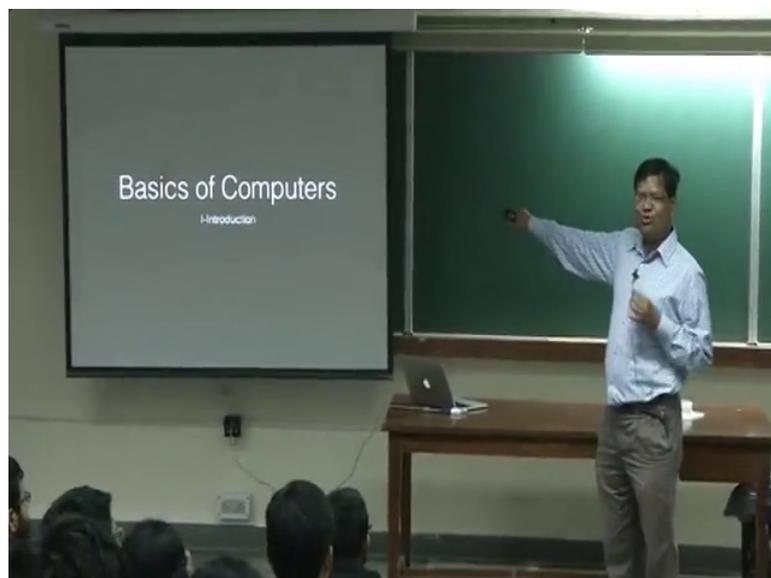


**Computational Science and Engineering using Python**  
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**Lecture - 01**  
**About Computers**

Programming is a good idea to know about computers. I mean, if you really write big programs, you need to know limitations of computers. I will describe that like, how much memory is there? What is the computing power?

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So, is relevant; I mean I do not know you may know already about it, but let us review it. In fact, I will ask questions on this in the homework. So, let us look at some of the stuff and it is really changing very fast. I cannot cope up with what is happening in the processes the speed is increasing every year. So, if you are in the supercomputing sector then you need to be up to date. So, we will see I mean this my data is slightly old, but it is rapidly changing. So, let us first focus on desktop computers that two is changing very fast, but it will give you an idea.

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In fact, the design remains the same. The units are getting more and more powerful. So, the components of desktop computers are like the computation unit this called CPU, a memory and input output.

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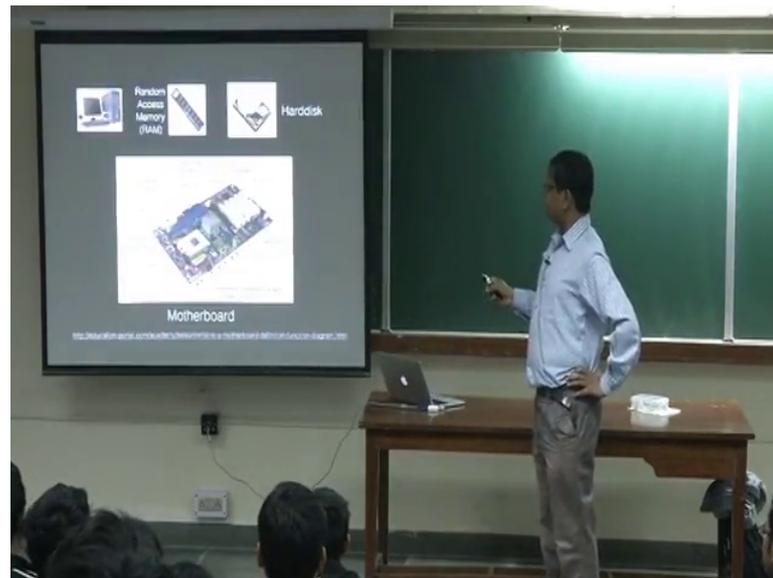


So, these are this is fundamental structure for normal kind of thought about this idea. You know bring these two are in fact, is segregated these functions these three unit is.

In fact, you see that there are different unit is in the computer, but our brain does it in for all three in somewhat same place here right of course, we get data from various places of

the body, but memory and CPU is done with the neurons. So, it is not clear, how we do it in computation in the brain, but anyway this is a design of a computer by basically for environment some you say turing had similar ideas, but the design of turing is was classified. So, we do not know much about turings well, we know much of something about it, but Neumann gets Feynman gets the credit, but turing had done similar work ok.

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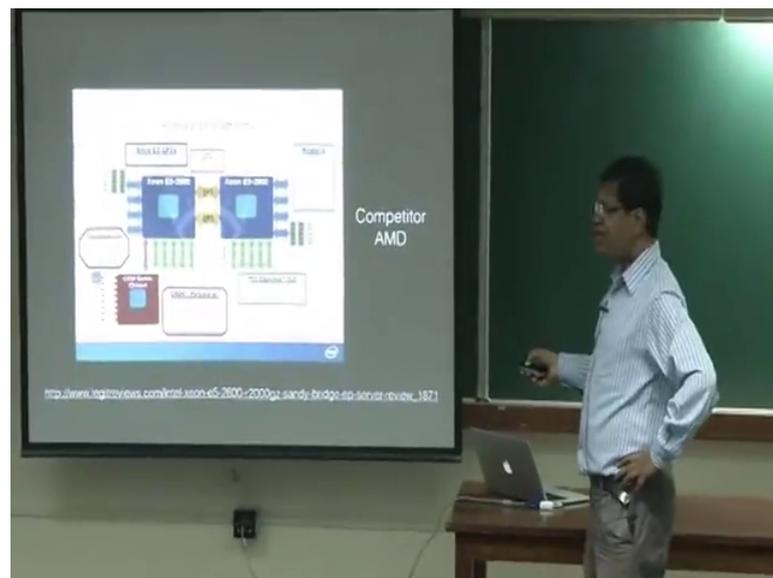


So, if you look at inside the computer, which I think you should so you see something like motherboard, this is a motherboard. So, a CPU sit is here. In fact, this is a fan which cools the CPU. So, there will be fan which is sitting on top of it. There are clever design to take the heat out it is very hot. In fact, typically is around 60 degrees, 50, 60 plus degrees temperature. So, you cool it otherwise it will just burn. So, this is a processor CPU. So, I said processing unit most of the computer well all computers computation is done here, then this called RAM-Random Access Memory RAM So, these are RAM slots, but the RAM looks like this. And we put quite a few of these unit is actually this is weak I think. So, quite a few of these unit are placed here right here. So, that is placed there. So, this is where them your data assets, live data there is something called hard disk, that is also memory; this one hard disk and that hard disk is connected from the CPU from this motherboard so to somewhere else.

