modify memory timings or change the system clock. All these settings have to be stored somewhere and that is done by the CMOS. This CMOS chip is constantly powered by the CMOS battery which is why your specific settings remain even when you shut your PC down.

Certain features may get updates as time goes by and you then receive a BIOS update from your motherboard manufacturer’s website. You then have to rewrite the BIOS chip with the new program and this is done via a process called flashing. As a golden rule, never ever flash your BIOS unless there is something wrong. The unnecessary urge to have the latest BIOS is something that users get carried away with. This is because the process is quite risky. If anything disturbs this process then by all means you shall have bricked your BIOS. Bricking is when the flash writing process is not completed successfully and the BIOS is unable to perform or even switch on. Higher-end motherboard models come with a backup BIOS chip. A recent innovation that has spread like wildfire is the UEFI BIOS which allows one to use the mouse in the BIOS screen. This has been customised to include a lot of eye candy and has made the BIOS a much more user friendly tool.

6. Backplate I/O
The backplate is the one avenue where you can connect your various peripherals (optional and essential). Your display (in case you are using the onboard graphics chip), keyboard, mouse, ethernet, USB peripherals, audio equipment etc, connect to your motherboard via the backplate. The dimensions of the backplate are standard so even if your motherboard supports a lot of connectivity options you can only fit so much into that area. Certain motherboards have buttons which trigger special functions placed on the backplate. Common among them are the Shutdown / Reset button, CMOS reset button and overclocking profiles button.

7. Headers
Whatever cannot be accommodated via the backplate is managed through headers. So your motherboard may support 12 USB 2.0 ports but your back-
plate only has 4, the remaining 8 are located on the motherboard and can be utilised by using header cables. The front panel audio and USB ports are actually connected to the headers. Basically, the most commonly used interfaces have a place on the backplate and the less common ones are accessed via headers. This is where you find legacy interfaces like floppy drive headers and COM port headers, both are a rare find. The headers are designed in a way that you can only insert the corresponding cable in one particular way, there will be a tab or a notch that makes it impossible to insert the cable anywhere else. One exception is the header than has contacts for the power LED, HDD activity LED, power and reset switches. Each manufacturer follows a different standard and cabinets have a bunch of cables instead of one unified cable for the same. Refer to your motherboard manual to figure out what goes where. For switches the polarity doesn’t matter, i.e. you can insert the cable either way but for LEDs the + and - symbols must be followed.

All over the motherboard you will find small 3-pin or 4-pin headers, these are usually for connecting chassis cooling fans, the three pin headers don’t support PWM while the 4-pin ones do. The 4-pin ones give your feedback from the fan by telling you what the current RPM is and you can increase the flow of air accordingly while the 3-pin fans are not localised and don’t give greater control.

8. Expansion slots
Expansion slots are used to accommodate various cards that add extra features to your computer. Discrete graphic cards are the most commonly known example. The current standard is to use PCI (Peripheral Component Interconnect) and PCIE (PCI Express) slots. PCI slots are slowly being phased out as the processors can now afford greater bandwidth that the PCIE slots have and there are better circuits for managing bandwidth between multiple add-on cards. PCIE have slots based on the bandwidth needed, and thus we have x1 / x4 / x8 / x16 / x32 slots but the x32 slots are not to be found on motherboards. The following table lists the bandwidth supported by various slots.

<table>
<thead>
<tr>
<th>Port</th>
<th>Bandwidth (Single direction)</th>
<th>Bandwidth (Dual direction)</th>
</tr>
</thead>
<tbody>
<tr>
<td>x1</td>
<td>200 MBps</td>
<td>400 MBps</td>
</tr>
<tr>
<td>x4</td>
<td>800 MBps</td>
<td>1600 MBps</td>
</tr>
<tr>
<td>x8</td>
<td>1600 MBps</td>
<td>3200 MBps</td>
</tr>
<tr>
<td>x16</td>
<td>3200 MBps</td>
<td>6400 MBps</td>
</tr>
</tbody>
</table>
PCIE has undergone various improvements across a few generations, the above table lists the bandwidth for PCIE 3.0. PCIE 4.0 which is due to come in the next two years will effectively double the bandwidth shown above.

9. Bells and whistles
Each manufacturer adds a little something to their own motherboard to set it apart from the competition. Some manufacturers use more copper in the PCB thus making it into one large heatsink and thus all components are much cooler. Certain manufacturers use military grade components which are rated for higher temperatures and are more durable.

Then there are enthusiast boards which are geared towards overclocking, each manufacturer has their own line up. These boards have really high end onboard sound with isolated power supply. They have customised BIOS which can be remotely monitored and settings can be changed on the fly without the need for a system restart. Other components that are often customised include better capacitors, better VRM circuitry, Gigabit ethernet port etc.

What to buy
When deciding on the motherboard keep the following points in mind
1. This is the first component that you are going to buy so list out all the features that you want so that you can select the chipset needed for your computer. Then list out what all connectivity options you need and raise that number by 1 or 2 for future upgrades.
2. Certain motherboards will have a physical 16x PCIE connector but internally they’ll be wired for just 8x bandwidth. Now this is absolutely fine for SLI / CrossFire configurations on both PCIE 2.0 and PCIE 3.0 ports. But when using a single graphics card then a 16x port is necessary.
3. A power phase design with 12 phases is more than enough for moderate overclocking. Most records are set on mid-range boards with a few physical modifications made by the overclocker.
4. Opting for features and then never using them is a waste of money, so unless you are absolutely sure that you are going to buy that extra add-on card within the next year or so, don’t go for the extra slots.
5. The placement of SATA ports right below the x16 PCIE slot may cause them to be inaccessible after a graphics card has been inserted, so take that into consideration.
Graphics Cards

A graphics card is what renders the image that you see onscreen. It’s like a CPU, it has to process and execute a lot of commands albeit these are fewer in number than what a CPU has to handle. The job is repetitive in nature, so graphics cards have evolved to handle a lot of calculation of the same type. A CPU can handle the same workload but it’ll be so overbearing that the entire computer will slow down to a crawl depending upon the workload. So now we have a system where the entire graphics workload is taken away from the CPU altogether and is managed by the GPU alone. Almost all CPUs released nowadays have an integrated graphics processor. This takes away the entire responsibility from the CPU, this way spikes in graphical processing will not hinder the entire computer. There are two major players in the desktop graphics market - NVIDIA and AMD.

Construction

The primary components of a graphics card include
1. The GPU chip
2. Video memory
3. RAMDAC
4. Power supply
5. Cooling

The focus on the power supply and the cooling are a rather new thing since earlier cards didn’t get quite as hot and the act of overclocking GPUs wasn’t that widespread. The GPU is where all the magic happens, programs send their calculations and this chip carries them out. The image created is sent to the RAM from where it will go directly to your monitor (if you use a digital interface like DVI or HDMI) or through the RAMDAC (converts digital image into an analog format which can be sent via the VGA port) to your monitor.

Like we talked about the power phase design in the motherboards section, graphics cards too have a power phase design. This is partly because the voltage levels that these work at are very low and the immense current consumption produces a lot of heat. Graphics cards that were meant to be overclocked have been seen with around 32 power phases, that is quite a lot.

Given the heat produced during heavy load almost all cards have an active heatsink. the more exotic versions come with 2-3 fans and copper heat pipes. There are a few common configurations used in designing the cooling system of a graphics card. One is to pull cool air from outside
the cabinet and then blow the hot air inside, the other way around is the more commonly seen variant. This is because there is much more airflow from within the cabinet since the cooling fan can pull from all directions instead of just one in the other scenario.

**Memory**

Graphics cards have their own RAM, this makes it faster to fetch data and it also creates independence, since the GPU has access it very fast memory there is no hinderance in it’s calculations, otherwise a slow RAM module would known down the performance of the graphics card because of the speed and also the availability in a shared memory scenario.

The big question is how much memory do you need? The RAM currently present on graphics cards are very fast and data doesn’t remain stored for long. However, if one were to use more than 1 monitor then the calculations needed to be performed increases by a huge margin. The greater the area that needs to be rendered the more RAM one needs. Even basic graphics cards have 2 GB of memory now which is enough for triple 1080p resolution display setup. But once you start amping up all the setting in new games then you are bound to need more RAM. So if you plan on gaming at the very highest resolution on three 1080p monitors then go for the 3 GB and 4 GB graphics cards.

**SLI / Crossfire**

Graphics cards can be hooked to other graphics cards to combine their processing power. When even the most powerful current generation graphics card can’t satisfy your visual needs then you can hook up 2, 3 or maybe 4 graphics cards together. For this you’ll need a motherboard with that many PCIE 16x slot, then you’ll need a SMPS which can handle that high load. Most high end graphics cards need a 600W power supply alone, having two or more cards would raise that number to 1000W.
When connecting two or more graphics cards together there are a few rules that need to be followed. NVIDIA requires that both cards be identical in series and model i.e., a 660Ti must be paired with another 660Ti. The brand need not be the same but to avoid any compatibility issues at all then stick to the same brand. Then you need a motherboard which supports SLI / CrossFire configuration and an SLI bridge which is what connects the two cards together. AMD on the other hand requires the family to be the same but there is no need for the model to be the same. So a 7770 can be paired with a 7970 without any issues. Also a motherboard with CrossFire / SLI support and a crossfire bridge are the other components. If at all you can’t find two NVIDIA cards that are the same then you can still hook the two cards together in SLI except one of the cards will become a dedicated PhysX card, we’ll get to this in a bit.

**PCIE 2 / 3**
A graphics card connects to the motherboard via the PCIE slot because of the high bandwidth requirement of a single card. That too it must be a x16 PCIE slot. However, when you go for an SLI / CrossFire configuration you need not need x16 bandwidth on the individual slots. Tests have proven that there is only a miniscule hit in performance when two x8 slots are used instead of two x16 slots. This test was run on a PCIE 2.x generation slot, so it still remains true for a PCIE 3.0 slot.

**PhysX/Havok**
PhysX and Havok are two physics APIs. Game developers choose either software API to handle the in-game physics like smoke effects, character model ragdoll effects and general environment interaction. Havok is supported on both NVIDIA and AMD cards while PhysX is purely supported on NVIDIA cards since NVIDIA bought their parent company.
There is a simple driver modification which when done allows PhysX to be run on AMD cards as well, though it is not officially and never will be supported by NVIDIA. Generally you have the CPU handling the PhysX calculations but with NVIDIA cards in SLI you can have a dedicated PhysX card. And that too you don’t need to follow the SLI compatibility rules. Any previous generation NVIDIA card which has PhysX support will do. The whole prospect of buying an extra graphics card just for PhysX is merely wasting money. You’d be better off having two equally powerful cards in SLI than having an older card as the dedicated PhysX card.

**Workstations**

Both manufacturers have specialised cards for workstations. These cards are for CAD software and other 3D modelling and animating software as these cards don’t have the technology that is otherwise useful in running games. You can play games on these cards but you’d be better off using a normal desktop card for that purpose. NVIDIA’s Quadro series and AMD’s FirePro are both better suited for CAD and other modelling software.

**NVIDIA CUDA and AMD APP**

CUDA (Compute Unified Device Architecture) and APP (Accelerated Parallel Processing) are API’s for running programs on NVIDIA and AMD cards respectively. Graphics cards are designed to process a huge volume of calculations using parallel processing. Using these two API’s programmers can make applications that can harness the immense computing capability of a graphics card.

**What to buy**

When shopping for a graphics card remember the following.

1. The generation of the GPU, the core frequency and the number of CUDA cores/stream processors it has should be given more priority over the amount of RAM it has.

2. For playing simple games you don’t need the latest graphics card it is the AAA titles that would probably tax your graphics processor. Get the latest card only if you wish to play the most latest games at the maximum possible settings.

3. Certain SLI configurations can leave a port or two unusable, so be cau-
tious and verify that your dual / triple monitor setup will be viable using the other ports.

4. Always ensure that your power supply can handle the graphics card’s full workload for around an hour. Cheap power supplies have been known to burn out both the GPU and other peripherals attached on the same rail. 📈
All data and instructions that are processed by the CPU requires some sort of temporary memory since the data to be stored is the resultant of some calculation process. They way processing works is that data that is to be used immediately is stored in CPU registers. But before data is to be computed upon it must be obtained, this data is obtained from the RAM.

Types
RAM is classified based on the type and also the speed at which they function. Thereafter lies the last classification which is according to the memory timing. Labelling is also done based on the rate of data transfer so DDR400 which works at 200 MHz but transfers data at a rate of 3200 MB/s is labelled as DDR400 and PC-3200. The type of RAM is Dual Data Rate (DDR) which is why it is labelled DDR400 and not 200.

RAM started out as a form of volatile memory that has gone through a few technical revisions and has come out in it's current form. There used
to be static RAM which could store data for longer periods and then came DDR RAM which increased the rate at which data transfer was taking place. The evolution happened in this order - SDRAM > RDRAM > DDR > DDR2 > DDR3. With each passing generation the improvements also included latency, speed and reduced power consumption. Physically they have been made to look a bit different so that they cannot be used interchangeably between different generations. This is achieved with a notch in the contact pins and each generation of DDR memory has a different offset as shown in the next page.

A few specialized RAM types exist :-

1. **ECC** - (Error Checking and Correcting) memory constantly checks the data received and verifies its parity. This is a way of counting the 1's and 0's and checking whether an extra bit has sneaked in a particular data stream or not. Such memory are usually preferred by servers since a small mistake creeping in one input could change the results completely.

2. **Buffered** - Another server memory is where an intermediate stage exists with a small CPU register that holds data which cannot be processed by the RAM presently, so the data is stored for a short while.

**Parameters / Specification**

1. **Speed** - Memory speed depends on operating frequency and bandwidth. An easy way to calculate is by multiplying the frequency with the number...
of bits that are transferred during one clock cycle. SDRAM transfers 8 bytes per clock cycle so when a PC133 RAM is considered it should transfer at 133 MHZ x 8 bytes = 800 MB/s. PC266 transfers at 2100 MB/s. This was when memory worked in a single channel mode, current memory works in Dual channel, i.e. 2 simultaneous connections. So a DDR2 800MHz RAM transfers data at 12800 MB/s instead of 6400 MB/s. This is a pretty huge gap and is the reason for a major performance boost when the dual channel memory kits started coming out.

2. Timing - Memory is like a grid made out of rows and columns. Since this form of memory is a random access memory the way a particular bit of data is accessed by referring to a row and the column of the memory. The signal is aptly named CAS (Column Access Strobe) and the delay that exists after the CAS signals a particular memory cell is called CAS Latency or CL. This time delay is based upon the number of clock cycles and are not milli-seconds as is commonly mistaken. The typical timing notation is a combination of 4 numbers - tRCD, tRP, tRAS and CL. They look like this - 7-7-7-21 or 9-9-9-24. What we will be focussing on is the CL timing which is the last number is the sequence. Lesser CL results in faster fetching of data from the memory module and they are equally expensive as well.

