Advanced Computer Architecture

Prof. Dr.John Jose
Department of Computer Science & Engineering
Indian Institute of Technology – Guwahati, Assam

Module No # 01
Lecture No # 01
Introduction and Course Overview

Hello everybody welcome all of you to the NPTEL MOOC's course on advanced computer architecture. Computer architecture is one of the basic core courses that students from computer science electronics as well as IT do there during their undergraduate level B.Tech program. In some universities this is one of the important subject in PG courses as well. This course is designed in such a way that at the end of the course the students will be able to appreciate computer architecture in general and multi-core advanced processors in particular.

Through this short video, I would like to introduce this course so that it will help potential candidates to take a decision whether this course is suitable to you or not. This course is designed in such a way that there will be total of 20 hours of lecture videos spanning across 8 weeks. Every week along with 2, 3 lectures there will be a couple of tutorial sessions as well which will help the students to appreciate the concepts that they have learned in the lecture videos.

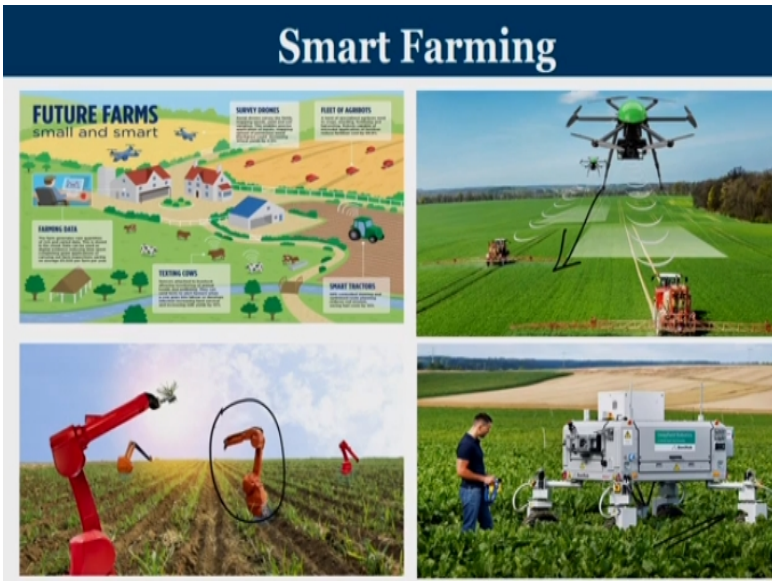
These tutorial sessions are basically problem solving sessions with numerical examples and this will help them to get more clarity on the subjects that they have learned. We are also planning to introduce an open-source simulator known as gem5 and working with these kind of architectural simulators will help the students to get better clarity on the concepts learned. Let me quickly go through what is the relevance of learning advanced computer architecture course in the present context.

(Refer Slide Time: 02:25)

One of the role of computer architects, applications and handheld devices are part and parcel of our day-to-day life. We are working with plenty of applications like this on a day to day life, these applications typically run on either tablets, handheld devices, mobile phones etc and how are all these done? it has an underlying microprocessor this is going to run these applications. And applications are basically instructions and these instructions are stored in memory of these devices and your microprocessor will fetch these instructions and execute.

In the Indian context what are the key applications in future decades that need high-end architectural support to sustain. Let me draw your attention to a couple of applications that are going to impact the way how we live and through these applications I want to draw your attention to what is the role of computer architecture for these applications to really perform well.

(Refer Slide Time: 03:32)



In a country like India smart farming is a very important domain, from the conventional way of farming, moving into mechanized way of farming is the need of the hour to increase the yield and to compensate with the reduced manpower that is available in this sector. From the diagram we can see that on one end we have drones that are going to capture pictures of farm field and from that using image processing algorithms we will be able to find out what is needed to be done on certain specific area of the farm.

We can also use robots called Ag-robots for planting seed or plucking weeds from among large farms we can also have special kind of robots that are to be used to check the fertilizer level the moisture level and many other parameters that are needed in determining the productivity and yield of an agricultural farm.