So, this is memory, these two are memory. So, CPU is here memories here and interface is there are all lot of connectors. I do not want to get into that part, but there lot of connectors which will connect to input output a graphics cards and so on.

So, you do not need to know all of it for this course, what is interesting? How is evolving? So, let us look at a little bit more.

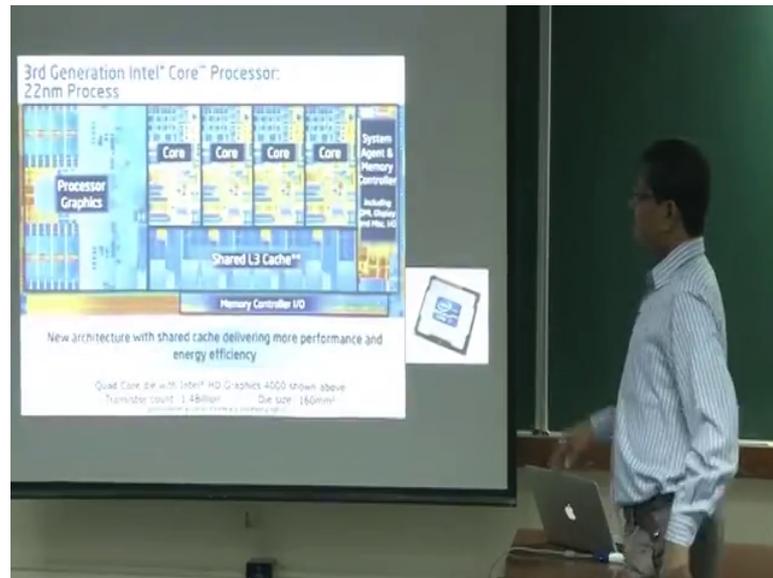
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So, it turns out nowadays motherboards come with not only single CPU, but you can place many CPUs. So, there was one place, CPU sitting here you can have two slots. So, multiple slots, in fact; you can put similar 8 CPUs, in modern motherboards 8 of them. So, these are there right now two CPU is sitting here and there are connectors to RAM. Actually, unfortunately it is not working. So, this is a RAM connection, that is also RAM, so this CPU is connected to this RAM, but they will talk with each other with this interface ok.

Now, we also have connection with pcis connecting to other hardware, like hard disk. So, this is a present design you populate more and more CPU that is what we are going towards. Put more power in a motherboard.

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Now, if you look at single CPU. So, remember there are two CPUs. Now if you look at inside a single CPU there are course there are core. Core is full see full processing unit within. So, multiplication, addition, data transfer all these are done by this single core has power of this. So, you can think of Ravan you know, so it has ten heads, right now this has 4 heads. So this so each the head can do it is function.

So, now there are CPUs which has 15 cores. A they designed for 60 cores by in the Intel. Intel may already has 60 core CPU, if you look at the GPU cards, you have heard of GPU no envy dell GPU that has 20,500 or 2,000 this cores, 2,000 heads

Student: (Refer Time: 05:54)

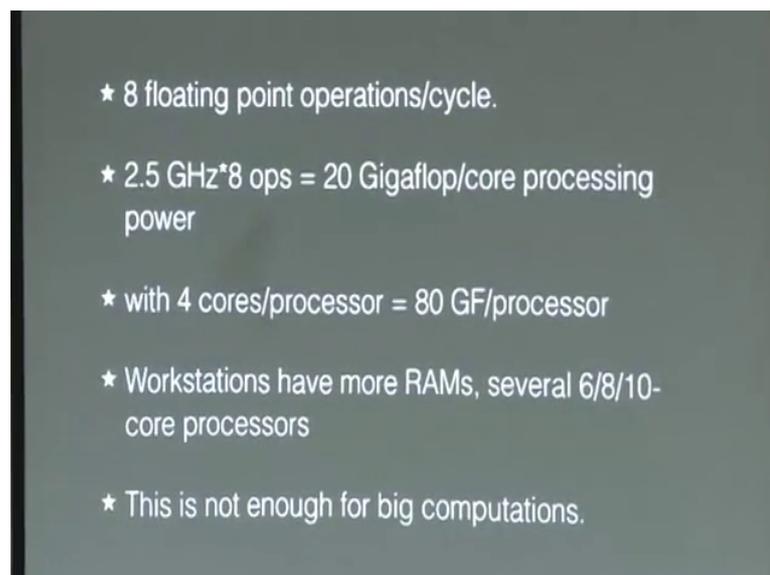
So, it is extremely large number of cores. That is why it can do things fast. There is something called cache if you are doing computing serious computing they need to know about so they also so memory, but the memory sit is very close to the CPU. So, more the distance longer time will take to access. Why? Because all of them roughly move the speed of light, so the longer distance  $\Delta t$  is  $L$  by  $c$ , speed of light. So, closer you are; faster it is. The present bottom neck present bottleneck is a memory axis. CPUs have gone very far; become very fast I will tell you some numbers, but the problem is the remember RAM which is slow. Hard disk is well, there is a hierarchy hard disk is slowest then RAM and then cache, now this called L three. There is something called L 1

and L2 cache. So the hierarchy of caches so some are fast some is not so fast, but they set very close to the core ok.