3. Capacity - A common concern when figuring out what RAM is to get how much you’ll need. This depends on the type of applications being used, simple ones like spreadsheet programs will utilise a few MBs while 3D model rendering will use as much RAM is available. Games use the VRAM that is available on GPUs for storing texture data and computer RAM is used to store level data. A simple method is to double whatever you need. If your OS and a few programs run fine on 4 GB for RAM then get 8 GB instead. If there is less RAM available then the cache is reduced or emptied on a regular basis. So applications load slower since all applications vie for whatever little memory is available. As a rough approximation, low end
users don’t need more than 4 GB, gamers don’t need more than 8 GB. 3D designers and programmers who deal with memory intensive programs need as much memory as possible.

**What to buy**

When thinking of choosing which RAM to get, remember the following:

1. More is always better though very few people need to populate all the RAM slots in a motherboard.

2. Purchase memory kits together i.e. same manufacturer and same batch. Since manufacturers mix up various brand of memory chips between batches there is a chance that the two RAM kits purchased a few months apart might give rise to compatibility problems.

3. RAM can be overclocked as well and certain SKUs scale better than others, reading a few reviews should tell you which particular SKU currently scales best. This way you can purchase a standard 1600 MHz module and overclock it to 2133 MHz.

4. Check your motherboard manual for a list of reliable vendors whose modules have been tested on your motherboard. Following this list ensures that you should have next to no problems getting your memory to work on the rated specification. Using modules which aren’t included in the list would either work perfectly or it might scale down to the base speed supported by the processor.

5. If your motherboard does not support high speed memory then installing the same will lead to the memory kit being scaled down to whatever value the motherboard supports.

6. Voltage is also an important factor, current RAM modules use 1.25-1.5volts, stick to whatever is supported by your motherboard to be on the safer side.

7. The performance difference between a 1333 MHz RAM and a 1600 MHz RAM is quite huge, however, above 1600 MHz the performance increment per frequency increment reduces severely.
HARD DISC DRIVE

The internal hard drive is something we’ve all known about whether we have a PC or not. It is the main source of storage space with the ability to store any type of data of varying sizes.

The C: and D: that you commonly see when you access a hard drive via windows explorer or “My Computer” is a partition and it may or may not refer to a single physical disk. While RAM is a volatile memory, hard disks are not. They retain data even after a power cycle. RAM uses a bunch of switching circuits while hard drives use magnetically aligned bits to store data.

HDDs

Sizes

There are a few options to choose from when buying a hard drive and they are:

3.5"

By far the most common form factor that you will come across, the 3.5” drive. Given their massive size they have the most storage space for a
given price point. They typically run at 7200 RPM and have multiple platters onto which data is stored. Standard capacity ranges from 500 GB to 4 TB.

2.5”
Another all too common form is the 2.5” drive which is standard in laptops and portable storage drives. They are low power drives with a single platter and don’t boast of much storage space. Recently, these drives have breached the 1 TB capacity limit.

1.0”
If you’ve wondered how miniature devices like PMPs boast of over a 100 GBs of storage space then this is the answer. The microdrive used to be limited to roughly 10-20 GBs but over the years we have seen capacities like 160 GB iPods which had microdrives in them.

Capacity
The early hard drive just had the one platter and two heads that simultaneously accessed the top and bottom sides of the platter. With improvements in technology the data that could be squeezed onto the platter increased tremendously. This is termed as density. Once the upper limits of density was reached the only step forward was to have multiple platters. This further boosted storage space to the extent that we now have 3.5” drives that can store 4 TB of data.

Speed
The speed at which data is accessed comes down to the RPM at which the disc spins at. The following table lists the range of common RPM values.

<table>
<thead>
<tr>
<th>Form factor</th>
<th>RPM range</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.5” SATA</td>
<td>5400 - 10000 RPM</td>
</tr>
<tr>
<td>3.5” SCSI or SAS</td>
<td>10000 - 15000 RPM</td>
</tr>
<tr>
<td>3.5” PATA</td>
<td>7200 - 10000 RPM</td>
</tr>
<tr>
<td>2.5” SATA or PATA</td>
<td>5400 RPM</td>
</tr>
</tbody>
</table>
The way hard drives access data is by moving the head across the surface and then seeking the beginning of the data stream, therefore, higher RPM drives have lower seek times and thus faster data rate. This data rate is also dependent on the interface attached to the drive. PATA drives were way slower than SATA / SCSI drives, this had a lot to do with one interface being serial and the other being parallel. While seeking data to alternating extremities leads to reduced data transfer speeds the normal user does not experience them as equally. So whenever such reduced periods would creep up the copied data would be transferred to the hard drive cache which would hold on to the data till the read/write head would seek to the write place. So having a higher cache also helps but anything above 32 MB is a bit overkill.

**Hybrid drives**
With SSDs becoming more and more accessible owing to reduced chip costs even hard drives started incorporating the chips into their design. This gave birth to the hybrid drive. There are two ways that this is accomplished. You can either use two separate drives (one SSD and one HDD) to create a hybrid solution where data would be transferred to the SSD quickly and then the drive took its own sweet time to transfer it to the HDD. Also frequently used programs and files were stored on the SSD to improve load times.

The true hybrid drive is when there is just one physical disk onto which a few GBs worth of memory chips are placed. They work in a similar fashion as explained above leading to faster transfer speeds and caching of frequently used applications.

**Interface**
PATA / IDE
ATA stands for Advanced Technology Attachment, its two variants are named PATA and SATA given their mode of operation (Parallel and Serial). PATA used flat and wide 40 pin connectors and were capable of transferring data at speeds of around 100-133 MB/s. This was the maximum potential,
however, as time passes the fragmentation of data lead to much slower speeds. PATA needed so many connections since it would transfer data parallely, i.e. each data line had one bit moving along it simultaneously. PATA was also known by the name IDE(Integrated Drive Electronics) or EIDE(Enhanced Integrated Drive Electronics).

**SATA**
SATA on the other hand uses serial mode of data transfer, so a stream of data would be sent in one burst leading to much higher speeds. SATA has undergone quite a few revisions and is now in it’s third avatar. The speed has also kept with the times, SATA had an upper limit of 150 MB/s and SATA2 doubled that with 300MB/s. SATA3 doubled even that to hit 600 MB/s. Hard drives could barely sustain 110 MB/s on their own so one wonders why was the new interface needed in the first place. The answer lies in RAID systems, this allowed people to utilise more than one hard drive as a single drive. Thus each drive transferring at 110 MB/s would contribute and cumulative the entire system would have increased transfer speed. Nowadays you can easily hit the SATA3 limit with two SSDs in RAID 0 configuration.

**SCSI / SAS**
SCSI or Small Computer System Interface is a technology attachment that is catered towards enterprise and server solutions. They are more optimised for systems where more than one hard drive is to be installed in single, JBOD(Just a Bunch of Drives) or RAID(Redundant Array of Independent Disks) configurations. They usually are faster, have low seek times due to high RPM and have hardware monitoring for the hard drive’s health. A variant of this is the SAS (Serial Attached SCSI). This interface ushered in even greater throughput than before. The connector is the same as SATA so normal desktop users can switch to SAS drives for the extra speeds. However, with the advent of SSDs and hybrid drives, this seems to be a more expensive option.
What to buy
When going in for a hard drive remember the following
1. When you want a lot of space getting a hard disk is the wiser option compared to SSDs.
2. Drives marked as eco-friendly or Green are likely to have poor transfer speeds but are great at saving power, only get these if you have a normal drive (7200 RPM) as your primary disk.
3. When going for a RAID configuration always opt for similar drives with similar capacities from the same manufacturer for best results.
4. Laptop hard drives use the same SATA power connector as desktop drives so they are used by folks who want a cheaper option to portable drives, though if you are a beginner we’d recommend that you stick to the portable drive instead of buying a naked laptop drive.

SSD
The latest entrant in the storage media evolution is the SSD or Solid State Drive. You’ve read about SSDs and you’ve read about RAM. One is faster than the other while the other is non-volatile so the logical step was to create a drive that would be faster and non-volatile. Thus, the SSDs were born. Now both RAM chips and Hard drives have been around for quite a long time but it was not feasible till this time owing to the low capacities per chip and the cost per chip. Even now the cost per GB for SSDs is quite high compared to HDDs.

Types of memory chips
NAND flash memory acts as the primary data storage chip for most SSDs. These are available in two variants - SLC (Single Level Cell) and MLC (Multi Level Cell). SLC is faster and has lower density than MLC, so they are expensive. They are usually found in enterprise and enthusiast drives where high transfer rates are necessary. They
are also more reliable and have higher operating limits (voltage and temperature). The memory chips then interface with a controller and a cache memory. The cache memory type depends on the main storage chips. MLC being cheaper and with greater density is found on entry-level and mid-range SSDs where space matters over speed. Either option is still faster than having a hard drive.

**Cache**

DRAM chips are used as cache in SSDs, they are pretty much the same as RAM and function in the same manner. Hard drives had cache memory which was limited to 64 MB and even that was too much. But SSDs have a much higher data transfer rate and thus need more cache memory. Typically a SSD has 256 MB to 1 GB of cache memory but there are entry-level models with cache memory as low as 32 MB.

**Interface**

SSDs use the same interface as HDDs except that the SSDs are more capable of utilising the full bandwidth that a SATA interface has to offer. The majority of SSDs in the market use the SATA3 interface which has a maximum data transfer limit of 6 Gb/s or 600 MB/s. There are more exotic SSDs which connect directly to the PCIE slot which has a much greater bandwidth. PCIE SSDs have a transfer rate of 830 MB/s, most SSDs lie in the 300 - 550 MB/s range.

**Controller**

This is at the core of the SSDs performance – The Controller. The controller’s job entails keeping a check on the data stored in each chip and optimize the way data is to be stored in the SSD.

The flash chips used in SSDs have a limited number of write cycles. Therefore, a controller has to ensure that no one section is overused compared to others. The work done by a controllers includes deciding which block of data needs to be written and when to rewrite a block. Other functions include

- Error checking and correction (ECC)
- Keeping track of bad blocks of memory
- Read and write caching
- Garbage data collection (data stored in non-initialised regions)
- Encryption
Firmware
The controller is basically a programmable microchip and it is the firmware which tells it how to do its job. This way whenever newer methods are invented, your old SSD can be updated to follow them. Though you can only use firmware that your SSD manufacturer releases and not the stock firmware that the controller’s manufacturer releases. This is because there are customisations performed by each manufacturer. There have been certain open source firmware released by third parties that promise better performance, but using them will void your SSD’s warranty.

So how good are SSDs?
We know that they are better in a lot of aspects when compared to hard drives so let’s take a look at all the parameters where they excel.
1. Speed
SSDs are much faster than HDDs since access times are way lower than HDDs and because of the fact that any section of the SSD can be read without going through it’s adjacent cells. Hard drives have to seek to a location in order to access it, SSDs don’t have this problem.
2. Boot-time
Due to the faster transfer speeds and the lack of a spin-up period the boot time when an OS is installed on the SSD is roughly under 30 seconds even after significant wear and tear.
3. Durability
Since SSDs don’t have any moving parts at all and that they are lighter than HDDs, they are much more durable and shock resistant. Most SSDs weigh approximately around a 100 gms, even with metal casings they don’t weigh more than 300 gms.
4. Noise
Since there are no moving parts, there is no noise at all.
5. Power consumption
At the heart of a HDD lies a very powerful motor and motors consume a lot of electricity. Then there is the read / write head which uses very powerful electromagnets, again something that consumes a lot of power. The SSD on
the other hand consists of a few memory chips which consume less than 10 Watts even at peak consumption.

6. Temperature
Given the lack of a motor and other mechanical components where electrical energy might be converted to heat energy, SSDs are significantly cooler than HDDs.

**What to buy**
Here are a few points to ponder over when buying SSDs

1. If you wish to buy one solely for a boot drive, then a 120 GB drive is best. This is because lower capacity SSDs are slower than higher capacity SSDs even when using the same controller chip and 120 GB of space is more than sufficient for a dual / triple boot OS configuration.

2. Opt for SATA3 SSDs only since SATA2 interface will hinder the drive’s performance, also ensure that your motherboard comes with SATA3 ports.

3. Check out reviews of different controllers and their performance when scaled in capacity, certain controllers do well in certain usage scenarios.

4. The IOPS (Input Output Operations per Second) that is mentioned on SSD packaging is tested with fresh drives that haven’t been used at all. This is not the typical usage scenario as after a few months this value drops down considerably, check out reviews which take into consideration preconditioning before testing.

5. Avoid defragmenting SSDs as it is an unnecessary operation as SSDs don’t have high seek times even with considerable fragmentation.
Now that most internals of the PC have been covered we’ll move on to the case in which you house your components and the screen on which you’ll see your PC come to life. We also cover Audio cards for the discerning few who want to indulge more than a few senses and Power supplies to power your creation.

Audio Cards
The audio card or sound card was a necessity since early computers were capable of only producing a single beep but programmers with all their creativity did manage to get some groovy tunes flowing by varying the frequency and duration of the beep. In order for a music to be played that didn’t sound like a 8 bit video game soundtrack you’d get a sound card.
The technology
Computers use digital data comprising of 1's and 0's. Sound on the other hand is an analog signal with smooth curves and varying frequencies brought together in a wondrous melody. So in order for digital data (which was all that could be found) to be converted into an analog signal we needed special encoders. So the basic sound card consisted of an ADC (Analog-to-Digital) convertor for microphones to connect to and convert the analog sound into a digital stream that could be stored within a computer. And a DAC (Digital-to-Analog) convertor which did the exact opposite. Since then the technology has significantly advanced and we now use single microchips called Codecs which incorporate the functions of both the DAC and the ADC. Conversion of an analog signal to digital does lead to data loss as digital signals are basically a step function, so in order to reproduce the analog signal accurately the sound card needs to sample the analog signal at a high frequency. Thus, the higher the sampling rate, the better recording you can get done on that particular sound card. Then again there are DSP (Digital Signal Processors) which are situated between the DAC and ADC stage and are capable of performing heavy duty calculations. These come with their own memory too. This way the processing of the sound signal is isolated completely from the computer processor. Otherwise, the job of the DSP is done by the CPU which puts unnecessary load on it.

