Design for Internet of Things
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Lecture - 01
Introduction and Definition of IoT

Welcome to this course, and I think we should start this course with a demonstration, because idea of this course is to actually show you the working of IoT systems, and how you design IoT systems. So, let us start with the demo.

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What I have with me is a mobile phone, which you know very well down one is a mobile phone, and what you see on top is this a Arete pop, if you go closer, you will actually see a Arete pop, this is an RFID reader. I know that you have no clue of what RFID is, we will go as we go along, you all will realize that but take it now that this demo, is a very interesting thing.

So, this is the reader, and this is a mobile phone, mobile phone all of us have used starting from phone which is no feature, simple display systems having no sensors and so on, up to very expensive phones we know, the whole spectrum, and on top what you see is this RFID reader. What I am going to do is I am going to start, you know, start off putting this phone into action, what you see is a blank screen here. So now I will say read, alright, so I will press a button called read.

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And you see it starting to read now, you see some line here, then there is one more tag here. So, I will read this tag and two lines have appeared now, then I will read one more tag.
So, you see multiple reads have also come on the right side, if you see, I suppose it is not so visible. But I can tell you that one tag was read 10 times. The other was read 16, and the other one was 17, and so on.

So, the origins for IoT actually started from this whole experiment, which I showed you and I am sure you are motivated to know more about RFID. It is evolution, as well as what are all the progress that you have seen over the years. I sort of did not even talk about the phone I only mentioned a few sensors and so on. Remember, this combination of RFID reader connected to this phone, and this being an IoT smart device.

And this RFID reader can do wonders. By the way, what I must also tell you is what I show you what I hold in my hand is exactly the same thing, but in a bigger size, larger range, in terms of functionality, no difference between what you see between the NHAI, the National Highway Authority of India. RFID systems, which are deployed in tollbooths to what I hold in my hand, this is a miniaturized version of the same technology.

Lower power, shorter range, different lab-based tags that I am experimenting for the purpose of teaching you. But the professional ones that are applied, are packaged better, have a different radiation pattern, perhaps which will allow you to scan the automobiles as they are passing through a tollbooth. So, it is exactly the same thing, there is a name to this technology in the RFID world, and we will come to that as we go along.

So let us now go and look up the thing related to how this name was coined. So, who coined this name, internet of things and how did it all evolve? That is the question. It may have bothered you on that. Actually, this name was coined by this Gentleman here.

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I would like to show you his name is Kevin Ashton. You see this is the person. In fact, download this article and read it for yourself. I will just tell you what it actually meant. His definition of the term IoT, which is written here, you can see that he mentioned the name IoT here is, what did it mean then and is the definition still valid. I think the opening line is fantastic.

It simply says it meant using the internet to empower computers to sense the world for themselves, amazing. You were not getting humans anywhere in the picture. It is not at all about humans, who generates traffic, machines generate traffic;

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Who consumes the traffic, machines consumed the traffic. It is so different from what we know very well. You sit in front of a computer, kick up your browser, you type Google or you type or Gmail or you type any of your email or go to YouTube or Facebook or whatever. It is the human, which is actually triggering things, not anymore. IoT does not say that, IoT says it is something that will empower computers to sense the world for themselves.

What is the ambient around me? What should I do? Should I not get data from the other sensors? And should my action not be dependent on what is happening around me. Very simple way by which how powerful this concept of IoT has become, what does it mean? Think about your house, and you have, let us say a lot of automation in your house.

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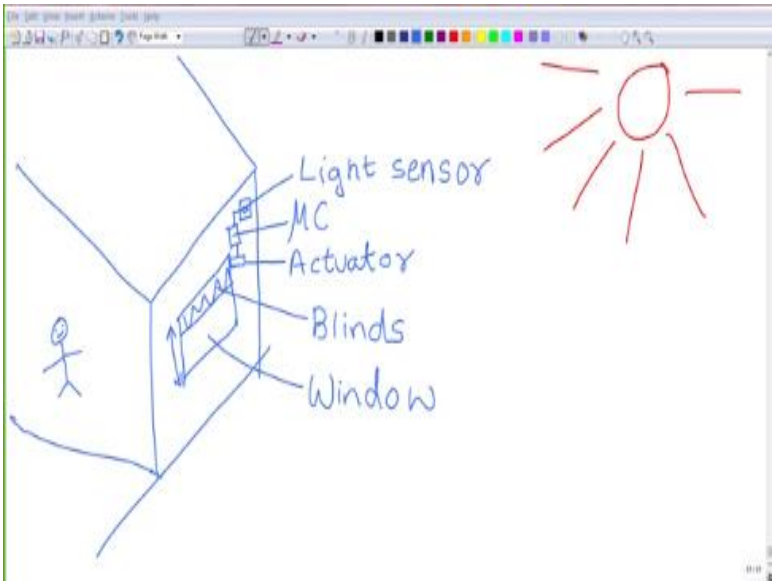

It is basically very, very hot or sunny outside, not hot, it is sunny outside, and you want your window shades to come down. One option is you get up from your seat, you press a button, the window shades come down. Another option is you put a sensor which is looking at the light outside. The light outside is sensed, and the sensor says, I am giving you this light output and it appears to be of some intensity.