Now, if I put more and more data in cache, then my computation will be faster. So, basically, if your grocery store is close to your home, then you can get things fast, but is far away then it will take longer time. So, is precisely similar design, you bring it closer and closer and put more storage in cache. So, you can see look at the size. So, this die size this whole size is 160 millimeter square. So, how much is CPU die size. So, like if you take the square root 13 centimeter by 13 centimeter. So, this is the size. And how many transistors are sitting there? 1.48 billion Sorry; 1.4 billion. So, huge number of transistors is packed in that unit. It is amazing that we could reach this kind of complexity. Now this is in a single layer. Now the idea is to put more layers, and then of course, connect it. So, that is another direction people are working on so.

So, this is roughly I mean of course, you can do full cores on CPU itself, but for us we need to know, how many cores? Cache these also some of it I am trying to inspire you that there is more to computing than Python program. Python program is only a single step, you will just get you are like a kid you know. So, you have to grow from that point. So, we worry about these aspects for efficiency in the code.

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- ★ 8 floating point operations/cycle.
- ★  $2.5 \text{ GHz} \times 8 \text{ ops} = 20 \text{ GigaFlop/core}$  processing power
- ★ with 4 cores/processor = 80 GF/processor
- ★ Workstations have more RAMs, several 6/8/10-core processors
- ★ This is not enough for big computations.

Now, let us look at some estimate; how fast it can compute. So, there is x, there is a clock. Every computer has a clock. Clock is like heart. So, it will synchronize various

processes in the machine. So in fact, every clock cycle is say you do this work. So, it is all synchronize by a clock. This is a very important aspect, but how many of a floating point average? Floating point is real numbers, real add, real multiply. How many operations can it do? It turns out it can do in the modern machines can do eight operations per cycle. This is a good number to remember 8 operations. So, add additions or well it is also complicated it can probably normally those 4 multiplication and 4 addition. It is arranged in a pipeline. So, it basically moves like assembly line.

But this again I will not discuss, but it just that it can do 8 operations per cycle. Now, how many cycles does it have per second, typically; it is 2.5 Gigahertz some are 3, 3.5, but nothing at 5, this is your limitation. This coming from a micro physics quantum limitation in fact, if you increase the clock speed things are just not working out. The power is requirement becomes more a there are lot of issues. So, there is a we reach the bottling in terms of clock speed. There is no breakthrough in increasing the clock speed beyond 5 Gigahertz.

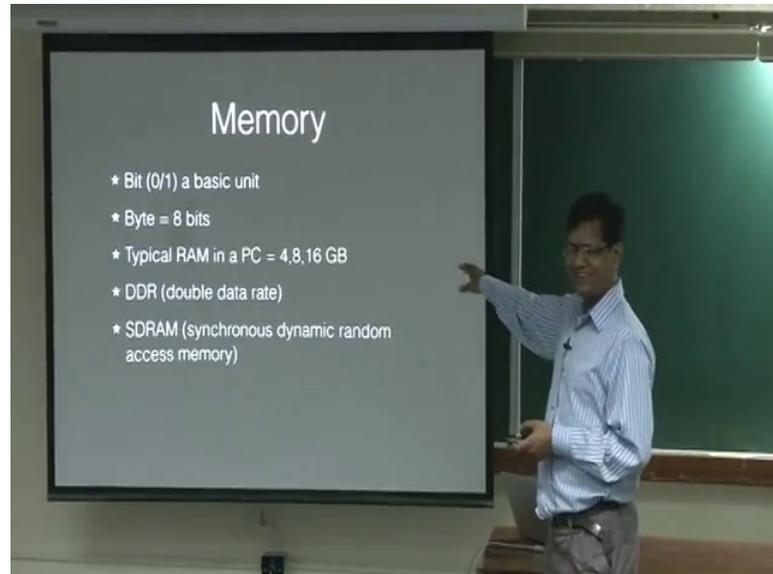
So, how many operations can it do per second? It can do 20 Gigaflops. Flop means floating point operation. Fl is floating, op is operation. So, it can do 20 gigaflop per second, each core this huge number I mean I can probably do 1 multiplication in 1 minute. So, this can do this many operations per second.

Now, how many cores desktop computer has? Typically, you are getting quad core machine no, quad core desktops or laptops. So, quad is 4, so it has 4 cores per process per processor. So, if your laptop with a quad core processor it can do 80 Gigaflop. So, 80 G for Giga floating point operations per. Now so, but it turns out this is not enough for computing which we need now for advanced computing this is really small. We will work out some numbers for slightly bigger problems in future, but it is huge power I mean this is really big power. It turns out you can buy workstations which are which can do more than desktop. So, there is a next class is called workstation.

Workstation will a better processor, you put 8 of them 8 CPUs in laptops you cannot put more than 2. So, it will heat up and you know your motherboard is not we will of course, cost more. So, everything if you more need more you need to pay more. So, works just more RAMs it can go up to 15cores. So, I put 6, 8, 10 we can also 15, but this is not

enough for big computations. Now I want to do weather prediction this would not be enough or if you want to simulate the DNA this is not enough. So, let us look at memory

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So, I will just give some idea about memory in very preliminary idea. So, a here is all based on binary classical computers. So, it has 0 and 1, so two states 0 and 1. So, every storage or computation will be in binary. Quantum computers if you know width of it have many states. So, that is a big plus for quantum computation, but classical computers are 0s and 1s. So, this is another number byte I did not mention it, but 1 byte is 8 bits. So, instead of 8 is just say 1 byte. A typical pc has 4 to 8 GB, depends I mean, I do not know, how many have sixteen GB RAM in your laptop? There will cost more money. So, you normally you keep it 4 or 8. 8 is already rich the laptop.