SSD
The latest entrant in the storage media evolution is the SSD or Solid State Drive. You’ve read about SSDs and you’ve read about RAM. One is faster than the other while the other is non-volatile so the logical step was to create a drive that would be faster and non-volatile. Thus, the SSDs were born. Now both RAM chips and Hard drives have been around for quite a long time but it
was not feasible till this time owing to the low capacities per chip and the cost per chip. Even now the cost per GB for SSDs is quite high compared to HDDs.

**Software API**

Now different operating systems and programs use different methods of utilising a sound card’s prowess, there are separate APIs accepted as standard by game developers which make it easier to create special effects like 3D sound. The more APIs your sound card supports the more accurate reproduction of the intended sound it can accomplish.

**Common APIs include:**
1. Microsoft: DirectSound
2. Creative: Environmental Audio Extensions (EAX) and Open AL
3. Sensaura: MacroFX
4. QSOUND Labs: QSo

**Onboard and discreet**

The reason why you’ll never have seen a sound card is that onboard sound Codecs have improved so much that certain low-end audio cards sound worse than onboard sound. They boast of significantly high SNR and are capable of driving quite a lot of mid-range headphones and speakers. Also since a good speaker system relies on an external amplifier so having one onboard doesn’t make sense, especially given the extra power needed which your power supply might not be able to sufficiently provide.

**Interface**

Sound cards are either internal or external. Internal sound cards use the PCI or PCI express slots. A 1x PCI express slot is more than enough and there is usually one in almost every motherboard. Since the card connects directly to the motherboard there is less noise given the low latency and
construction of a motherboard. External audio cards are those which connect via USB or other similar ports. They are comparatively prone to distortion since the audio has to travel through the USB chip before getting to the platform controller hub.

Sound cards can have a host of connectivity options for speakers and microphones. Common connectors include
- 2.5 mm audio socket
- 3.5 mm audio socket
- 6.35mm TRS socket
- S/PDIF - Electrical or optical
- RCA socket

It is common for a single stereo socket to exist with adaptors provided to switch between sockets.

**What to buy**

When shopping for a sound card, remember the following points
1. Isolated power supply helps out a lot in reducing noise from creeping into the sound signal.
2. Depending upon what kind of speaker arrangement you are going for, ensure you have sufficient connectors on the sound card. If not, invest in adaptors to get the job done.
3. Most onboard cards are not capable of driving high impedance headphones that’s when you know that you need a sound card.
4. Similarly, having a good sound card and not having good headphones / speakers defeats the purpose of buying the sound card in the first place.

**SMPS**

The SMPS or the Switching Mode Power Supply is where the computer gets it’s power from. While it does plug into the AC mains, computer components inherently work on DC voltages ranging from 1.8v to 12v. The SMPS, however, provides 12v, 5v and 3.3v from AC power mains. This is further brought down to various levels as required by the particular component. Now different countries use different voltages as the standard, we have the
United States using 110v and we ourselves use 230v. Earlier power supplies had a small switch in the back to select the voltage, but with improved technology this is accomplished within the SMPS itself.

**Why switching?**

Power supplies in general can be either Linear (only uses a transformer to bring down AC power supply before rectifying it into DC) or it can be switching as most power supplies are today. Now the difference between 230v AC and 12v DC is pretty huge, so the transformer used to convert this would traditionally be huge as is the case in linear power supplies. Now the number of coils of winding in the transformer is dependent on the frequency of the input voltage, the lower the frequency the bigger the transformer. So switching mode power supplies increase the frequency of the input voltage, thus, reducing the size of the transformer and subsequently the size of the power supply unit.

**Form factors**

Now computer cabinets come in all shapes and sizes given the way it is to be implemented, server power supplies are lean and long while desktop power supplies look like one half of a brick. When computers are concerned there are two form factors which are the most popular, ATX12V and EPS12V. The standards not only dictate the dimensions of the outer box but also the values of voltages that are in the power supply.

**ATX**

A standard throughout the 90s and the early 2000s, the ATX form factor is what standardised by IBM. It is difficult to get your hands on any of these now but they were notable in bringing about a few changes. The 3.3v rail was introduced with this form factor and so was the 20-pin motherboard connector. The major change was that you could now use your operating system to power down the system. Back in the days of Windows 95, your PC would not power down completely, rather it would reach a state where you had to manually switch it off. We now have the revised version of ATX where the 20-pin motherboard connector is replaced with a 24-pin connector and certain changes were made as to how much current should be allowed on each rail. CPUs were given separate connectors and no longer shared the motherboard’s power supply.
EPS12V
This form factor introduced an additional 8-pin connector purely for the processor instead of the earlier 4-pin owing to higher power processors being released in the market. Though originally designed for servers with 2 sockets, this schema has been adopted for desktop use as well.

Connectors
The usual desktop SMPS comes with the following connectors
1. 20+4 pin motherboard connector for hooking up your motherboard.
2. 4+4 pin or simply one 4 pin connector for your CPU
3. 6 pin or 6+2 pin connector for your graphics card
4. 4 pin molex connector for your PATA / SATA drives and also for auxiliary uses like extra power and chassis fans.
5. 15 pin flat SATA power connectors

Efficiency
Efficiency of a power supply is defined as the ratio between the power pulled from the AC mains to the power provided by the power supply. Now, power supplies heat up a bit and we have a little loss in energy over there, similarly, there are other avenues for loss in energy. A good power supply has high efficiency and thus, is economical in the long run. A simple example is that if your power supply uses 100 W to provide 70 W as output then your SMPS efficiency is 70%. There is even a system of certification for SMPS. You'll see it as a small badge called 80+ efficiency. The following image should give you an idea of the different badges.

Now the higher the efficiency the better the power supply, but the price increases likewise. This shouldn’t be a concern as in the long run a SMPS with higher efficiency will save you a lot more on your electricity bill. Also since the efficiency is high the power supply does not lose much power to heat loss. Hence, it will be cooler in the long run too. It has been found that power supplies are the most efficient when the load on it is
median, i.e., around 50%, this isn’t a fixed figure as there are a lot of factors that determine this figure, but it generally is median. So getting a 80+ efficient power supply that is roughly twice your power needs would be the best choice, it also helps that future upgrades which might consume more power would be easily accommodated with the power supply you buy. This is also going to cost you a bit more than what you’d generally spend on a SMPS.

**Power calculation**

A rough power calculation should be performed before you decide what power supply to buy. For this you need to know what component uses what voltage level.

The following chart lists the various components and the voltage level they consume.

<table>
<thead>
<tr>
<th>Component</th>
<th>Approximate power consumption</th>
</tr>
</thead>
<tbody>
<tr>
<td>CPU</td>
<td>55W - 150W</td>
</tr>
<tr>
<td>GPU</td>
<td>35W (Onboard) - 180W (Discreet)</td>
</tr>
<tr>
<td>RAM</td>
<td>7 - 15W per GB</td>
</tr>
<tr>
<td>Motherboard</td>
<td>30W - 60W</td>
</tr>
<tr>
<td>HDD</td>
<td>15W - 30W</td>
</tr>
<tr>
<td>ODD</td>
<td>20W - 40W</td>
</tr>
<tr>
<td>SSD</td>
<td>5W - 8W</td>
</tr>
<tr>
<td>FAN</td>
<td>2W - 5W</td>
</tr>
<tr>
<td>USB peripherals</td>
<td>2.5W per USB 2.0 device</td>
</tr>
<tr>
<td>PCI cards</td>
<td>5W - 10W</td>
</tr>
</tbody>
</table>

All you have to do is list your components and multiply by its power requirement and then total up all the figures. This should give you a rough approximation. There are several online power calculators (eXtreme Power Supply Calculator) which are much more specific to individual model numbers so that would help even better.

**Protection features**

Now a disaster isn’t always far away when electricity is concerned. Voltage fluctuations and other problems are quite common. Getting a UPS is always recommended but when your power supply is a true sine-wave SMPS then even getting a compatible UPS becomes a pain. Then again, problems need not be external in origin, even when computer components get short-
circuited there arises problems. The following are some common protection mechanisms built into power supplies.

**Circuit Protection (SCP):** If any output from the SMPS is shorted then the SPMS shuts down.

**Under Voltage Protection (UVP):** There are threshold values assigned to each voltage line and when the value drops below the threshold value, the SMPS shuts down.

**Over Voltage Protection (OVP):** Similar to under voltage but works in the opposite fashion.

**Over Current Protection (OCP):** Each voltage line has an upper limit to the current it can supply, when that is exceeded this causes the SMPS to shut down.

**Over Power Protection (OPP) or Over Load Protection (OLP):** Switches the SMPS off when excess power than rated capacity is drawn.

**Over Temperature Protection (OTP):** Switches off the SMPS when temperature goes above a certain limit.

Now all the above protection circuits might not be present in all SMPS, but you can figure out just by reading what they do that they are quite important. While SCP, OVP and OCP are quite important, having the rest goes the extra mile. OTP is pretty much common in a lot of modern day circuits.

**What to buy**

When considering a new SMPS for your PC keep the following points in mind

1. Efficiency matters, higher efficiency power supplies are economical, have better protection mechanisms since they are a bit expensive and are cooler than normal power supplies.
2. Manufacturers rate SMPS a bit conservatively, i.e., a SMPS rated for 850W might be able to provide roughly 1000W but such scenarios should be avoided.
3. Always keep in mind how many connectors you'll need, buying a cheap power supply and daisy chaining everything onto one rail will damage the power supply in the long run.
4. If you are more of a 24x7 computer person then go for a higher wattage SMPS than you need since SMPS capacitors lose their capacities due to overuse so within a year your SMPS’s wattage should fall a bit below the rated value.
5. If your SMPS is a pure sine wave SMPS then you should get a compat-
ible UPS, do not use a cheap UPS with your expensive SMPS, you might ruin both.

6. Certain SMPS are rated as peak power and continuous power. peak power is what you get for a very short time (under a minute) after which the SMPS might shut down or catch on fire, while continuous power is what the SMPS can provide 24x7.

Monitors

The monitor is the gateway to your computer, all the expensive hardware that you purchase in order to make your computer faster and show better graphics is relayed via the monitor. Gone are the days of staring at your screen being bored out of your mind, the monitor of today has 3D and sometimes bigger than your TV.

**LCD, LED, Flatscreen and TFT**

They are the same! It’s just the backlight that differs, in LCD monitors you have a cathode tube similar to your tubelight which provides backlight while LED monitors have, well LEDs to provide the backlight. Early monitors were CRT (Cathode Ray Tube) that were huge, bulky and consumed a lot of power but the colour reproduction is something that today’s monitors still have to look up to. CRT monitors had a picture tube which was the primary component and the insides of it were covered with phosphorus compounds which when hit by charged particles would light up. Thus by varying the charged particles one could create pictures. LCDs use a different system, they have two panels which are polarised (they need to be electrified to let light pass through) and in front of the panel lies another panel that has minute cells like a spreadsheet. Each cell has 3 sections consisting of the primary colours. The sections are turned on / off to produce a certain colour. These small cells are called pixels, an all too familiar term. Since a lot of companies were researching LCD panels simultaneously they each came up with
their own panel technology, each with its own merit, we’ll cover those in the following pages.

**Panel technology**

There are three primary types of panels available in the market, namely, TN (Twisted Nematic), VA (Vertical Alignment) and IPS (In Plane Switching).

**TN** - Pretty much the oldest and thus the cheapest of the bunch, TN panels form the majority of monitors around. They have faster response times (2 - 5 ms) and high brightness levels. The major drawback is the narrow viewing angle for the panel. Moving out of the view cone results in changes in the perceived colour and viewing from an extreme angle means that you’ll barely even make out anything on the screen. The situation is worse when moving vertically as compared to horizontally.

**VA** - Vertical Alignment panels had even worse viewing angles when they first came out, but within a few years some modifications were made which resulted in greater viewing angles compared to TN panels. VA panels have two major sub-groups - MVA (Multi-domain VA) and PVA (Patterned VA). All these are pretty similar to each other with some focus on one or two aspects. MVA tend to provide better viewing angles and have a higher contrast range as compared to TN and IPS panels whereas PVA panels excel a bit more in the contrast parameter. There are more variants like Premium MVA, Super MVA and Advanced MVA. Every two years or so a new panel technology is invented.

**IPS** - In Plane Switching panels offer the best colour reproduction and wide viewing angles. This comes with a drawback which is that they are inherently slower, have less brightness and are quite expensive. Wide viewing angles combined with great colour reproduction results in the same picture quality no matter from which angle you look at it. They are thus preferred by people working in multimedia design and animation. Even IPS panels have their minor variants like Enhanced-IPS, Super IPS and Advanced Super-IPS. Each variant improves a bit on the drawbacks of the previous generation.

**What’s new?**

**OLED:** These are by far the most expensive panels you can get your hands on, the technology is so new that panel sizes are limited which is why they are more common as displays for mobile devices rather than monitors. OLED and its successor AMOLED boast of the best black levels that can be achieved. This is because in LCD panels the backlight is never switched
off and thus a little light escapes here and there resulting in a bit of grey tinge being displayed rather than absolute black. OLED panels have LEDs instead of a tube backlight and each pixel has its own little LED backlight which can be switched off to ensure absolute blackness.

**3D Monitors:** These monitors are designed for a better 3D viewing experience. Normal monitors can display 3D content but with low refresh rates it is difficult to make sense of a scenario with a lot of rapid movement on the screen, 3D monitors have higher refresh rates (120 Hz) which reduces the ghosting effect.

**Touchscreen monitors:** While desktop monitors aren’t seeing a lot of touchscreen monitors the laptop market is quite the opposite specially after the launch of Windows 8 which has a tablet-like interface in place of the traditional Start Button menu. They are pretty much like mobile touchscreens with multi-touch capabilities. The panel technology is the same as normal monitors with the exception of having a digitizer layer added on the top of the panel.

**Parameters / Specifications**

**Contrast Ratio**

Quite simply put the monitor’s contrast ratio is the difference between the two extreme levels of brightness - absolute black and maximum brightness. There is no standard to measuring contrast ratio which gave rise to idiotic marketing terminology such as Dynamic Contrast Ratio. Ideally contrast ratio refers to the difference in brightness levels with the backlight kept static, i.e. the brightness of the backlight remains the same while the picture on the screen is turned to white / black. What Dynamic contrast ratio refers to is when the backlight is varied along with the image on screen. So a dark image is measured with the backlight set to the absolute minimum (a scenario which will never be reproduced during normal usage) and then a white image with the backlight set to a level higher than what a consumer model comes with. The resulting ratio is quite high, you see contrast ratios ranging in the millions. Always compare monitors with the actual contrast ratio and not dynamic.