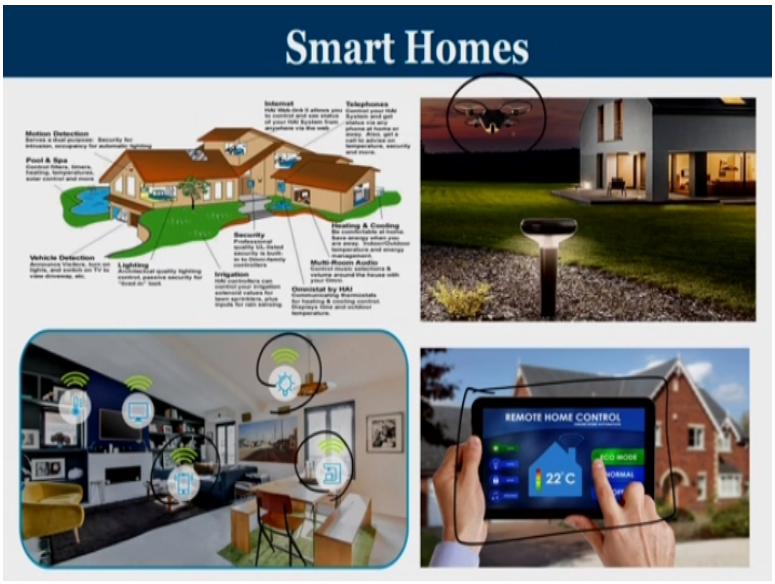
How are all these turns? Is basically done with the help of sensors that will capture the data and these sensors are going to give us inputs, this inputs are processed in high-end computers which will give you statistics and results which can be either fed to farmers to take appropriate decisions or it can be said to the control system which is going to automate the whole farming process.

(Refer Slide Time: 05:10)

Let me draw your attention to another important sector which is called the smart healthcare. Nowadays very important high precision surgeries can be done without the presence of a doctor in the operation theater, what you see here is doctors viewing the body of the patient on the operation theater and the patient may be far away with real-time image processing mechanisms.

Doctors can see the visual effects of the anatomy of the patients and then take decisions by pressing buttons or sending signals which will activate the robots so that we can perform robotic surgery. Similarly there are a lot of sensors that can be fitted in the inside or outside body that can regularly track the body enzymes and here also it is all about sensors that will produce the data and this data is been operated on to take effective decisions for smart healthcare.

(Refer Slide Time: 06:19)



Coming into smart homes, our future homes are going to be smart homes, what do you mean by that? The appliances that are in the home will be connected to internet and many a times using your phones or remotes, we can completely control all these appliances. These appliances can be controlled in a remote fashion and sometimes a direct intervention of a human being was required, will be replaced with robots, sensors and for security kind of things. Even we can think of drones taking care of the security of our homes.

(Refer Slide Time: 06:57)

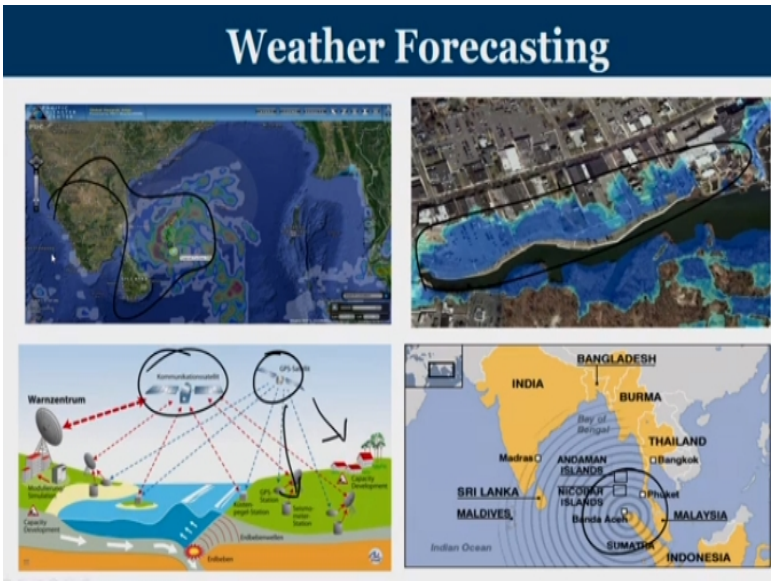
We are heading onto the era of driver-less cars. Intelligent transportation systems are going to conquer our roads. In this context also whatever we discussed previously capturing data from the

nearby workers or from the nearby infrastructural points and then take intelligent decisions what normally a driver does can be replaced with the help of programs. So we are actually heading on to autonomous cars a lot of intelligence is being fed into these automobiles. Here also lot of sensing a lot of processing and lot of data analytics is required.