Pc also mean laptops are now as powerful as the pc. So, this is one word, I mean this memory is also evolving very rapidly. So, this called DDR is double data rate, but the names are changing almost every year. Now we have this fast switch, solid state RAM, solid state hard disk. So, that does not has spinning parts. So, that is quite fast. In fact, RAM and solid state device solid state hard disk are roughly similar speed. So, it is a, but RAM is faster definitely. So, please remember the difference, hard disk is outside. I did not show you if your hard disk will be a disk of this size, which should be not on the motherboard which somewhere else and RAM will be sitting on the motherboard.

So, if you are closer to the CPU is faster. So, these are different names as I said this technology is changing. So, SDRAM is another new name for faster RAM. So, we I will not discuss that, but just to tell you that, things are changing very fast.

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	Description	Size	Range
char	Character	1 byte	0 to 255
C-int	Integer	4 bytes	-2,147,483,648 to 2,147,483,647 [ $-2^{31}$ to $2^{31}-1$ ]
C-long	Integer	8 bytes	-9223372036854775808 to 9223372036854775807 [ $-2^{63}$ to $2^{63}-1$ ]
bool	Boolean value	1 byte	0/1
C-float	real	4 bytes	$\pm 3.4e(\pm 38)$ -7 digits
double	real	8 bytes	$\pm 1.7e(\pm 308)$ 15 digits

We need to know little bit about how much storage are required for each unit of data.

So, character. So, if I try to text know. So, like your sms you are doing it. So, each character is stored in the computer, and it requires 1 byte 8 bits. So, you can see, how much how many characters can I store in a byte? You know this stuff know this is cool stuff. So, if you have 1 bit then 0 and 1 only two choices. If you have 2 bits then have four choices 0, 0 to 1, 1. So, if you have 8 bytes, 8 bits, then I have 2 to power 8 options. And 2 to power 8 is 256. If these numbers again this is easy. So, characters you have 256 of them. So, a, b, c, d their numbers for each of them a, b, c, d, e, f, g, h like that; for no alpha, numerics, dollar and so on, but now a days in at least in the browsers we have two bytes for a character, it was a multilingual know so hindi also this store as a number you you are not storing as a font that will be too expensive to put. You understand? You know we are no send a image of. So, you has yeah code for a image will be more it will take more bigger data.

So because of all this different language so now, characters are stored is two bytes. So 16 so 2 power 16 characters. And 2 or 16 is how much? I will tell you number 2 power 10 is 1000 you can just work it out. So, 2 a 16 will be 2 power 6 into 2 power 10.

Student: 64.

64,000 so you can store 64,000 characters in modern, because of this called unicode. So, unicode is two characters. Integer in Python it will be any integer, any length. So, you can store 64 digits, whatever digit is you like, Python will adjust it is length or how much bytes are required to store it? But, it is also important to know what FORTRAN or C does. C will be assigning 4 bytes for a character, f for a integer. So, 4 bytes integer will store maximum and minimum. So, this is a max. So, this is going 2 to the power 31, because 1 will be sign bit. So, 1 is reserved for sign, and remaining is 2 to the power 31. So, you get minus 2 to the power 31 to 2 power 31 and this little bit of 2 to the power 31 minus 1. So, that is a bit technical issue, but you can store up to 2 billion. The number is cannot be sitting in 2 plane for integer.0 If your number exceeds that it will cause errors.

So, this important if you are doing c programming size of a number; especially when you have big data size, then your data index it itself will exceed this number my array is sometimes 2,000 cube like if I am trying to emulate whether then my data will be 2 billion sorry 2,000 cube each direction. So, how many point data up will be there, 2,000 cube it will be 8 billion, 8 billion etcetera. So, you have to be careful, what is a your index? I mean if you are done bit of programming you know that array index has to be integer right. So, I need to say I cannot use this integer.

This is one common source of error. So, I have to use long int, this again part of C. You have to use long int which allows you to use 8 bytes. And 8 bytes let us you have 2 power 63, here is limit for maximum number this is big no data size will be at least at present in this arrays. Boolean in C stores as 0 and 1 and in Python it will I think it takes 4, 4 bits, but if C it will take one (Refer Time: 19:00) byte is inefficient you need only one bit, but it store as one byte. So, if you want to use Monte Carlo Izen spin. So, you can pack lot of spin in a single byte, I mean you can store 60. Well, how many? 256 izens spins. So, we have to I mean we have to program wisely; you know you do program in a more intelligent way, if you want to use that, but C will this I am basically telling about C.

C also has float. Now this is for real numbers. Now Python real numbers again it can be of any size I will. So, these are some differences between C and Python. You should know this when you are writing in Python, but it will adjust it will allocate, whatever is

required, but in C the real numbers are 4 bytes. Now, I will tell you little bit later about how is this stored. So, the maximum with a real float, so in C is called float and it can go only up to  $10^{38}$ ; nothing beyond. So, it will be error if your number is beyond  $10^{38}$  or below  $10^{-38}$ . So, Planck constant can be stored, but if you do Planck constant square error, Planck constant square you will get  $10^{-68}$  and error. So, you have to be careful what operations you are doing.

Now, a days is standard you use double. So, double has 8 bytes and 8 bytes can go up to  $10^{308}$ . So e is you know this notation, e is  $10^x$ . So,  $10^{308}$  to upper side is  $10^{308}$  and what is precision. So, with float I can store up to 7 digit is. So, precision only  $10^7$ . Any number which is lower than I mean you need precision more than 7 digit is problem, with real with float, but with double you can go up to 15 digit is ok.