**Pixel pitch**

Pixel pitch / dot pitch refers to the space between the pixels on the screen. The smaller the pixel pitch the more dense the panel is and thus better your image quality becomes.
**Response Time**
The response time refers to the time taken for a pixel to turn from a state of brightness to a state of darkness and back again. They are commonly referred to as Gray-to-Gray timing or tr:tf time. What you need to know is that tr:tf time of 5 ms or lower is best for monitors since ghosting would be negligible in these monitors. Gamers in particular prefer TN panels as they have the least response time and are best suited for FPS games. For movies and more relaxed work a monitor with 12ms response time is sufficient.

**Size**
The size of a monitor is measured from one corner to its diagonally opposite corner. Now aspect ratio does come into play here as widescreen monitors (16:9) have a different aspect ratio compared to normal screens (4:3). The bigger a monitor gets the greater resolution it must support or else you start seeing the individual pixels and it defeats the purpose of having a big monitor.

**Resolution**
The resolution refers to the number of pixels that lie horizontally to the number of pixels that lie vertically. There are a few standard resolutions like 1280 x 1024 and 1920 x 1080. Almost all software and media are produced with a certain aspect ratio which looks good on monitors which have the same aspect ratio. Deviating from the standard values would result in a skewed image reproduction.

**Refresh rate**
Measured in hertz, this parameter tells you the rate at which the entire image displayed on the screen is produced per unit time. What you need to take care of is that your graphics card should be set at whatever refresh rates your monitor supports otherwise you might end up damaging the monitor for good.

**On Screen Display**
The OSD menu shows all the properties of a monitor that can be changed on the fly. The colour temperature is one such parameter which can affect the way monitors reproduce colours, so if a certain colour doesn’t seem the way it is in actuality then it can be adjusted by switching between
different colour temperature levels. Also brightness and contrast can be changed via the OSD. Certain monitors allow you to create profiles which are basically a collection of all the various settings you have access to. This way you can have one profile for watching movies and another for reading etc.

**Interface**
The type of connector between your graphics card and your monitor does affect your picture quality. Certain interfaces have higher bandwidth and can support greater resolutions. The common interfaces in use today are VGA, DVI-D, DVI-I, HDMI and DP. VGA has been the standard for quite a long time and with higher resolution displays being produced the need for an interface with greater bandwidth arose and the DVI interface was introduced. As for monitors with inbuilt audio, you could either use a audio jack to connect to your monitor or use a HDMI connector which has the video signal along with the audio signal. The newest entrant in the market is the Display Port which is quite similar to the HDMI interface. The difference lies in the security features and the increased bandwidth of the cable. Also the newer interfaces can carry signals for longer lengths as compared to previous generation interfaces.

**What to buy**
When buying a monitor remember the following points:
1. A huge monitor which only supports lower resolutions isn’t worth buying.
2. Always stick to a standard aspect ratio.
3. The monitor must have an interface which is supported by your graphics card, using adaptors is one way out but using a low bandwidth adaptor on a high resolution monitor doesn’t do justice,
4. Choose your panel type based on your usage scenario.
5. If you wish to wall mount your monitor then go for a monitor that supports the VESA standard. There are lots of mounts available which support this standard.
Cabinets

If the word cabinet didn’t ring a bell then quite a lot of people refer to it as the “CPU” and they couldn’t be more wrong. We are talking about the big hunk of metal in which all the essential components of the computer are mounted. From the motherboard to the power supply and every other thing except the display, keyboard and the mouse.

Form factors

While motherboards are categorised as ATX, ITX and mATX, the cabinets are built around these dimensions, so they come as:
1. Mini-ITX
2. Mini-Tower
3. Mid-Tower
4. Full-Tower

The bigger ones generally support all smaller sizes, you just have to mount the screws in the right holes, however, it would be a bit ridiculous getting a colossal cabinet for a mini-ITX motherboard unless of course you plan on stuffing a lot of hard drives in there. The full-tower has a lot of space and can support a host of peripherals that you may deem necessary for your configuration. The mid-tower is the most common size available owing to its familiarity and price. The mini-tower and the mini-ITX are sort of the most difficult to put together unless they come pre-assembled. You need to follow a particular sequence in order to fit stuff in it and even then you are unlikely to be able to have the big graphics cards that are all too common nowadays. The sequence stays true for almost any assembly but you can mix it up a bit when dealing with a mid-tower and a full-tower.
Build quality

One of the most important things to look out for when pondering over a cabinet is its build quality. The materials that go into building a cabinet tells you whether it can handle the hardware that you put it. A full body made out of aluminium or steel is preferred over sheet metal because they aren’t prone to dents as much and aluminium is a good heat conductor. Then come the locking mechanisms, the traditional screw-in panels are always preferred over the much more “accessible” cabinets since the only time you’ll ever need to open your cabinet is when you clean it and when you are adding / removing components. Other things that are scrutinised are the quality of the plastic fittings. A strong frame implies that deformities caused by accidents like toppling over will not get the side panels jammed. The quality of the paint coat also is to be checked to see if the case will rust easily. Dust is your enemy since clogging up vital ventilation pores is what it does. Dust goes into your cooling fans and weighs it down and the build-up reduces air flow. Dust settles onto electrical contacts and with high moisture content it will short circuit your components. A mesh design with very fine holes or a removeable plastic mesh over a window are effective methods of reducing dust intake, however, regular cleaning is still recommended. The material of the cabinet is of great importance if you live by the sea since the saline air pretty much eats through iron and some steel.

Features

1. Multiple mounting locations for cooling fans

The pure number of combinations of component configurations that you can achieve while building a PC implies that there can never be a few fixed places that would cover all your cooling needs, you need to study the way air flows through the cabinet and figure out the fastest way to let cool air in and hot air out. Having more options to mount fans makes this possible. Also fans come in either 80mm, 120mm, or 140mm diameter, so a cabinet with mounting holes compatible with all three fan sizes is helpful.

2. Water cooling support

When going in for the extra chilling factor with water cooling, you need a cabinet which was designed for the purpose. Common elements in a water cooling system include a radiator, motors, component mounts, tubing and a reservoir. Majority of these components lie inside the cabinet, only the radiator which is from where the heat transfer takes place is placed either
on the outside or on the cabinet body. So if it were to be placed outside then you need holes for the tubing to go in and out of the cabinet. However, if you aren't planning on going in for water cooling now (they can be quite expensive) but might consider later then having a cabinet with all the features is optimal. Radiators come in different shapes but are somewhat standardised based on the number of fans it can mount, so common radiator sizes are 120m, 240mm and 360mm in length, there are mounting holes for radiators either on top or on either side of the cabinet.

3. Large PCIE cards
With each new generation of GPUs entering the market we are seeing bigger and bigger GPUs being released. Now the standard cabinet configuration has the hard drive bays directly ahead of the PCIE cards, so either the hard drive cage is rotated by 90 degrees or the cabinet has more depth and width. These PCIE cards blow out a lot of hot air either out from the front or the back so having a fan mount right beside the GPU location is ideal. Most new cabinets come with a huge 200mm fan in the front which blows air or the hard drives and also on the GPU.

4. Toolless design
Something we are getting to see more commonly nowadays are cabinets with toolless design cabinets. The upside is that you don't need tools to open the cabinet or mount most of the hardware except the motherboard, so far we haven't seen any of those. Even drive bays and PCIE slots have snap on tabs which can be flicked to lock / unlock the hardware components. The downside is that they are often made out of plastic that happens.

5. Drive bays
We have HDDs, SSDs and ODDs which come in either 3.5” / 5.25” or 2.5” width. Generally, cabinets have one or two drive bays for each size but that limits your ability to set components as per your liking, so we have adaptor kits that are shipped with 2.5” devices so that they can be affixed onto the
3.5” drive bays. Similarly, removable drive bays with holes for both 2.5” and 3.5” devices are commonly seen.

6. Extras
Every manufacturer comes up with their own extra feature that might just be what you need. Front panels with audio in / out and USB 2.0 ports are seen on mid-range cabinets, sometimes you’ll get the USB 3.0 port along with a FireWire or eSATA port. Higher end cabinets will feature even more things like swappable SATA bays for accessing SATA drives without opening up the cabinet. Then a few cabinets might feature fan controllers fitted onto the front 5.25” drive bay.

What to buy
Here are a few things to keep in mind while shopping for cabinet.
1. If you are going in for a lot of hardware then there will be a lot of heat produces, so cabinets with a lot of cooling vents and fan mounts should be preferred.
2. Remember what kind of GPU you are going to buy and find a cabinet that will fit the GPU while allowing a few inches of extra space.
3. Cheap cabinets will come with a power supply included, these are pretty much worthless and if you care about your hardware it’s best to throw the included SMPS out.
4. Full tower cabinets are quite expensive and not always the recommended buy, unless you happen to go for a triple SLI / CrossFire with a bunch of hard drives and a water cooling setup. The same can be easily managed with a mid-tower cabinet.
5. When available go for a cabinet with cable management facility.
Keyboards, Mice and other peripherals complete your PC requirements. But there’s a lot more to these ancillary components than meets the eye.

Keyboards
The keyboard is pretty much one of the components of a personal computer which we tend to take for granted. The average user doesn’t have to type much and subsequently getting one of those Mouse + Keyboard combos for Rs.500/- is more than sufficient for the majority. However, when we look at the technology that goes behind different keyboards, we find that they are not that behind in variety and complexity as the other components of a personal computer.

USB vs PS/2
The two common interfaces that we have today are the PS/2 and the USB. They both have their own pros and cons. PS/2 is a much older technology but motherboards that come out these days still feature them and will continue to do so in the near future. Both USB and PS/2 are serial interfaces, which means data is sent one after another instead of being sent parallel to each other. This doesn’t make any difference to the majority of the users but for people with really fast typing and pro gamers tend to favour the PS/2 and we'll tell you why as this section progresses.
At the technology level the USB port uses polling to figure out if any particular port has anything to communicate. Whereas PS/2 is what we call an always on device. The way they both handle interrupts is different.

**Key Roll Over**

Interrupts are sort of handshakes which are used by devices to initialise a communication. Once an interrupt is sent by a hardware device the computer knows that it will start communicating soon and listens to that device for data. On the USB, the interrupts are sent in packets, i.e. a cluster of data is sent to the computer and the computer has to break it down to figure out what key was pressed. The average person doesn’t squeeze multiple keys at the same time. At most we press 3 keys which is what most operating system short-cut keys are limited to. Gamers on the other hand have the habit of mashing keys together, they develop key combinations which when executed in the right sequence could pretty much win the game for them, these sequences can sometimes be very rapidly executed. We know for a fact that multiplayer RTS games like StarCraft II have specific terminology for this, they call it APM or Actions Per Minute. A professional gamer has an APM upwards of 500-600, this equals to about 10 key presses per second and this is just the average. In heated moments this can scale much higher. Now keyboards were designed to handle around 3 simultaneous key presses, you could try this with your own computer, try pressing 4 keys which are in a horizontal line at the same time. If you do get it right then at most 2 keys should register(unless you are using a high end keyboard).

This is because the keyboard is unable to distinguish between multiple key presses and singles out what it can definitely say has been pressed. This is called KRO or Key Roll Over.
Quite simply put KRO is the ability of a keyboard to distinguish all the keys that are simultaneously presses. The notation is preceded by a number which tells you how many keys can be pressed at the same time. This way 3KRO means that 3 keys can be pressed simultaneously and they keyboard will recognize each key press. There are keyboards that come with 6KRO and nKRO(any number of keys may be simultaneously pressed) they are generally a bit expensive given that this functionality is present in most high end keyboards. PS/2 keyboards are theoretically capable of figuring out each and every key pressed but that is when each key is wired separately. This is not the case with keyboards as most keyboards use two pastic sheets with circuits etched over them with mutually isolated contact points that are are very close to each other. These contact points register a keypress when the space when the space between them is closed by the key.

**Ghosting**

The above image shows a typical keyboard membrane, you can see how most of the contact lines are placed in a grid like pattern. Each key is not separately connected but rather a combination of horizontal row and vertical columns are used to figure out which key was pressed. Now imagine if three keys were to be pressed in the same row. Only one row would light up while three vertical columns will light up. This tells the keyboard circuitry that three keys have been pressed. Now if 4 keys were to be pressed and that too 2 keys in one row and the 2 immediate keys right above them. This square pattern now registers 2 rows and 2 columns. Again the computer know which keys were pressed. Now finally remove one of the keys pressed in the previous combination. This still triggers 2 rows and 2 columns. So even when you’ve pressed 3 keys the computer is unsure whether it was 3 or 4. This phenomenon of detecting a key that hasn’t been pressed is called Ghosting. The whole issue has less to do with PS/2 or USB but rather the way the membrane is designed.

**Layouts**

The keyboard is broken down into certain groups. Most of the alphabets form a huge chunk of the keys and are aptly called the character keys. Then there are Modifier keys which consist of Shift, Alt and Ctrl which we use to give commands of access Menu bars. Then come the navigation keys which allows the user to move about the workspace. The number keys exist in two places, the first is right above the character keys for ease
of accessibility during typing and another called the Number Keypad (or Numpad for short) exists on the very right which came in sort of as a legacy add-on for people involved in the number crunching business. Finally we have the Function keys F1 through F12 on the top and a few system keys like Esc, Caps lock etc. Laptops tend to do away with the Numpad to save space and to make it compact.

The standard keyboard that most of us use is said to have a QWERTY layout. By glancing at the top line of your keyboard you should be able to tell why. This arrangement is something that was derived from the age of using mechanical typewriters. They hand levers which would spring forth for each key that you pressed and hit the centre of the paper. Now when more than one key was pressed at the same time two or more levers would come to strike the same place, though there was no reason for two simultaneous key presses there was the problem with rapid key presses. So to avoid the issue altogether keys that were bound to used in succession were placed at opposite ends of the keyboard so that the levers had ample time to get out of each others’ way.

**Alternate layouts**

Since keyboards don’t have the problem with levers anymore people started experimenting with layouts and now a lot of such layouts exist. Most of these are regional, i.e. the standard QWERTY keyboard with regional lettering placed as an alternate option. The one that deserves a mention is the DVORAK keyboard named so after it’s inventor. Dr. August Dvorak noticed which keys were used the most frequently and came to the conclusion that typing mistakes tend to happen when people deviate from the home row, the home row is the row of alphabets in the middle, namely, ASDFGHJKL. So by taking the most commonly used alphabets and putting them all on the same row the typist doesn’t have to move away from the home row and
thus the tendency to make mistakes reduced greatly. Also it is a healthier option since stress endured during lengthy typing sessions is reduced.

You can convert your normal keyboard into a DVORAK keyboard easily by changing the keyboard settings in the control panel. Then all you have to do is to take out all the keys on the keyboard and arrange them in the DVORAK order. As for gaming, you'll have to shift back to QWERTY as there are hardly any games that support DVORAK.