(Refer Slide Time: 07:40)

Security is an important threat that everywhere we are facing. There are a lot of limitations in handling security related things with the help of only human beings. Lot of monotonous work like monitoring and surveillance can be replaced with intelligent devices. We have drawn security, we automated security of videos that has been captured from different points and we can write programs which we look into these videos and take intelligent decisions about whether there is an anomaly or a security breach or not. Here also it is sensing plus data processing that is a most prominent activity.

(Refer Slide Time: 08:27)



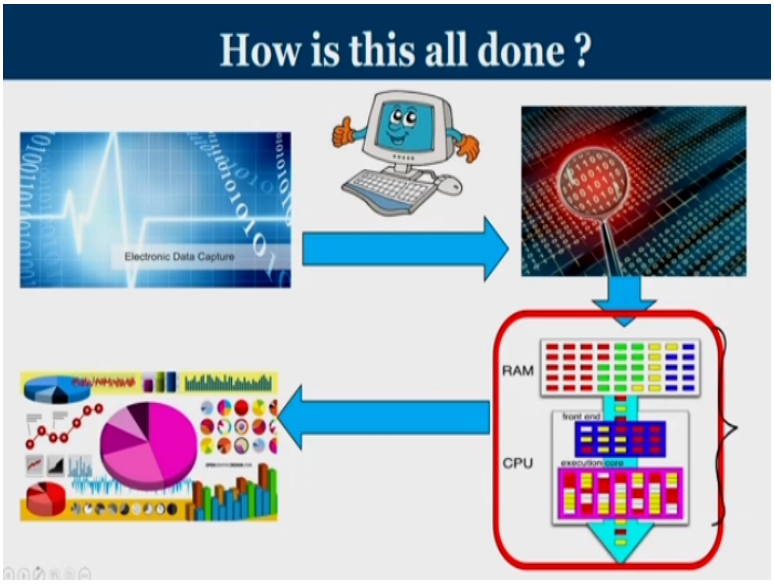
Over the last few decades we have improved a lot in predicting the weather that we are going to experience. In this context also we are in the world of automated weather forecasting, where your GPS satellites, your weather satellites are going to capture vital data and they are going to be passed on to households and to public information systems. With this we will be able to predict the rise of water level whenever there is a tsunami or what is impact of something?

What is the impact of floods in certain specific areas all these can be monitored under this context.

(Refer Slide Time: 09:08)

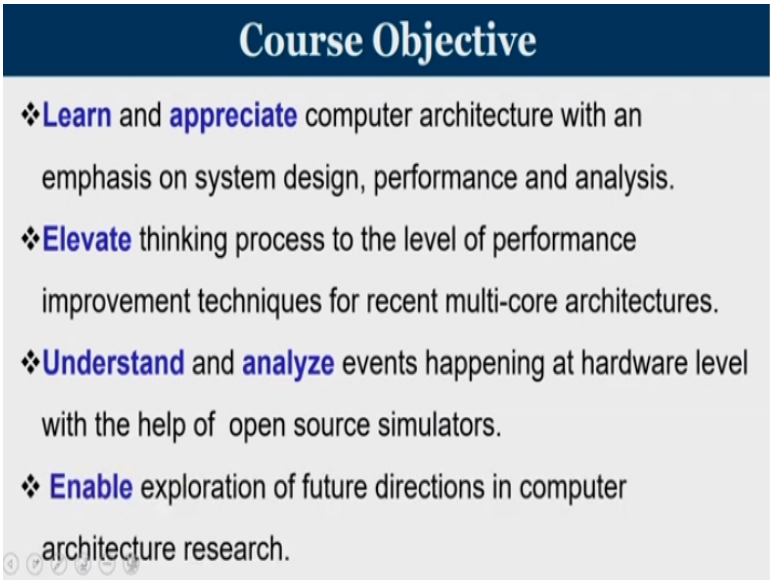
So all together we are going into a smart living ahead with lot of Technology with smart mobility, smart homes, smart healthcare, smart buildings, smart energy systems, IOT and overall we are now living in a smart planet.