So, 15 digit accuracy is allowed in C programming with double. If you want more sometimes we need more precision, then you need to write program yourself there are packages, we will allow you to use 16 bytes, double of double, but that will be standard well there will be some other function you have to program yourself. Is that clear; I mean this is something which we need to know I will let you I mean I will tell you a little bit about how Python handles it today only, I mean we will we will reach there.

So, let us do some estimate.

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## Estimates

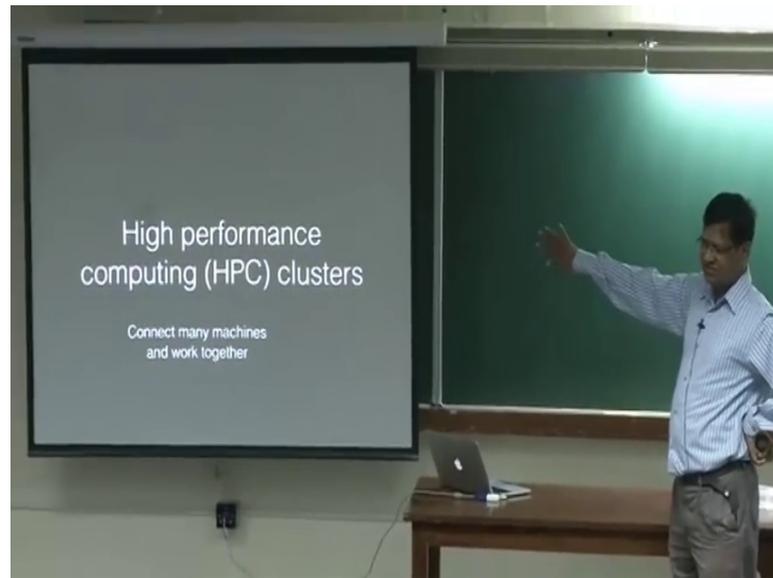
- ★ Typical desktop has 4 to 8 Gigabytes of RAM.
- ★ To save a matrix  $A(N,N)$  with  $N=10^3$ , we need  $8 \times 10^6$  bytes for double, and  $4 \times 10^6$  bytes for float
- ★ We deal with  $4096^3$  array. Memory requirement is  $8 \times 64 \times 10^9 = (1/4)$  Terabytes.

So, typical desktop has 4 to 8 gigabytes. Please look at your in phone in your laptop. Figure out I mean you should not be using it as just like a dumb machine. You know you should know what is there inside. So, how much memories are there it will come about computer, it will come. To save a matrix 2D matrix of thousand cubed. So, you are saving a matrix, which is not on common 1000 N square each n is 10 cubes. So, what is the data size required? This will be stored in a RAM your memory. So, it will be how many data is there N square. So, 10 power 6, but each of them require 8 bytes. So, 8 million, so 8 million is the size of your array.

So it will just occupy that much RAM. If you are asking using float, then it is going to take 4 million. Now is not uncommon we have program on this array. So, 4,000 cube. Now how much is the RAM required? So, how many data points are there? 4. So, 4, 9 4096 you can approximate to 4000, 4096. So, 4 cube is 64, so 64 billion. So, there is 64 billion that is your data the 64 billion, now each of the 8 bytes double, so it requires 1quarter terabytes that is impossible in a laptop or a desktop computer. So, you need a supercomputer for this application.

So, immediately you can see that, if I want to do realistic simulation. Then you need bigger machine. I hope it is clear to everyone. So but laptop is also powerful, but you can do a course project with your laptop, but if you want to publish a paper (Refer Time: 24:07) we need to move on to bigger machine. So, I will tell little bit about this in this course we will not discuss this.

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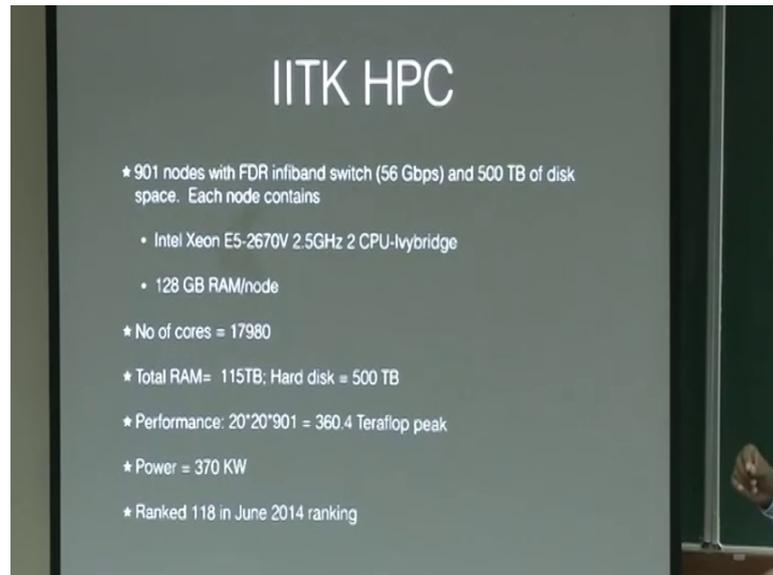


I did offer a course last semester, but if you want then of course, there is a whole things to whole new things to learn. How to handle HPC? So, I will just give you a very brief idea about, what the computers are? How much power does it have? And the basic idea now, I mean there are different ways to make super computers. The one design which is most popular so, there again the different some of them are not popular they are very fast, but they are not popular also cost. Cost is a big issue. So, the present popular design is connect many machines and make them work together.

It just a I mean more students get more work out that is about it. Is not that you are making one student very smart or genius something you just say well every student will work equally and you get work out. So, that is the idea of present machine. So, you have basically desktop computers connected together. It is not desktop, because if you want to put desktop in a room, how many can you pack in this room? When I could pack may be 1000 right I mean just fill up everything very few thousand and not good enough. I will show you the numbers; we are able to pack 1 million processors in a machine.