**Keyboard Technology**

We have plenty of options to choose from these days when it comes to the type of keyboards available.

### Normal

The keyboard we all use today which uses a set of plastic/metal keys which when pressed trigger a key press. The have membranes with circuitry and a rubber dome overlay. When a key is pressed the rubber dome makes contact with the membrane and triggers a key press. Mechanical keyboards use mechanical keys instead of rubber domes and are much more durable, we’ll go into the different mechanical keys available in the next section.

### Foldable

These are similar to the normal keyboards except that the body is made out of flexible rubber or silicon. These are preferred by folks on the move since they save a lot of space when folded up. A good flexible keyboard types just as you would on a normal keyboard but most cheap keyboards will be a bit stiff on the keys and it requires a bit of stomping to trigger them.

### Optical/Laser

These new age keyboards have a criss cross grid of lights on a surface with all the letters printed on the surface. When a finger is placed over a key, the light beams are blocked by the finger and subsequently the light sensors can
detect which key was pressed. Needless to say the absence of any moving parts makes this one of the most durable keyboards that can exist.

**Projection**

Similar to optical keyboards with a twist, projection keyboards project the entire keyboard pattern onto any surface that reflects a sufficient bit of the projected light. When a finger is moved across a key a camera detects which key is pressed and sends the data to the computer. The main concern is that you can’t rest your hand on the keyboard as you would on most keyboards.

**Mechanical Key types**

Mechanical keyboards use different types of keys most of them are manufactured by the same company. The Cherry MX series comes in multiple variants with each variant suited for specific purpose. When some keys are pressed you’ll actually get a feel that the key has been pressed without actually looking at the screen. This feel is known as tactile feedback. Some keys make a click noise when pressed and can be quite the earful for insomniacs. Some keys are stiffer than others, the weight needed to register a key press is called it’s actuation force. The most popular keys are the Cherry MX key and they come in a lot of variants which include - Cherry MX Black, Cherry MX Red, Cherry MX Brown, Cherry MX Blue, Cherry MX Clear, Cherry MX Grey, Cherry MX Green, Cherry MX White, Cherry MX Super Black, Cherry MX Dark Grey, Cherry MX Lock etc.

There are more mechanical keys available but almost all mainstream keyboards use the above keys. Each key type has it’s own unique signature and have their own audience. The most common among these are the Black, Red, Blue and Brown switches. Other variants are used for specific purposes like the Lock switch is used for Caps / Scroll / Num lock while the stiffer switches with high actuating force are used for the space bar key.
Specialised keyboards

Gaming

Gaming keyboards form the higher end of the keyboard pricing spectrum with features most haven’t even heard of. NKRO is a common feature for almost all mid-range and high-end keyboard. Another common feature is backlighting, when you are typing normally any error encountered is fixed with a backspace or the delete key, this is not the case with gaming. A mistake could possible mean the loss of hours worth of effort and this can be quite frustrating. So during those intense moments we gamers like to make sure which key we are pressing and having a backlight helps immensely at night. But it has to be ambient, overly bright lights are rather distracting at night. Also most gaming keyboards use more durable switches for WASD since they are the most used keys while gaming.

Macro keys are quite a useful function whether you are gaming or not, the ability to store a sequence of keystrokes so that you can use just one key instead of repeating the entire sequence is quite convenient. Macros are not limited to just gaming keyboards but are there in normal high end keyboards as well.

Ergonomic

While ergonomy is a factor that is part and parcel of any product design, there does exist a market for people who’ve been afflicted with some malady or the other (like arthritis or carpal tunnel syndrome) and have to resort to a much stress free layout. Ergonomic keyboards tend to come with special attachments to adjust the rest pad’s height or depth altogether. They can be split in half down the middle and the angle between them adjusted to suit the user’s natural arm resting position.

What to buy

When looking to buy a keyboard keep the following points in mind.
1. Mechanical keyboards are much more durable and last longer.
2. Opt for a spill-proof design whenever possible.
3. If you are going in for a mechanical keyboard try out the keyboard before buying to see if you prefer the key type, whether you prefer the
click noise, tactile feedback etc. Getting used to a mechanical keyboard takes time but it is quite worth it.

4. Having gold plated contacts on the USB or PS/2 port prevents corrosion but other than that there is no advantage to having them.

5. Wires with braiding are good if you are going to be be flexing it a lot, otherwise it is a luxury.

6. If having macros will be a boon with your work then go for it.

7. When going in for a keyboard with backlighting, ensure that the brightness can be adjusted.

8. Go for a PS/2 keyboard when you have a PS/2 port available since you’ll save a USB port.

9. Wireless keyboards do have issues with latency so avoid those when gaming.

Mouse

Tracking technology

There are three prominent motion tracking technology in use today. Tracking is basically how the mouse figures out in which direction the mouse is being moved in 2D space. The common forms of tracking technology are as follows.

- **Optical** - These mice use an LED to illuminate the surface and another sensor rapidly takes images of the surface as the mouse is moved over a surface. By comparing these images with each other the mouse can plot the position of the cursor. Optical mice require that the surface be opaque as it depends upon the reflected light to capture the images. This is why most optical mice won’t track properly or track at all on clear thick glass.

- **Laser** - Similar to optical mice but with a minor difference, the laser mouse uses a coherent beam to track the surface, this makes the mouse track on glass surfaces and even at a significant distance from the surface, i.e. you could probably life the mice above the surface about an inch or so and it will still track.

- **Trackball** - Originally all mice were of this form and consisted of a weighted ball that made contact with the surface. This ball as it moved across the surface also rotated two axle in the body. Each axle corresponded to the horizontal and vertical axis. This way the distance a mouse moved along each axis was measured and the combination of these values was used to plot the position on the mouse cursor. The trackball in it’s own had two variants, with the trackball on the bottom and the other with the trackball
on the top. Then there are some variants with a trackball on top and a laser / optical tracking technology on the bottom.

Inertial / Gyroscope - A rarer find, the gyroscopic mouse relies on inbuilt gyroscopes which detects the acceleration in whichever direction the mouse is moved to plot the cursor. Needless to say these mice are surface independent, i.e. you can move them anywhere you want and they’ll still track in 2D space.

3D - Using the same technology as inertial / gyroscopic mice but with three sensors instead of two, thus it can track along all three axis. This is pretty much the technology behind the Nintendo Wii remote.

**Gaming Mice**

**Input**

The standard these days would be a three button mouse with a scroll wheel. The scroll wheel doubles up as the middle mouse button. However, now we have macros on mice too. That’s right, 14-button mice are a common find. It’s like a mouse with a numpad on it’s side. These are programmable macros and even the standard buttons are programmable. These mice are designed with gamers in mind since the common keyboard mouse setup requires one hand on the mouse and the other on the keyboard. The thumb on the mouse hand is where most macros are placed, sometimes you’ll even find an extra scroll wheel at the thumb.

**Customizability**

Gaming mice You can adjust the acceleration of the mouse scroll wheel and turn on or turn off the tactile feedback from it. You can adjust the sensitivity on the fly too, with 3-6 different CPI settings which you can shift between. Then there are mice that come with different grips. Whether you have a big hand or a small one, whether you have long fingers or short ones. There are all sorts of options available to get your mouse into the shape and form you are most comfortable with.
**Ergonomic mice**

As with keyboards, even mice come in ergonomic variants. These tend to have your arm in a more natural position on its side, thus alleviating any pressure on the carpal tunnel.

**What to buy**

When looking to buy a mouse keep the following points in mind.

1. A standard mouse is more than enough for most users, games weren’t designed with gaming mice in mind so you won’t be at a disadvantage unless you play MMORPGs.
2. When going for gaming mice think about getting a heavy mouse or at least one with adjustable weights. Extra features like multiple profiles is something worth investing in.
3. Laser mice track well on all surfaces and are more accurate, therefore if you are into design as a profession then a laser mouse should be preferred over an optical mouse. However, the best thing would be to get a tablet.

**Tablets**

Whether you call it a tablet, a digitizer or a digital graphics assist tool, it is the same thing. You’ve probably seen people in documentaries scribbling a pen directly onto a huge screen or jotting things down on a small pad while looking straight at the computer screen. These are graphics tablets which substitute the mouse for these guys. It’s quite helpful since it mimics the natural way we humans hold a pen and draw, so by bringing the input device closer to our habits, we are guaranteed the same flexibility that we’d have while working with pen and paper.

**Types**

Basically these digitizer devices function by have a sensor either in the stylus (the pen like object) or the tablet but there are variations in that too like newer technology helps figure out the proximity of the stylus too and then there are auto pressure sensing devices too. The basic way that these tools are designed is by having a grid like structure embedded in the surface of the tablet, this grid formed out of horizontal and vertical lines.
are uniquely transmitting their own individual codes. When an stylus is brought close to the structure the unique code is read and thus the tablet knows where the stylus has been placed.

Active - An active model would have an actively powered stylus, i.e. both the tablet and the stylus are actively communicating to and forth. These are comparatively more responsive than passive tablets.

Passive - The passive model doesn’t have any active electronics in the stylus, it merely acts as a device that bounces off whatever information that it receives. So the grid must act as both a transmitter and a receiver. In one instance the grid transmits the co-ordinates, this is temporarily stored in the stylus and then when the grid becomes a receiver it reads the information back from the stylus to know it’s position. Since there is a rapid switching happening the tablet has to process information twice as fast to achieve the same capability of an active model.

Optical - These tablets have a miniature camera in the stylus which determines its current place on the tablet.

Acoustic - An acoustic model relies on creating a small spark between the stylus and the tablet, there are microphones positioned on the tablet which listen on the intensity of the spark and figure out the proximity of the stylus to the mic. Two or more microphones can then be used to plot the position of the stylus with respect to the tablet.

Capacitive - These tablets have capacitive banks arranged in a grid like pattern across the surface, when a certain spot on the surface loses its charge due to contact with the stylus the screen detects the contact.

Size

Needless to say for an input device the size of the writing surface is a primary concern. Tablets come in a wide array of sizes and the bigger it gets the more expensive they tend to be. For tablets the size refers to the actual drawing are and does not include the bezels or the buttons that surround the tablet. The entry models come in sizes like 4”x5” and
6”x8”. Mid-range can be as big as 9”x12” and the top models come in sizes as big as 18”x12”. This really comes down to user preference, a smaller surface allows you to work just as one would on a bigger tablet except there isn’t much need to zoom in and out constantly. Once a user gets accustomed to a smaller surface then there would be next to no difference in productivity when compared to a person working on a bigger screen. Also smaller screens result in less movement of the arm and subsequently it is less stressful.

**With or without display**
The bigger models are similar to monitor displays with a touchscreen overlay. The tablet is one huge screen where you can actually see what you are working on, this makes for a much more natural approach and also a much more expensive tablet. Don’t be worried about getting a tablet without a display as the tablet is still able to track the stylus over its surface even when the stylus is not making contact so you can figure out where on the screen your hand corresponds to.

**Interface**
The stylus which we’ve talked about so far also has buttons on them, and these can be programmable buttons so you can have a delete function or swap a tool in photoshop without having to move all the way to the tool bar. Also normal mouse operations like left-clicking and right-clicking also can be accomplished using a stylus. These buttons are often on the stylus itself or sometimes on the bezel of the tablet.

The tablet itself has a host of programmable buttons, from navigating across the workspace to saving macros, the versatility that a tablet brings is commendable. Most mid-size and large-format tablets are ambidextrous by design i.e. the buttons on one side will be replicated in the exact fashion on the other side. For smaller tablets you can simply flip it about and use it with the other hand.

Pressure sensitivity is another factor to consider. The pressure sensitivity allows you to adjust the thickness or texture or colour on the fly. It feels much more like drawing on paper so the harder you press onto the tablet the thicker a line gets. Tablets come with varying pressure levels, common among which are 256, 512, 1024 and 2048. Basically the higher the pressure level the greater flexibility you can achieve. Don’t press too hard though, you don’t want to damage your new tablet.
**What to buy**

When looking to buy a graphics tablet keep the following points in mind.

1. If you are starting out with graphics design then a small to medium size tablet is more than enough.
2. Don’t worry about the mouse, you can either use the tablet as a mouse or use the mouse and the tablet simultaneously.
3. Pressure levels matter, get one with at least 1024.
4. Ensure that the model you are purchasing offers local warranty and that replacement parts are easily available. The tip of the stylus tends to wear out pretty quick and you’ll go through 2-3 replacement nibs in a year.

**Game controllers**

Now the tradition keyboard and mouse combination has been more than enough for ages and will continue to be so for a long time, however, the gaming industry did start off with arcade machines and then progress down into consoles and finally to the home computer. Along the way gamers were faithful to their own camps whether it was the console or the PC, so game controllers suited for computers came along which formed a transitional tool for members of either camp to try out the other. While history may be a bit fuzzy on what happened exactly, what we know now is that games that are made for consoles can be ported to the PC and vice versa. What remains a pain is the way it was designed, console games are inherently better off played with game controllers and PC games are better off with the keyboard and mouse. A few years back even someone new to gaming could easily pick out which game was a console port and which games were designed for PC simply by playing the first few minutes of the game. Horrible camera angles and controls that wouldn’t work intuitively were primary signs other than the major setback in visuals. But when played with a controller you could barely notice the control issues and since
then controllers have been given a good preference over the keyboard and mouse combination. Games these days are not that easy to tell if they are console ports but nevertheless let’s have a look at what all controllers we can get our hands on.

**Types**

In order to give players a more rich experience game controllers were designed to mimic the environment in which the gamers would be within the virtual world, so we have joysticks, steering wheels, gamepads, motion sensors and even cockpits. We’ll focus on the more commonly available ones here.

**Joystick**

The joystick is what you’d like to use for aircraft and space simulators. There are plenty of buttons on most joysticks so you can do away with the keyboard and mouse altogether and play the entire game using just the joystick. Joysticks tend to come in two common variants these days, the 4-axis and the 6-axis. The axis refers to the degree of freedom a joystick has. Technically, they are referred to as pitch, yaw and roll and can be envisioned as the image below. A 4-axis controller is a more accurate depiction since in airplanes the yaw (or simply turning left / right) is controlled via pedals and you can get a good joystick with pedals as an accompaniment. So a 4-axis controller means the controller stick moves back and forth, and then moves left and right. Adding the ability to rotate the stick to the left and to the right adds two more degrees of freedom and makes it a 6-axis controller. A few buttons are placed on the joystick where the thumb comes to rest, these are generally for triggering weapons. So you can imagine that the experience of using a joystick simply is unparalleled to that of a keyboard.