(Refer Slide Time: 09:26)



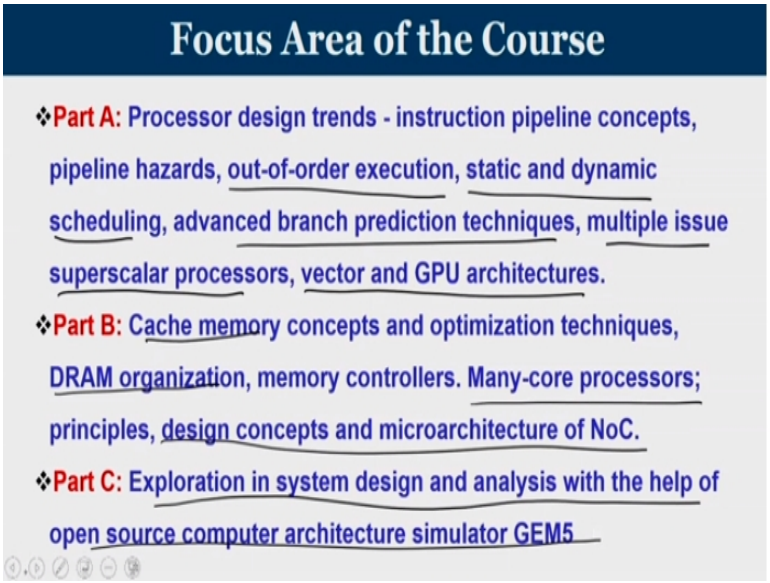
How are all these things done? Basically in all the applications that we discussed we have electronic data capture and this data is going to be stored in a binary format and then using powerful computers we analyze these data and then we are going to make meaningful conclusions out of this. This course will be focusing on what should be the architecture of these powerful computers which are going to operate or manipulate on the data.

(Refer Slide Time: 10:00)



The main objective of the course is to learn and appreciate computer architecture with an emphasis on system design performance and analysis and to elevate the thinking process of the students who are taking this course to the level of performance improvement techniques for recent multi-core architectures. And to understand and analyze events happening at hardware level with the help of open source simulators. And to motivate a couple of you to explore computer architecture research.

(Refer Slide Time: 10:30)



Having said this let me focus on the important domains this course is going to touch upon.

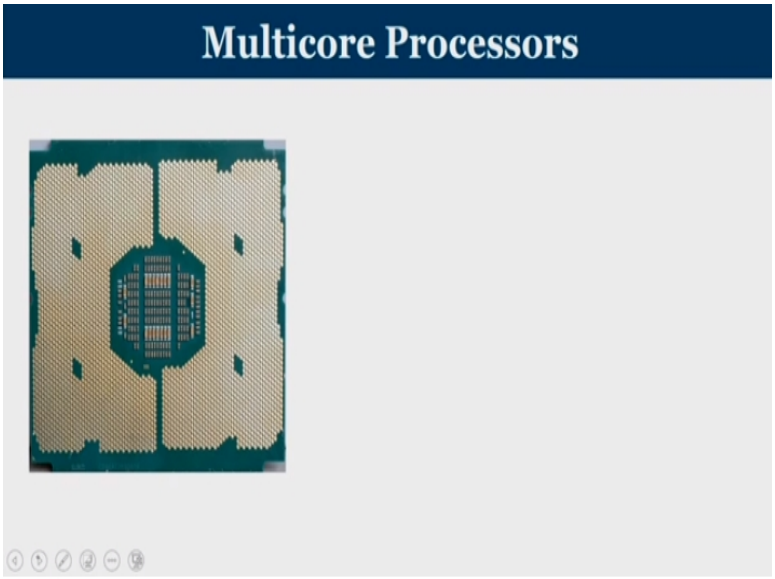
Part A in the course we are going to understand about processor design trends, basically consisting of instruction pipeline hazards. So these are basically on techniques that are used to execute instructions which are there in memory.