So, the designs basically we pack more and more CPUs in a clever way. It is a good idea to see our computer center. So, there is a room where this big supercomputer is housed you cannot see inside, but you can basically see the racks. So, a each rack has many processors. I do not have a picture here, but you can easily see in Google, how does it look? So, the IIT Kanpur HPC.

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HPC means high performance computing. People do not use the word supercomputer anymore; this is the more common HPC, but which means the same.

So, these words called nodes. So, each node is like a, it has more processors each node. So, each node is like a, you can think of one motherboard sitting there with some more stuff. So, it is like a box this thick inside. The sizes like this like a diary. Let us call a node. So, there are 901 nodes in our machine here. Now if they are working together you need to make them talk with each other. If they do not talk work cannot proceed, I mean it may be this part, but you need to talk with other person, if you want to work jointly. So, there is a connector this called switch which is infiniband switch. Again is a technical name there are lots of switches, most popular is called infiniband switch. And so how much is each processor within a node.

So, within each node the two processors sitting there, now I hope you understand; I told you each processor many cores many heads, but there are two processors. So, we have 2 Xeon 5 processor, so 2 CPUs and this linguistic Ivybridge. So, each of them has 10 cores, 10 cores. So, 10 head this is really round the sun. So, 10 into 2 is 20. So, 20 cores in each node and it has 120 Giga bytes of RAM like it is quite huge compare to your laptop. So, each node has these packs and then 901 of them. Some of them master node has less cores. So, overall if you see the numbers we got 17000, 18000, that many cores in our HPC, which is a big number. This machine is rank was ranked now it is slipping down

118 in the world. So, this could top 500 dot org. So, it was 118 in June 2014. Now how many operations can it do?

So, again the same numbers I told you before. So, each core can do 20 Gigaflop 20 Giga floating point operations per second. So, multiply 20 into 20 cores right I had said 10 cores in each node and there are 901 nodes. So, it turns out to be 360 Teraflop. So, Tera is  $10^{12}$  or 0.3 Peta  $10^{15}$  is Peta. So, 0.3 times  $10^{15}$  operations per second. And how much power does it take? It takes 370 Kilowatt is 0.3 Megawatt. So, Megawatt is the power basically for a village full village or IIT this will consume is something like 1 quarter or one-fifth of the full power. So, it is a big problem how to make it efficient green supercomputers, as a too much of a power. And how much RAM does it have? It has a RAM of 115 Terabytes and hard disk 500 TB. So, it is a big machine. A problem is we do not have programmers. So, who can use the full machine?

So, you need to write a program which will use all the machine. Now it is not easy; it should be efficient program I mean you cannot say well I mean I write something and put it there. So, you need to make efficient program and it is a big task. So, let us look at other machines. So, top 10 HPC systems I did not write the site you can just look at top 500 Top 500 dot org you see more information on these machines. So, I will just show you the top machine, where is it from you know top machine China.

China has a top most machine. So, I hope this is visible this is like not very clear. So, China has the topmost machine, that number 1 and how many cores does it have? So, do not worry about inside what is written there.

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RANK	SITE	SYSTEM	CORES	SMAX (TFLOPS)	RPEAK (TFLOPS)	POWER (KW)
1	National Super Computer Center in Shanghai, China	Tianhe-2 (Mikoyan-2) The 4th XE3 Cluster Intel Xeon E5-2692 V2 2.000MHz, 70 Express, 1 Intel Xeon Phi 3101P NUDT	3,120,000	33,862.7	34,702.4	17,800
2	Oak Ridge National Laboratory, United States	Titan - Cray XT5 Opteron 6274 140 2.200MHz, Cray Gemini accelerators, 4000k K10 Cray Inc.	561,600	17,390.0	27,112.5	6,200
3	Oak Ridge National Laboratory, United States	Sequoia - BlueGene/L PowerPC 44x 1.66 IBM, Custom IBM	1,372,864	17,173.2	28,122.7	7,800
4	Wright-Patterson Air Force Base, Dayton, Ohio, United States	Itanium 2, SPARC6x V90 2.00MHz, Sony interconnect Fujitsu	788,024	15,510.0	11,200.4	12,600
5	Oak Ridge National Laboratory, United States	Mira - BlueGene/L PowerPC 44x 1.66MHz Custom IBM	794,432	6,556.4	10,004.3	3,743

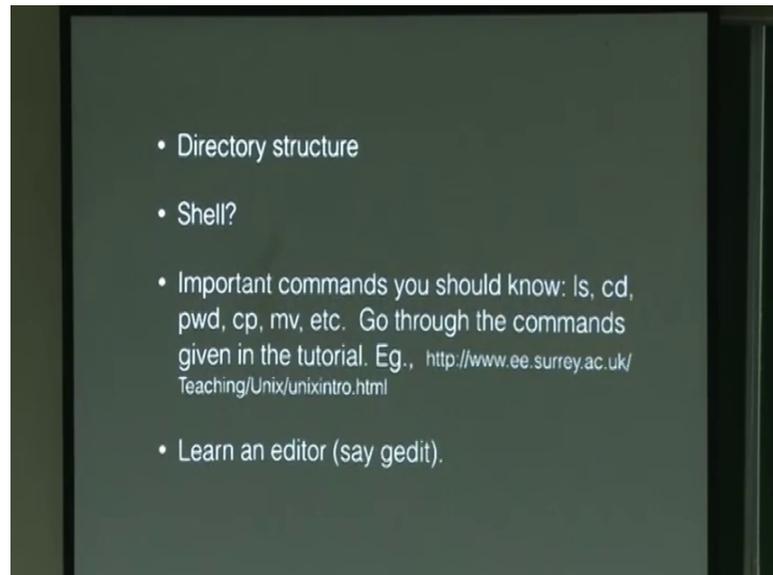
It is a 3 million. So, 3 million is a big number. So, 3 million cores sitting there, what is the peak rating of this is 33 Peta flop. So, this is in Tera T flops. So, is 100 times faster than our machine. Now how much power does it take the last column, 17 Megawatts.