**Steering wheels**

Playing a racing game on a keyboard and on a steering wheel feel miles apart. That’s just not it, a good set of
controllers would include a gear shift and pedals. They all have clamps so as to affix them onto your computer table so you can customise your cockpit as per your preference. Force feedback is another aspect that manufacturing companies have gotten right and it’s been around for a long time. Basically, when ingame you can actually feel like you are controlling a real car. When your car travels over a bumpy terrain your steering wheel will jitter accordingly, when you crash into a wall then the steering wheel will give a massive jerk to one side. These things feel so real that wrist injuries have been reported occasionally. The steering wheel have an array of buttons on the front and the back of the wheel, so you can map other functions to the wheel itself and do away with the shifting stick and the pedals.

**Gamepads**

The humble gamepad has come a long way from being a single stick and two buttons to its current form with analog sticks and triggers, rumble / haptic feedback and motion sensing capabilities. Gone are the days when games needed just two buttons and a directional pad, the controller of today is quite versatile and even the greater number of buttons is not enough for games as quite a few games have started implementing combo keys. This may be done to provide a similar level of control to that obtained using a keyboard and mouse. The Xbox 360 controller can be used on the PC too by purchasing a wireless receiver, so this controller is more preferred by gamers as you cannot only play on your Xbox 360 but also on your PC without the added investment of buying a new controller altogether. The design of a controller has progressed such that it pretty much combines all the unique technology that it’s predecessors had. The analog sticks ensure that your input is weighted to the amount of displacement you provide, thus while gaming, a little nudge translates to minor movement in the game while jamming the stick to a side would ensure a much faster reaction. The placement of the analog triggers are such that it literally feels like shooting
a gun. If you prefer the Sony’s SIXAXIS controller then there are plenty of models available with similar construction.

**Motion sensing**
While it hasn’t come out for PCs yet, this is the future. All next gen consoles, the XBOX One, PS4 and the Nintendo will feature motion sensing controllers as part of the core package. Even current generation consoles use motion sensing controllers but they are marketed as an supplement rather than a core item. The Nintendo is the exception as it pretty much started the trend on consoles.

**The rest**
The joystick, steering wheel and gamepad cover the majority of the games amongst themselves, however, there are others in the market also. There are controllers which are only useful on one game genre like the dance pad which is used for games like dance dance revolution, then there are pistols which are a bit more cumbersome as you need to have a lot of rapid movements. Needless to say these give a much more natural experience and what we are seeing is an evolution into virtual reality. Considered to be really expensive till today, these new controllers utilise motion sensing along with virtual reality headgear to give a truly immersive experience. The technology has been in existence for ages and is used for training pilots and soldiers in simulator machines. The Oculus is one such device which has already been shipped to game developers worldwide, so you can be assured that these games will soon be an affordable reality.

**What to buy**
When looking to buy a game controller keep the following points in mind.
1. They aren’tpokemon monsters, you don’t need to get a wheel, a game pad and a joystick to be able to play all games, just having one controller and mapping its keys can make it quite versatile.
2. Current gen console wireless controllers use proprietary technology so cross compatibility with the PC is not possible, you need to get the appropriate wireless receiver to be able to use them on the PC.
3. If you are planning to buy a new controller you might want to wait for the next gen consoles to come out this November, not only will older gen hardware be selling at a discount but the new gen may be what you actually want.
4 There are plenty of review videos on Youtube so you can check them out to decide which controller would suit you the best.

Optical disk drives
Optical disk drives have been losing popularity for quite some time quite simply due to the fact that flash memory has become a lot more cheaper and the rewrite capability, the transfer speeds and the convenience of USB. However, we are not going to see the demise of the optical disk drive yet.

Types
There are over 20 types of optical disks in use this day apart from the very popular CD + DVD + Blu-Ray combo but we’ll focus on just these three since that’s pretty much all that we’ll be seeing when dealing with computers.

CD
The compact disc has been around for quite some time and isn’t quite frequently used these days owing to it’s low capacity. Nevertheless, we can still find audio CDs and low cost video CDs on the market and that is not going to change for some time. The average CD comes in multiple formats, some can be written only once or as it is called in optical terminology, “burned” once. Then there are re-recordable ones that are good for about 25 write cycles. Burning is the process in which the CDs are actually burned with a laser so as to create miniscule dots and dashes. These dots and dashes are binary code for data. CDs are limited to 700 MBs of storage capacity.

DVD
The Digital Versatile Disc came forth as the successor to the CD bringing for much greater capacities. This is due to the fact that you now have dual-layer DVDs and double-sided DVDs. So capacities range from 4.7 GB to 17.08 GB on the double-sided dual-layer DVDs. Though CDs, DVDs and Blu-Ray are all equal in diameter the density if data is not the same and this is why with every new generation of optical medium that we get to see greater capacities.
Blu-Ray

Blu-Ray drives were pretty expensive till a few years back and thus this medium hasn’t achieved much penetration yet. However, things have begun changing, laptops are increasing shipping with in-built Blu-Ray drives instead of CD / DVD combo drives. They come in a few variants with the highest capacity rated at 128 Gigabytes. With the current trend of increasing display resolutions, providing high quality media requires a proportionally increasing amount of space and the Blu-Ray delivers that. The PS3 used to be favoured purchase if one wanted a Blu-Ray drive as you could not only use the disc drive but could also play games, however, Blu-Ray players have become cheap enough since the last two years so getting one is easier on the pocket now.

Write speeds

When you see an optical drive or a medium then you’ll likely notice a set of numbers and x(s) like 52x / 48x / 16x, these simply refer to the speed at which the drive can read / write and rewrite discs. The “x” or the multiplier varies from medium to medium. For CDs the x translates to 150 KB/s. So a 52x drive can read a CD at 52 times 150 KB/s data rate.

There is a simple labelling system used on CDs and DVDs that tells you what all can be accomplished with the particular optical medium. This is done by using the letter(s) R or RW in conjunction with a - or + sign. Here is how they are to be deciphered.

1. R – a plain R written as “CD R” stands for Recordable, i.e. this means the disc is not a pre-burned medium, however, the R notation is preceded by either _ or + sign.
2. -R – this means that the CD or DVD can only be written once and that too must be done in one session. So if you burn a CD-R disk then it is finalised and no further write cycles are possible. There are certain exceptions on the hardware side as certain optical drives will burn multiple sessions onto a -R disc.
3. +R – this means that the disc supports writing once but in multiple sessions. So you can use these as backup discs and add data from time
to time till the disc is full. Once that happens no further write sessions will be supported. There is also the added option to delete previous sessions on +R discs but this won’t allow you to re-record onto the deleted portions, so the deleted space is deemed lost forever.

4. **RW** – this indicates that the disc is re-recordable. So not only can you write in multiple sessions but you can rewrite over a deleted session. Depending upon the manufacturing process the number of times that they can be reused varies between 25-100 times. However, you should be thankful if you can manage to hit 25 since these are much prone to scratches compared to -R / +R discs.

**What to buy**

1. While CDs and DVDs aren’t as economical as they used to be given the reducing prices of flash drives there still are plenty of reasons why one would need access to a CD / DVD ROM drive. But if you already have a laptop or PC with an disc drive, then you really wouldn’t need another disc drive. Even operating systems which could only be installed via bootable CDs are now available as images which can be copied onto bootable flash drives.

2. A Blu-ray writer is not a necessity and will not be for a few more years to come, so you can simply settle for a player instead.

**Portable storage drives**

Moving data between different computers began with the use of punching cards, then progressed to different types of magnetic hard drives and floppy drives and has now finally come down to flash storage. So how far have we come in terms of durability and reliability while increasing storage space? Read on to find out.

**Types**

**Portable hard drives**

These are geared towards high capacities since they house traditional hard drives within a durable casing. While depending upon the power requirements you may find either a laptop hard drive which is smaller (2.5 inch) and consumes less power or a regular desktop hard drive (3.5 inch). The ones with desktop hard drives are not termed to be portable as they require much greater power than most interface ports like the USB or Firewire can
provide. So they have a power adapter to provide external power, thus, making them non-portable in true definition. Then again, finding a power socket next to a computer isn’t that difficult a task. Laptop drives have only recently achieved the 1TB storage space limit while remaining low on power consumption. When more storage is required you’ll have to go in for a 3.5 inch drive storage which can store up to 4TB of data. Also, 3.5 inch hard drives are inherently faster than 2.5 inch hard drives since they not only consume more power but also spin at a higher rate (7200 RPM) as compared to 2.5 inch drives (5400 RPM), so the transfer speeds on 3.5 inch drive are higher. However, with the recent introduction of hybrid drives that utilise flash memory along with the traditional magnetic drives have given a much needed boost to memory transfer speeds.

**Flash drives**

Flash drives use EEPROM (Electrically Erasable Programmable Read Only Memory) memory chips instead of magnetic disks for data storage. These are much faster than hard drives and durable too. Flash drives don’t have any moving parts at all, the slide flash drives that you find on some drives aren’t part of the circuitry so even if that breaks down the flash drive will work perfectly. They are also pretty shock-proof, we’ve had flash drives that have handled a 100 foot drop pretty good and continued to function properly. The drawback is that they are limited to a certain number of write cycles. This depends on the technology used to manufacture the drives in the first place, if SLC (Single Level Cell) memory is used then they’ll handle about 100,000 write cycles and if MLC (Multi Level Cell) memory is used then expect to get about 4,000 write cycles out of your flash drive. SLC flash drives are also expensive as compared to MLC drives. When you start noticing dropping speeds while using your flash drive then you can be assured that it is nearing the end of its life and it’s time to get a replacement soon. Given the high transfer speeds you can get flash drives that use either USB 2.0 or USB 3.0, the USB 3.0 drives will have a blue plastic tongue beneath the contacts or the plug.
**Portable SSD**

We’ve covered SSDs in detail in the storage section so we won’t be going into all that detail again. SSDs are pretty new on the market even though they have been around for 3-4 years so they aren’t economical in any sense. A 240 GB portable SSD costs around ₹13,000 -14,000, you can get over 8 TB of space in portable hard drives for the same price. However, it is the ridiculous transfer speeds that these drives offer which makes customers buy them. Like flash drives they too are pretty light and have no moving parts which makes them a heck lot durable than portable hard drives.

**Interface**

Having a fast technology behind a type of portable storage requires an equally fast or faster interface for data transfer.

**USB**

Universal Serial Bus has been around for more than a decade and we have seen two major revisions to the USB protocol and both are in popular use around the world. The USB 2.0, USB 3.0 interface and the recently introduced USB 3.1 interface are what the majority of storage devices use. Each revision is backwards compatible, so you can use your new USB 3.0 flash drive on your old computer that only has USB 2.0 ports, of course you’ll not get the speed that USB 3.0 support but data can be transferred. Similarly, USB 3.0 ports can accept all previous generation USB devices. The respective speeds are listed below:

- USB 2.0 – 480 Mbit/s
- USB 3.0 – 5 Gbit/s
- USB 3.1 – 10 Gbit/s

With each revision the power that can be supplied along each port has increased tremendously (USB 3.1 can supply 100W), what this means for portable drives is that the ones that needed external power would no longer need them. This does not mean that you can take your current hard drives and hook it up to a USB 3.1 port and expect it to function without external power. Your drive must be designed using USB 3.1 specifications, just being backwards compatible only helps with the data transfer.
FireWire / IEEE 1394 / i.LINK / Lynx

FireWire is an uncommon interface to come across. The IEEE 1394 standard as it is officially known is called by different names by different manufacturers. Apple calls it FireWire, Sony’s version is called i.LINK and TI calls it Lynx. Chances are you’ll never come across these are there are much widely accepted interfaces like the USB and eSATA that completely outshine the IEEE 1294 in terms of market share and compatibility. They are however, found on video cameras. The two common variants namely FireWire 400 and FireWire 800 boast of transfer speeds of 400 Mbit/s and 800 Mbit/s respectively.

Thunderbolt

The Thunderbolt is only two years old and is yet to be widely adopted. Apple's devices will feature these ports as a standard so more Apple portable storage devices come with the Thunderbolt port as a standard rather than USB. Also, these portable devices can only be used on Apple and Linux devices out of the box as the file system is different as compared to Windows. They deliver high transfer speeds averaging 10 Gbit/s and the next revision is supposed to deliver twice the current rate of transfer.

eSATA / eSATAp

eSATA stands for external SATA and as the name suggests is an extension of the SATA port for data transfer devices. These ports don’t supply power to the device so external power is needed in all cases. Sometimes the eSATA port has a power molex socket next to it for the same reason. These ports don’t have any extra interface between them so they suffer the least from latency issues. The eSATAp is a variant of the eSATA which allows for power supply via the port. It is a combination of the USB and the eSATA ports and allows you to insert both devices alternatively, however, the power
supplied is not enough to drive a hard disk so you still have to resort to an external source.

**Hot Swap**
Hot Swap is a feature of SATA architecture, so we now have computer cabinets with one SATA + power port sticking out onto which we can directly place a hard drive without any sort of casing or intermediate interface. Since the power is sourced directly from the power supply unit you don’t have to worry about external power in this case. Once inserted the drive will show up in your task bar under the “Safely Remove Hardware and Eject Media” icon. This allows for removing your hard disk completely from your computer and thus leaves it vulnerable to the elements. Also you need to be extra careful since there is no protective casing for your drive. If your computer cabinet does not have a hot swap bracket then investing in a hard drive dock could prove to be prudent, these docks tend to have a host of connectivity options so you can hook it up using USB, FireWire or even Ethernet.

**Security**
A big concern while moving data around is security and manufacturers have done a good job at including biometric security measures in some of the devices that we can buy. However, you can encrypt your drives using easily available open source tools too. There is TrueCrypt which can be used to encrypt just a folder or the entire drive itself. Software encryption is comparatively easier to crack but depending upon the algorithm the time needed to crack an encryption can easily take more than a 100 years, so a hardware encryption is strong but the absence of it shouldn’t be a major reason for you to not get a particular product.

**What to buy**
While getting a portable storage device keep the following points in mind.
1. Getting a high transfer speed device with interfaces like eSATA won’t help with increased transfer speeds unless you have an equally fast hard drive within your computer. So don’t unnecessarily splurge on top of the line products without having the proper hardware to back it up.

2. There are plenty of models available that have swappable interfaces, so you can opt for those models in case you want more flexibility from your product.

3. USB 3.0 is backwards compatible but unless you have a USB 3.0 port you won’t enjoy the native transfer speeds supported by USB 3.0

4. Warranty is important while getting hard drives as they are pretty susceptible to shock and no matter how good you handle your product, it is bound to develop some issue as time goes by.