So how your memory and processor is going to interact and once you get the instructions in the processor, how the processor is going to execute these instructions in order to complete a desired task. And then we look into certain advanced features like out of order execution, static and dynamic scheduling and branch prediction techniques. This will give you the deeper understanding about how some of our modern processors work.

So right from the elementary process of a scalar in order pipeline, we take you all the way to super-scalar processors and part A conclude with certain specific types of processors known as

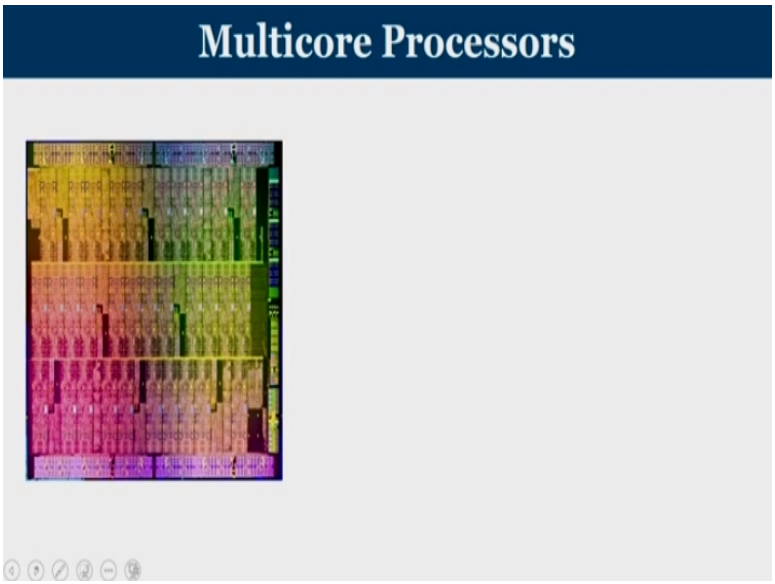
vector and GPU architectures. In Part B we are going to talk about the memory hierarchy which consists of cache memory and DRAM and working principles and optimization techniques in cache and DRAM and then we introduce you to many core processors. Quickly touch upon the design concepts and micro architectural features of communication infrastructure in these many core processors. And then to supplement the concepts that we learned in part A processor and part B memory and interconnect, to exploration in system design and analysis with the help of open source computer architecture simulator gem file.

(Refer Slide Time: 12:11)



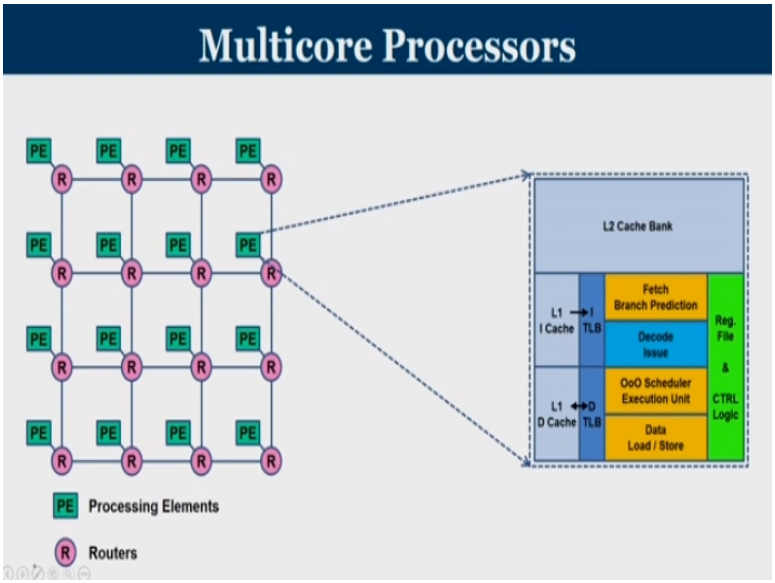
So at the end of the course you will be able to appreciate what a multi-core processor is? So these are our modern multi-core processors that we are using for our day-to-day activities and these processors are having lot of pins through which these processors communicate to outside world.