Student: 17 Megawatts.

So that is the power. So, it is a huge power, I mean you need a basically a generator power station not generator power station for this machine. So, that is where in fact, that is another saturation a how do make machines which are fast, but the consume less power and the candidates are GPUs are one strong candidate or your mobile chip. So, people are building supercomputers using mobile chips. Mobile chip there is a limitation is power. So, you can. So, the it is already there it is a supercomputer using mobile chips. There are other machines like this is second is US. So, US is the leader in terms of number of machines.

So, there are 200 from US, china has 100, and they are really putting lot of effort in supercomputing. India is 11th I have marked just for information there is a another machine sitting in Saudi Arabia that is where we run. So, we have access to this machine and it is very fast this machine (Refer Time: 31:52) 0.2 million cores and it is 5 Petaflop. So, number is in India, there is only one machine with Petaflop rating which is in ISE 1.2 Peta flop it is the same machine, but less cores. So, this is about super computers.

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So I need to talk little bit of software, this again I will not enforce that you should be use Linux, but it should really use Linux is a I mean this is a what is called cautionary warning know you can smoke, but smoke kills. So, similarly you should use Linux that is good for you.

But if you were like not wanted to change is I mean you can do Python programming in windows. So, I will tell you which package to install, but the strong I mean if really want to do something good then you should use Linux or MAC MAC is Linux know MAC is UNIX. So, this machine is UNIX. So, I should not preach without practicing. So, this is UNIX. So, the thing which you need to know UNIX you also need to do a bit of tutorial not part of the course I cannot do it, but there are nice tutorials to get to know UNIX just for a user. So, you need to know what is the directory structure shell is.

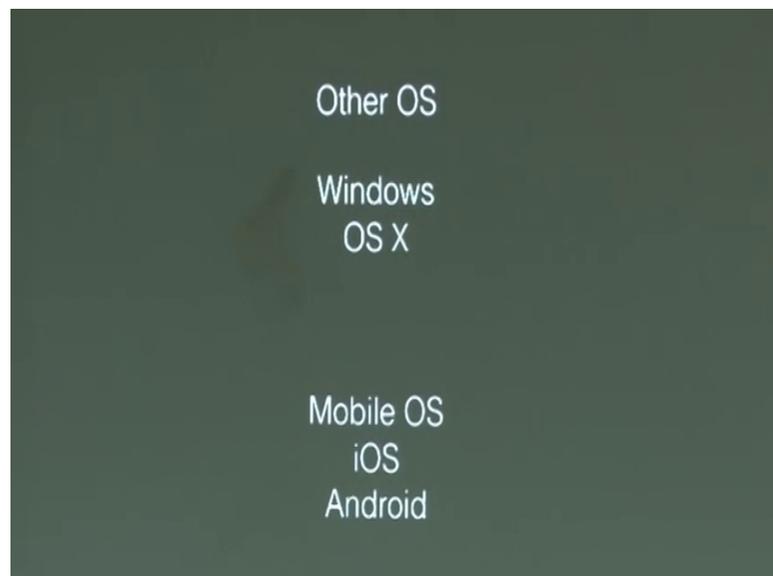
So, these are operating system sitting at the bottom operating system. So, hardware without program is nothing you cannot use it. So, program is run makes this hardware alive is called operating system, but operating system programming is very difficult. So, it is I cannot do it. So, the computer science they are very smart people who program the operating system this is called Kernel, Linux Kernel if you use the word Kernel, but Kernel is those things are not easy. So, this is a layer above the Kernel. So, there are layer realities of different layer levels. So, these are this called Shell.

Shell will talk to the user is that clear. So, there is a there is a person boss sitting inside who is the Kernel, but the secretary sitting outside which is the shell. So, you talked to the secretary you really cannot talk to the boss well I mean you can, but then you require some special permission. So, shell is what we need to we need to talk and shell has this commands, I mean if you know bit of UNIX so.

Or some of you are probably experts of UNIX. So, ls for listing directory structure a cd change directory. So, these are the commands you need to know. Tutorial you will basically you need to spend may be 3 hours and you can get to a big reasonable user of UNIX. So, this one site, I will post it in a in a website. Well, I will probably do something. So, that you can get access to my PPTs and you need editor for using the cc machines you need editor. Linux machine cc machines. So, the editor I recommend is g edit. So, that is part of Linux there other editors vi, vi is not. So, good I mean again it is like a cryptic vi or vim I recommend g edit ok.

But, please get use to it otherwise; you cannot do your home work you need to use one of the editors and I think this slide has probably ending.

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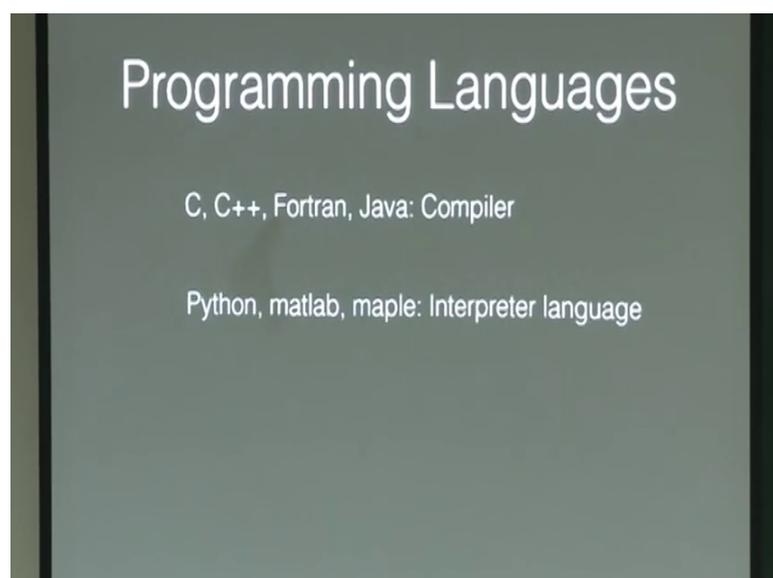
So, that is one. So, Linux is one, well Linux derives it itself from UNIX. UNIX was a very clever design. It is one of the best thing which happened in last century, best including science and engineering. UNIX is a very clever fundamental design, then in bell labs, but it was made for workstations also where basically to workstations IBM and