Webcam

Embedded in laptops and a common purchase for PCs the webcam is not as staple as one would imagine. Popularly used for video conferencing and in certain situations for security purposes the webcam is a device with quite a wide variety to choose from. Let’s have a look at the important features that you’d want to have. Since these are meant for capturing and transmitting video feeds over the internet they have to be light on the bandwidth by design but internet speeds and penetration have increased by a huge margin over the years and we now see a lot better hardware in today’s webcams.

Hardware

Resolution – Earlier, even the good ones felt like cheap run of the mill webcams that shoot video so poor that you couldn’t tell the difference between the person on the feed and the wall behind him/her. However, times have changed and a 720p or for that matter a 1080p webcam is really affordable. Going for a higher resolution is advised if you are planning on setting up a professional video conferencing setup. Also, these webcams can easily double up as an extra camera for taking still
shots. If you have a high bandwidth available then the software used these days will scale your image quality upwards accordingly to give you the best visual performance so don’t worry about getting a low resolution camera just because your internet speed is low, even video compression has come a far way.

Frame rate – The downside of having a high resolution is that a high amount of data needs to be processed every second, this slows down the frame rate. So even if you are going in for a high resolution webcam, unless it has the processing power to back it up and get you a decent 30 frames per second frame rate your video feed will seem like a stop motion animation sequence. So ensure that the camera you’d want can deliver high frame rate at the mentioned quality.

Autofocus – All webcams come with autofocus, however, the implementation differs from manufacturer to manufacturer. Different algorithms decide what to ignore and what to focus on though we don’t see any way of figuring that out by just looking at the product box, only reviews can do any help here.

Inbuilt mic – Webcams do sometimes have an inbuilt mic so you can do away with a separate microphone. Though the distance at which the mic can pick up sound, i.e. the mic gain does matter, so it’d be wiser to invest in a separate microphone.

Grip – This is an important aspect to webcams, a flexible grip that can be modified to affix to any surface is necessary, also having a heavier base helps. If the base isn’t heavy enough then fiddling with a webcam becomes quite the nuisance. We have webcams coming with claw grips, gorilla grips and the simple flat metal base, so you can take your pick.

Lens – The difference between having a plastic lens and a glass lens in front of the webcam is that plastic tends to get scratched much easily as compared to glass, so even frequent wiping to clean the lens may inadvertently fog up the lens in the long run and ruin your webcam.

Flash / Lighting
Webcams have sensors built in to detect low light conditions and subsequently switch on LED lights to illuminate the subject. Webcams and mobile phone cameras are known to function poorly in low light conditions, so having this feature is a big plus. The cameras that can double up as a motion sensor do tend to have infra red LEDs so you can be assured of a good coverage even at night.
Software
Though not as important as the hardware, the software does come into play if you plan on using the webcam in ways that aren’t traditional. Webcams come with simple image filters like the ability to apply sepia or inverting colours. What you need is a webcam that comes from a reputable manufacturer, this way you can be assured that there will be third-party software available that can use your hardware with ease. Some cheap brands tend to have drivers available only for Windows and no other operating system and since they aren’t popular the chances that you’d find a community made driver for that model is remote.

Security concerns
While a webcam can double up as a home security device with the majority of the models coming with motion sensing capabilities there is also a rising concern regarding privacy. Malware unleashed by hackers and also by government security agencies have been known to remotely activate your webcam and transmit without your permission.

What to buy
When looking to buy a webcam keep the following points in mind.
1. High resolution must be accompanied by frame rates above 30 fps.
2. Pick a webcam with glass lens over plastic lens.
3. A good base/stand/grip is absolutely essential.
4. The versatility of the webcam depends upon the software suite that accompanies it.

Computer Audio
The personal computer is pretty much incomplete without a set of speakers. Whether you prefer to listen to music or simply teleconference, a set of speakers are an absolute must. Computers these days have an ample amount of audio output ports so you can hook-up your speakers on the front or at the back. However, the average computer speaker isn’t going to give you great sound quality and if sound quality is something that you are a stickler about then you probably don’t need to be reading this section anyways.

You can get speakers and microphones separately or you can combine the two and get a headset. It’s your choice, however, the common trend is
to get a good set of speakers and a headphone so that you can listen to stuff without broadcasting the sound to everyone in the room.

**Speakers** - The common models available follow a simple convention. The 2.1 set indicates that there are 2 normal speakers (called satellite speakers) and 1 bass speaker (they’re also called woofers). A 5.1 system comes with 5 satellites and 1 woofer, so you can see how the notation is used. Motherboards don’t have audio amplifiers that can output much power so the advantage in getting these speaker systems is that they have their own audio amplifier built into the woofer unit. These speaker sets often have an audio jack for headphones so that the moment you plug them in the external speakers get muted and only the headphones give any output. The bass and treble can be easily adjusted via knobs present on the woofer unit or a separate remote control. The remote may be wired or wireless so choose whatever you fancy.

**Headphones** - A headphone is a combination of two miniature earphones, one for each ear. A headset is a combination of a headphone and a microphone. The microphone is usually mounted on an adjustable shaft, so the orientation and length can be easily adjusted to one’s liking. Nowadays headsets do come with multiple speakers built into each earpiece, so you don’t have to be concerned about poor bass reproduction when using the headset. Headsets are generally huge and sit over your ears but there are ones that sit right on your ears perfectly, each arrangement has its own advantage.

**Types**

- **Circumaural** - These headphones are pretty huge and come to rest on your head while completely encompassing your ears. The design by itself isolates a lot of outside noise but complete noise isolation has a lot more to do with the circuitry rather than just the construction.

- **Supraaural** - These headphones are the same size as your ear and come to rest on your outer ear.

- **Earbuds** - These sit just outside the ear canal and do not have a headband to hold the two earpieces together.
IEMs - In Ear Monitors are those earphones that you squish into your ear canal, they generally come with different sized rubber tips so you can choose which size is comfortable for you.

Almost all the above types are further broken down into two sub-groups - closed back and open back. The difference that this approach creates is how the sound is perceived by the listener. Closed back earphones don't let much ambient noise in so it feels like the sound actually originates at your ears while open back earphones feel like the sound is coming from a farther source. This adds a bit of depth to the audio perception.

**Microphone**

While there are quite a lot of aspects to consider while buying a microphone for a professional setup, the average user has no use for all the extra pizzaz. A simple condenser mic is more than capable of picking up your voice. The further distance that you put between the mic and yourself, the higher gain the mic should have in order to pick up your voice, so either you move the mic closer to you or you invest in something more expensive, we can all see the obvious choice.

**Types**

Microphones can be classified based on build as well as its polarity. Polarity refers to the ability of a mic to pick up sound from a particular direction. There are microphones that pick up sound from all directions and they are aptly called omnidirectional microphones. Then there are unidirectional microphones that pick up sound from only one direction. Here are a few diagrams that show the different polarity that microphones have.

The coverage angle refers to the directions from which the sound is picked up. The angle of maximum rejection refers to which direction the sound is completely blocked from. Rear rejection refers to the ratio of sound intensity that the microphone is sensitive to when the front side is compared to the rear side. Ambient sound sensitivity is pretty self explanatory and the distance factor tells you from how far a microphone can pick up sound as compared to the omnidirectional microphone.

**What to buy**

When looking to buy an all-in-one printer / scanner / copier keep the following points in mind.

1. Spending an awful amount in a good set of speakers and not having the right environment for it is not a prudent decision.
2. A good system will have adjust knobs for bass and treble or at least bass on the woofer unit.

3. There aren’t any good manufacturing facilities in India, so getting an expensive model would mean that you’d have a long waiting period on warranty claims and not all manufacturers provide a replacement piece for the time being.

4. Unless you are going in for professional sound recording or making YouTube videos for that matter, a normal Rs.200 microphone is more than enough for video chat.

**Printer / Scanner / Copier**

If you are buying a computer from a single shop then you might be getting an all-in-one printer as a freebie. We wouldn’t call it an absolute essential as printing services are available at every other corner down the street, however, it is really convenient to have one within the confines of your home.

**Types**

In the early days you’d have to buy them separately, a printer a scanner and a fax machine. They were pretty expensive on their own but now you get all in one single device. You still can get the three components individually but the average user has no need for overlooking the convenience of an all-in-one printer. Primarily, these devices are classified on the basis of their printing technology. You have laser printers and inkjet printers which form the majority of the models available, then there are other less common printers.

**1. Laser**

The way these printers work is that there are roller drums in the printer that are constantly coated with very fine plastic particles. However, the particles are electrostatically charged, therefore, they only stick to those
portions on the drum where there is an opposite charge. This is done with lasers, by moving a beam across the drum, it becomes charged and then when the drum is coated with the toner you have a replica of what needs to be printed on the drum. Now the paper is sent in and rolled over the drum and heated. The paper has a much more rougher surface and thus the toner sticks to the paper and not the drum. Laser printers have a higher printing resolution and create printouts of a higher quality. You do have to be careful of touching the printed material as it comes out of the printer as you might smudge the fresh print.

2. Inkjet
Featuring a simpler mechanism the inkjet printers are much cheaper than laser but the print quality also suffers a bit. These printers feature either liquid or solid ink which is then heated and ejected through micropores on the printing head. The printing head moves rapidly to and forth as the paper slides underneath it. These are easier to maintain and clean as compared to laser printers. The method of heating and ejecting ink has evolved over time to such a level that expensive inkjet printers produce the same or even higher quality printouts than cheap laser printers. This might seem to be cost effective at a glance but manufacturers have been sneaky by embedding the print head in the disposable cartridge you are ensured consistent quality at a higher cost. You can subvert the need to be a new cartridge every few months by having your cartridge refilled.

3. 3D
A new entrant into affordable home printers, the 3D printer like the name says produces objects from three dimensional CAD (Computer Aided Design) drawings. Significantly expensive than the other two options and in a league totally different altogether, 3D printers are more of an enthusiast buy. These printers use spools of thin plastic filament as the raw material. The filament is heated up and then laid onto a flat surface layer by layer. Slowly the layers build up and we begin to see the model
take shape. From vanity dolls to fully functional assault rifles, these printers are capable of printing just about everything.

**Features**

LAN - Having a printer with an ethernet port is not that important in small businesses and homes but for medium to large business it is a must. It is not just LAN printing but also the ability to print from anywhere on the planet. Google’s cloud print is one such service that you can make use of. Just set it up and work on your document from anywhere. Hitting deadlines just got a heck lot simpler.

USB - By USB we don’t mean that it connects to a computer via USB but that it has a USB port for flash drives. So you can simply get your thumb drive to the printer and figure out what to print. The printers come with their own custom operating system so you don’t have to worry about infecting the device with a computer virus.

ADF - Automatic Document Feeder. When you have a lot of papers to copy or scan then going through them one by one is a mind numbing menial work, at such times the ADF comes to your rescue. Simply ensure there are not staples or pins attached to the paper stack and place it into the feeder. The all-in-one will pull each paper one by one and scan them, single side or double side it does both.

Easy back compartment access - Printers get jammed an awful lot, this is not simply the fault of the printer but also depends upon the quality of the paper being inserted. If the paper is too thin and multiple sheets get pulled into the printer then sometimes these extra sheets get stuck near the rollers. Also dust clogging the system can divert the paper and make it go along a route that it normally shouldn’t. Having easy access to the drum / roller assembly not only makes it easier to remove paper jams but also helps to clean the insides.

Scan resolution - For simple text, a resolution of 100-200 DPI is more than enough with 300 being the absolute maximum, however, when scanning photographs you need a lot more. If you work on scanned images then a resolution of 1200 DPI is the bare minimum.

FAX - With the inclusion on an ethernet port you can send faxes over the internet but in order to use the telephone system an RJ11 port is a must. Mid-range to high-end printers have them in almost all models. Companies prefer to have a fax machine separate though, as having a lot depending on just one machine is too big a risk. These days rarely does anyone use a
fax machine and if you operate from your home then there are plenty of affordable internet fax services.

**Controversy**
There has been a bit of a concern over two things with printers. Manufacturers have installed microchips on the cartridges that self-destruct once you near the end of the cartridge capacity. This makes it impossible to refill a cartridge and forces the customer to spend a lot of money on buying an official cartridge.

Companies even have print counters installed in new printers so that once in its lifetime if the total amount of printouts exceed a certain threshold level the printer becomes useless. This counter then has to be reset manually. Enterprising people on the internet have come up with software and tutorials that allows customers to reset these counters for a few bucks.

**What to buy**
When looking to buy an all-in-one printer / scanner / copier keep the following points in mind.

1. The speed at which a printer can function should allow you to estimate whether a printer will be able to handle your workload without being a bottleneck in the entire work process.
2. Inkjet printers are cheap and easy to refill, so they are economical in the long run.
3. If your network router has a USB port then you can connect your printer to the router directly and thus avoid having to turn on the PC which might otherwise be connected to the printer.
4. The more complex a printer and more features it has, the more likely it has to undergo maintenance. So when buying a printer for someone that is not technically inclined, stick to a simple printer.
5. While the manufacturer may claim a certain cartridge will output 1000’s of pages they don’t mention that in their test conditions they only require each page to have approximately 15-20% ink coverage. So printing a full quality image that covers an entire page will consume about 5-10% of your cartridge’s ink capacity.
NETWORKING

Great now that you know everything about what goes into a PC, how do you make it connect to the outside world? After all a lonely PC is a sad PC.

Most of you have an internet connection at home and are quite capable at troubleshooting when things go wrong. Some have a ‘guy’ whom they can call to get it done while others call tech support. However, most of the hardware was chosen for you, this eliminated the entire task of going through the vast array of devices which you could have used. How many of you use the stock router/modem that your ISP provided? That too you might be paying rent on that every month. Let’s say you now want to optimise things a bit, get the WiFi in all corners of the house and get rid of all the wires. Read on to figure out what hardware does what and make an informed decision.

Types of connections

Networking by definition is about bringing two or more computers together, now you must be getting your internet either as part of a group (LAN) or individually. They can co-exist too.

Dial-up

Dial-up uses a phone call via your telephone network to connect to a modem operated by your ISP (Internet Service Provider). The modem is a device
which we will look at in the next section, till then think of it as the device
takes information from your computer and converts it so that it can
be sent over the telephone network. This was one of the early methods
of connecting to the internet and is still used in some remote places over
India. Since it is an old generation technology the transfer speed is also
pretty low, typically limited to a maximum of 56 kbit/s. This was more than
enough in those times as most webpages back then were text heavy and
images were rare. One major drawback with this type was that you could
not use your internet connection and the telephone at the same time and if
anybody called your line then the connection would disconnect, quite the
inconvenience. Also the dial-up tone during the process of making a new
connection was pretty iconic.