(Refer Slide Time: 12:31)



And if you zoom in to what is there inside you have a lot of functional units and logic circuitry inside that. But what we are looking at is the architecture perception of these processors are like this.

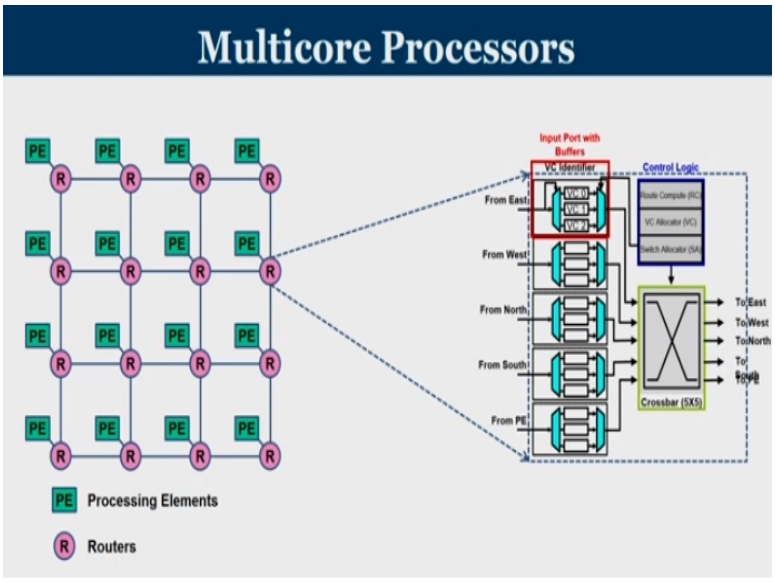
(Refer Slide Time: 12:41)



This is a 16 core processor and which consists of a set of processing elements connected by routers and if you look into what is this processing element? We have fetching, branch prediction, Decode, issue, scheduling, execution, load store operations plus one or two levels of caches which will take care of your instructions as well as your data.

And the whole thing is controlled by a control logic and you have internal storage for this processing elements called registers.

(Refer Slide Time: 13:18)



And then these processors are going to be connected with the help of routers. These are all communicating infrastructure inside a chip. We have buffers wherein this data is going to reside when they reach the routers, then basically the purpose of routers to forward your data coming from direction to another, router of crossbar and it is going to deal with the control logic.

So with this background I hope you got a fair idea of what are we going to study in this course. A basic understanding of computer organization or a micro process of course is desirable, but if some students who do not have these basic courses also done can also take this course in the initial few lectures, I would like to give you some introduction or quick review of computer organization concepts which will help you to understand the rest of the course.

(Refer Slide Time: 14:13)

This course is for those who are willing to take up the risk or enjoy the beauty in understanding how processor, memory and communication technologies of a computer work by exploring deep into its architecture. The main purpose of taking NPTEL course is probably maybe some of you wanted to get a grade, it is always well and good to get good grades in these courses but it is not the destination that is a final grade in the course but the unique experience in the journey of the course.

By journey I mean discussions in the lecture videos and tutorial sessions and the deeper insights you are going to gain while solving the assignments that is more important. So I promise that you will really enjoy the ride for the 8 weeks that you are going to learn about advanced computer architecture. We will be having a couple of live sessions also wherein if at all if there are any queries by the students we can address them.

I request all those who are interested in exploring the hardware of a computer to take this course and enjoy the learning experience. As a course instructor I promise you that at the end of these 8 weeks you will be having a fair good idea about computer architecture.

(Refer Slide Time: 15:39)

And if you have any queries feel free to drop your queries in my mail, you can also visit my website. I wish to see you in large numbers that registering for the course thank you.