so on it was 70s so, but in 90s there is a Travis; Linux Travis he could ported to desktops in 90s.

So, desktop had less RAM. So, actually operating system sits in the RAM. So, it will take space of the RAM if you do not have enough RAM then hard luck, you cannot put in the UNIX. UNIX is it is a good OS. Now I will not tell you why it is a good OS, I does not have virus it is it is secure. So, all that features are there. So, he could push the sub section of Linux, UNIX to desktop and that is called Linux. So, Linux is UNIX for desktops, but it turns out it has evolved now. So, (Refer Time: 36:28) I have Linux installed there. And there are probably 500s different variations of UNIX Linux and some are useful for some people like some so, the most popular is Ubuntu right. So, Ubuntu is safe easy not probably the best, but for it is like windows actually this is easy. So, the otherwise are a window which I do not recommend and OS X is for mac, but it is UNIX based it has a layer above it.

So, the layer is useful that it makes my life simple, but it is based on UNIX. This another operating system which is coming up in a big way is Mobile OS. So, I must say that the iOS is for MAC or for I phone and. So, this is apple OS for mobile and this is android is for by Google this for other phones. And the Window, Window is also has it is own OS the third one I did not write it here. So programming languages.

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So, we need to know at least a roughly, what are available? There well after the languages are probably more than 100. So, you need to know some at least I do not know the language names of many of them, but they are just huge numbers and they are each of them has their specialty.

But, as the phases we need to know, well I do not know Java, I simply do not know Java, but I should know what Java is for? So, these three are quite popular among phases. The Fortran was traditional, in fact; there is one of the first languages in computer. So, you need to know one of the three. If you want to do computing, you need to know one of the three. We will not do it in this course; the reason is to know this you need something like 20 lectures. A Python you see that it is basically three lectures I can communicate you can become really good user of Python is quick, but C has it is own the barrier. So, these are called compiler languages. So, I did not mention, what is Compiler? So, we will take this text and I will convert into 0s and 1s in one short. So, after you write a program, you need to compile. Then you need to execute it. So, that is why it is slightly longer process, there will be compiler errors and there will be a runtime errors. So, error while compiling it itself there will be a type also some typographical error. So, it will catch compiler will catch. And once you succeed to compile then, you will execute then you will get some errors.

So it is a bit lengthy process. So, for first language, I think many of you under that is know C, I mean C was the language some people knowing here C so, in fact; I did not given the advantage. So, Python will bring everybody well known there I did not give advantage Python people who do not know will be able to and people who know C is Python is useful to know it is not that is useless is. In fact, this C is the language which being used I think I mentioned in the last class that around 20 percent universities are using Python is the first language and I am pressing our cs department to move to Python for the first year.

So, other languages which are called interpreter languages, so Python is one language, MATLAB is another one. So, MATLAB quite of you will know. So, MATLAB so, I will I will show you will just run Python which very similar to MATLAB. So, like what he did 2 plus 3 is 5, you can plot; you can do sin of 5, sin of x. So, all that you can do with MATLAB and Python, but it is a interpreter language, when as soon as enter it will run. So, you do not want to compile separately. So, as soon as you enter the computer

compiles it without you knowing it, is that clear. So, you do not have to compile send a command for compilation.

So, it will do compilation line by line. So, that is why it is quick for programmer, programmer can simply say well I am lazy I just do line by line I just do not want big program to be written. So, it is quick. So, that is why it is fast to code. So, interpreter languages are slower than compiler languages, because compiler I told in the last class it is a very intelligent program which will make a efficient object code efficient 0s and 1 code which will give you result which is. So, whether prediction is never written in Python. You can write a prototype, but not in the real code, because it will too slow. So, typically this language this program can be 100 times faster than Python codes 100 times.

People are of course, working to make Python fast. I will tell you a bit later, maybe towards the end how can you make Python fast, but the number of lines we write in Python the average line is 10 times slower, lower. So, this code would be 100 line this is only 100 lines. So, thus the plus and minus of these two languages. So, this is finishes include two computers and I think you need to know it is not that you simply get to programming. So, now, let us get to a bit of a starting two program. So, I am starting Python now. So, we have 7 minutes. So, the first thing is. So, Python again it has. So, a Python we can install in different ways. So, one thing is to there are lot of Python is not a single program, single package; it comes with lot of libraries. So, floating is a different library linear algebra package is different, this package for various applications. I will discuss some of it in due time. So, but I recommend that you can install Anaconda. So, these are package, how many you succeeded to install this?

Great, very good. So, you just go to the site I Anaconda dot com I think, just said Anaconda Python you will get to the site and install Python 2, not Python 3. So, I think it is 2.7 is a current one for download. Python three is slightly different, but there will be problems. So, the syntax is slightly different. So, it is older, but things will be consistent lot of so, the first well basically Python 2. So, it is much easier to use a rather than installing separate packages. So, SciPy, PyLab. So, you do not want to install iPython. So, is we will do in one shot.