**Multilink dial-up**
An improvement of the dial-up, this type of connection used more than one
telephone line and combined their individual bandwidth to increase your
net internet speed. This still suffered from the troubles with telephone calls
where only one service could run at any given time.

**LAN**
Local area networks (LANs) simple refer to a network of computers over a
small area. If you have multiple computers at home accessing the internet
then you can establish a LAN within your home. Similarly, schools, col-
leges, libraries, offices etc provide internet access to computers and other
devices via a Local Area Network. LAN can be wired or wireless, wired
networks are typically faster as they don’t have to deal with interference
from the environment. So the average LAN connection has a 100 Mbit/s
upper limit, when you are connected to the internet and you move the
mouse over the internet icon in the taskbar you’ll see ‘10/100Mbit’, this
is the maximum speed that can be attained via your hardware but that
does not mean that you’ll get that speed over the internet as this speed
is dependent on all the intermediate hardware between your computer
and your ISP. Also, your speed might be limited to ensure everybody
on the network gets uniform access to the internet as a ‘Fair Usage
Policy’. However, the 100 Mbit/s speed can be easily achieved over the
LAN when sharing between computers which are members of the same
network. Even then you might not achieve the speed because your hard
drive simply cannot cope with such high speeds but if you have an SSD
then you can hit the upper limit. These days 1 gigabit/s hardware is becoming commonplace.

**Broadband**
This is a blanket term that applies to a host of technologies which allow for greater download speeds using different delivery technologies. It may be wired or wireless.

**ISDN**
Integrated Services Digital Network (ISDN) is a method which was used to transport voice and digital data at the same time. So it overcame the drawback that dial-up had. Before the advent of high def video streams, ISDN was used for voice and video conferencing.

**DSL**
Digital Subscriber Line (DSL) was yet another connection type which used the telephone lines but without the disconnection issues when the two services were utilised simultaneously. The process is called multiplexing, wherein multiple data streams are transmitted via the same medium using different frequencies. Higher frequencies were reserved for DLS while the lower frequencies were for the voice data. The two signals were separated using a filter which had to be placed before the line was branched for any device. Improper placement of the filter still led to disconnections when using the telephone.

The most common technology under this is the ADSL (Asymmetric Digital Subscriber Line). It is called Asymmetric because the upload and download speed were different, download was significantly higher than upload. A variant of the technology called SDSL (Symmetric Digital Subscriber Line) overcame this, however, majority of the internet users worldwide do not need great upload speeds and hence SDSL is used only in specific scenarios. Further variations like ADSL+/VDSL are all improvements over the upload and download speeds.

**Cable**
Cable networks made use of coaxial copper/aluminum cables similar to the ones used to connect your TV with your cable provider to connect to the internet. Cable provided a significant speed improvement and was equally widespread in use. However, this does not work like DSL, you don’t have the same cable for both the TV and the internet, they had to be separate.
FTTx

Fiber-to-the-x is a family of technology that uses fiber optic cables to bring really high speed internet to the ‘x’. The ‘x’ may refer to B-Building, H-Home, C-Curb, D-Desk, P-Premises, N-Node. The ‘x’ refers to the end point of the connection which utilises the fiber optic cable. The devices that come after the ‘x’ get connection via the gateway which is established at ‘x’. Generally, there is a problem with signal attenuation, which means the longer distance the cable has to cover the more interference creeps into the signal. The attenuation is combated using either repeaters at regular intervals which regenerate the signal or by using cables technology that suffer less from attenuation or by a combination of both. Fiber optic cables are not as prone to attenuation like phone lines or other co-axial cables, hence, it offers a much greater bandwidth over a much greater distance. In India, BSNL and MTNL have already started rolling out this new technology.

Power-line Internet

Using an approach similar to Dial-up, Power-Line Internet makes use of an existing infrastructure to bring the internet to people’s homes. However, this isn’t as popular as the other technologies known to us as the transmission speeds are pretty low, usually ranging between 256 kbits/s to 2.7 Mbits/s. One major drawback of this technology was that the internet signal could not pass through certain elements of the power system and required extra hardware to be installed depending upon the number of connections. This meant that in a more populated region the number of extra hardware installation would rise significantly and would not be worth the extra expenditure given the paltry speeds obtained via this network.

WiFi

WiFi is a lot more common technology these days with implementations in all sorts of hardware like mobile phones, televisions, refrigerators, printers, laptops, tablets etc. The IEEE designation for WiFi is 802.11. Over the years there have been numerous improvements to the protocol and newer revisions have been brought out with the latest being 802.11ac. WiFi is somewhat limited in range with interference and line of sight issues. There are different signal bands on which transmission occurs, namely, 2.4 GHz and 5 GHz. The 2.4 GHz band can go through walls and thus goes a much greater distance but a lot of devices use the 2.4 GHz band and thus interference from those devices knocks down your transmission speed, 5GHz on the other hand is
not that popular so offers consistent speeds. But it does not penetrate walls and other obstacles the same way the 2.4 GHz band does and thus offers a significant disadvantage as well. Typically, you should have good speeds till 30 meters, greater than that you should still be able to access but with a lot of signal drops it would hardly be worth the effort. Hybrid devices exist that use two bands at the same time to double up the transmission speeds.

WiFi routers these days adhere to a multitude of 802.11 protocol revisions, i.e., the same router supports 802.11b / 802.11g / 802.11n / 802.11ac. The primary difference is the bandwidth that they offer. The following table lists the same for each revision.

Now you need to understand that there are data streams allocated to each band. The typical annotation will be 1x1 or 2x2 or 3x3. This means that there are ‘upload streams’ x ‘download streams’. Each device that connects to the device gets allocated a portion of the net bandwidth that the router can support. So when a router boasts that it can handle 900 Mbit/s it means that overall it can output that over your LAN but individually you might get somewhere around 130-150 Mbit/s.

**WiMAX**

A relatively new entrant, WiMAX or IEEE 802.16 is a technology that uses huge transmission antennae to provide internet access over a huge area, typically around 40-50 kilometers. It offers 1 Gigabit/s transmission rates for fixed stations. By fixed station, we mean a stationary receiver. Mobile users will suffer a significant reduction in transmission speed. 1 Gigabit/s

<table>
<thead>
<tr>
<th>Release Date</th>
<th>Standard</th>
<th>Band (GHz)</th>
<th>Bandwidth (MHz)</th>
<th>Modulation</th>
<th>Advanced Antenna Technologies</th>
<th>Maximum Data Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1997</td>
<td>802.11</td>
<td>2.4</td>
<td>20</td>
<td>DSSS, FHSS</td>
<td>N/A</td>
<td>2 Mbits/s</td>
</tr>
<tr>
<td>1999</td>
<td>802.11b</td>
<td>2.4</td>
<td>20</td>
<td>DSSS</td>
<td>N/A</td>
<td>11 Mbits/s</td>
</tr>
<tr>
<td>1999</td>
<td>802.11a</td>
<td>5</td>
<td>20</td>
<td>OFDM</td>
<td>N/A</td>
<td>54 Mbits/s</td>
</tr>
<tr>
<td>2003</td>
<td>802.11g</td>
<td>2.4</td>
<td>20</td>
<td>DSSS, OFDM</td>
<td>N/A</td>
<td>54 Mbits/s</td>
</tr>
<tr>
<td>2009</td>
<td>802.11n</td>
<td>2.4, 5</td>
<td>20, 40</td>
<td>OFDM</td>
<td>MIMO, up to four spatial streams</td>
<td>600 Mbits/s</td>
</tr>
<tr>
<td>2012 (expected)</td>
<td>802.11ad</td>
<td>40</td>
<td>2160</td>
<td>SC, OFDM</td>
<td>Beamforming</td>
<td>6.75 Gbits/s</td>
</tr>
<tr>
<td>2013 (expected)</td>
<td>802.11ac</td>
<td>5</td>
<td>40, 80, 160</td>
<td>OFDM</td>
<td>MIMO, MU-MIMO, up to eight spatial streams</td>
<td>6.93 Gbits/s</td>
</tr>
</tbody>
</table>
is way more than most users need so any significant reduction in that speed would still be more than enough for the average user.

**Types of hardware**
A typical home user or small business user can manage their own networks by understanding what kind of hardware they are using and what would be needed to improve upon their current situation. The image below shows a typical network setup found in most homes, here the modem and the router are shown separately whereas in most instances they’ll be in one device.

**Modem**
A modem (Modulator-demodulator) is a device that modulates an analog signal to carry digital information and then demodulates the same at the receiving end to extract the digital information. The purpose was to utilise existing infrastructure namely the telephone network to increase the reach of the internet.

**Router**
Now the modem creates a network between two computers or two nodes. However, what if the data were to be sent to another place without actually going through the hassle of demodulating and modulating at each and every node, this is where the router comes into the picture. Data is sent over the internet in the form of packets. Each packet has a header which is a label of sorts. It tells where the packet originated from and where it is headed and when it was created etc. Basically, it tells the router where it wants to go and the router accordingly dispatches the packet in the right direction. Routers can be wired or wireless. A router may or may not have a modem in it, this is an important thing to remember when buying wireless routers, if you plan on using just one router to connect to the internet then having a router with a modem is needed.

**Switch**
Routers and switches are very similar in function except for a few differences, routers have very few ports (4-8) while switches can have quite
a lot (24-48) of ports. So it is economical to have one router and then one switch which can effectively handle 48 wired computers than have 7 routers to do the same job. Also switches can’t perform NAT (Network Address Translation) which is needed to figure out which packet is directed to which computer. There are a few more differences at the protocol level but nothing the average user needs to worry about.

**Range extenders**
The problem with WiFi is that it is often limited in range (30 meters) also those at the periphery of the WiFi range suffer from frequent drop in signal strength and accordingly speed. There is where range extenders or repeaters are used. These devices simply take the WiFi signal, and rebroadcast it at full strength. This dramatically increases the range and ensures less complexity of the network. Medium businesses often use Range extenders, even folks with big apartments use range extenders. Another use is to eliminate dead spots, WiFi transmitted on the 2.4 GHz band is capable of going through walls but when multiple walls or obstacles are encountered then signal strength is lost. Range extenders can boost the signal in these situations.

**WiFi dongle**
A WiFi dongle is an USB device which allows access to the internet via USB. This is helpful if your existing hardware is indisposed with some other function and you need to connect to the internet. Also people with old hardware tend to use them to gain the extra speed offered by newer 802.11 protocol. A GSM/CDMA dongle is similar except it uses mobile telephony to get access to the internet.

**Network Cabling**
The cables used to connect two or more networking devices look pretty much the same but there exists a pretty rigid standard for these. Straying from the standard doesn’t mean your connection won’t work but you can be sure that there will be a few kinks along the way.
RJ11 and RJ45
When you look at the rear of a router you’ll see two about 5 rectangular sockets with 4 being larger than the fifth. The bigger ones are RJ45 and the smaller one is RJ11. Telephone networks use RJ11 and ethernet cabling uses RJ45.

The one on the left is the RJ11 socket while the 5 bigger ones on the right are the RJ45 sockets.

Cat5/Cat5e/Cat6/Cat6a
Ethernet cables follow a twisted pair design, i.e., two wires are twisted together and the twists/meter is limited. There are 8 such wires and 4 twisted pairs formed using them. The way these are wired are also standardised. There is the 568A and the 568B standard which decides which wire gets paired with which other. It pretty much doesn’t matter which convention you follow as long as it is the same at both ends. The twisting in the cable is of prime importance. Every cable emits some interference, twisting two cables cancels out the said interference and reduces loss of signal strength due to attenuation. The more the twists the greater frequency the cable can handle, subsequently the higher the frequency the greater the bandwidth. The following table shows the different cables available and the bandwidth supported by them.

Cat5/5e is the most commonly found cable and offers approximately 1 Gbit/s bandwidth, however, given the choice go for Cat6 as it is pretty much priced the same and offers higher bandwidth. If your home has a network storage with multiple users accessing it at the same time then a Cat5/5e will be sufficient but if you can go for Cat6 then why not. All the above cables are limited to a distance of 100 meters after which it is necessary to attach a repeater to regenerate the signal.
Crossover cable
We know some might have tried to connect two computers using your ethernet cable, that doesn’t work as you need a Crossover cable to do this. The only difference here is that two pairs of wires are swapped positions to make a Crossover cable. If you are using two laptops then creating an Ad-hoc network would be more convenient.

Network Attached Storage
A network attached storage is simply a hard drive or array of hard drives connected to the network. NAS devices can simply be used as a communal storage device while maintaining the privacy and security of the individual members of the network. Then again NAS devices these days are much more versatile with devices being brought out with custom OS on them and the ability to increment the features thanks to numerous official and community plugins.

A good NAS device can act as a storage medium, web server, media center and torrent box at the same time. If you have a good internet connection then you can host your personal website on a NAS device and do away with hosting charges altogether. They also have RAID functionality so your data is safe and secure and you have utmost control over it.

What to buy
When deciding on what hardware to invest there are a few pointers which we think you should consider.

1. Count the number of wired and wireless devices in the house / small business. Each router comes with a fixed number of ports (around 4 ports on mid-range routers) if you plan to connect more than 4 wired devices then invest in a switch.
2. Ensure as few breakages in cabling as possible, and no cable should be

<table>
<thead>
<tr>
<th>CATEGORY</th>
<th>BANDWIDTH FREQUENCY</th>
<th>SPEED</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cat4</td>
<td>20 MHz</td>
<td>16 Mbit/s</td>
</tr>
<tr>
<td>Cat5</td>
<td>100 MHz</td>
<td>1000 Mbit/s</td>
</tr>
<tr>
<td>Cat5e</td>
<td>100 MHz</td>
<td>1000 Mbit/s</td>
</tr>
<tr>
<td>Cat6</td>
<td>250 MHz</td>
<td>10 Gbit/s</td>
</tr>
<tr>
<td>Cat6a</td>
<td>500 MHz</td>
<td>10 Gbit/s</td>
</tr>
</tbody>
</table>
more than 100 meters in length without a repeater inline. Go for Cat6 cabling if possible as they are future-proof and offer better latency.

3. Not all wireless routers available in the market have an inbuilt modem, check twice before buying a router.

4. In a single band wireless network the protocol used is dependent on the lowest common denominator. For example, if all the devices are 802.11n and one device is 802.11b, then the entire network gets dragged down to 802.11b standard.

5. If your house / business is encompassing over a large area then invest in range extenders to be placed at strategic locations to ensure maximum coverage.

6. A slightly expensive trusted brand is always better than a cheaper option. Check user feedback on hardware market sites like Newegg. If any model has quite a lot of negative feedback then avoid it at all costs.

7. A router with a USB port is a good choice for attaching a hard drive and streaming movies. Do check what capacity the router can handle as higher capacity portable drives require slightly more power.
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