Another sensor says the intensity of this light is high. So, I must perhaps bring down the blind all by myself. So, the other computer now brings down the blind all by itself. What have you done? No human interaction is required. These are simple examples. But think about what all you can do when one machine is talking to another machine. So you build like this, and then this machine now says and I am going to get it done.

Next, you can complicate it, you can say, here is this guy who is sitting inside the house, he likes not full darkness, he likes a certain amount of light. He likes a certain amount of light. So, this machine did a dumb thing. What it did was moment the light was very high, which was given by the light sensor, the other machine went and crossed the blind, the room became dark, the human sitting inside said, hey, this is annoying, it too dark for me, let me go and press the button again.

So, he presses the button and adjusts it, moment it adjust certain amount of light comes in. Now the ambient is good for him. He says Aah great. This is the right amount of lighting that I like. Now, for that amount of lighting, this computer which closed the blind says, this is the

level at which the human is happy. The amount of light that he wants looks like Prabakar is happy with this amount of light inside the room.

He tells the sensor hey, you are now looking outside. Why do not you twist inside, come inside, rotate yourself inside and then tell me what is the light inside. So the sensor maybe as a motor or something or there can be two sensors. There is one looking out, there can be one sensor looking in. The sensor that is looking in or the sensor is rotated itself looks up and says this is the value I wish to report to you.

Now this blind controlling computer, now says Prabakar requires this threshold. So let me adjust the blind. So, the next time around something happens. The blind computer or the blind controlling computer or the light controlling computer which is turning the blinds on for the window knows very well what is the comfort level of the human. Folks you can think of any number of products out there in the market.

This is the essence you take the thermostat application from NEST it is doing exactly this, but that is for other thermal comfort. That is for keeping your room cool. I gave you an example of light; you cannot take it for thermal comfort inside the homes. Learning is important, the computer associated with the blind actually learned what is it that I am comfortable and adjusted it to yourself. This is the power of IoT, and this is the single line that Kevin Ashton said in a very cryptic manner.

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And so let us move on to the most important thing that I wanted to show you is the formal definition of IoT. This is the formal definition of IoT, folks I could not find a better definition than this, a global infrastructure for the information society, enabling advanced services by interconnecting physical and virtual things based on existing and evolving interoperable information and communication technologies.

So, what we discussed about computers blind, and so on and so forth, are all about computers, which are connected to those systems. You can also talk about virtual connecting to virtual systems, what could be a good example, think about the following folks, you are in front of your laptop and there was a chair, there was a table, and then the laptop kept in front of you.

And then you came in from somewhere and sat in front of your desk, in your chair, in front of your desk, and open the laptop. Moment the laptop opened, the computer already knows that you were reading page 136 of some book, and it goes directly and opens that page for you. Where is that physical page? No, it is a virtual page. It opens a virtual page for you and then moment you finish reading it might even swipe through the next, go to the next page and next page and so on.

So, you can have physical systems talking to virtual systems and these are excellent. So, you can connect the physical world to the virtual world.

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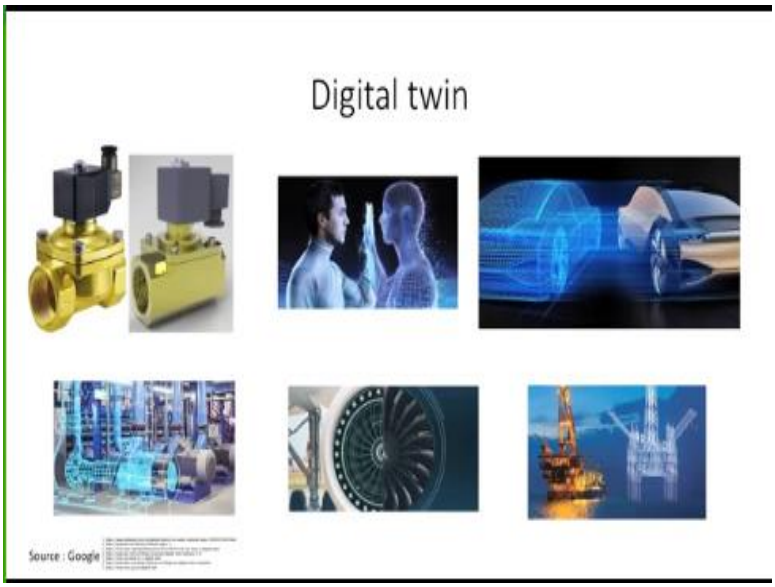

People today talk about digital twins. Digital twin is an exact digital copy of the physical system. Think about a solenoid valve, solenoid valve that you see is physical. Supposing I have a copy of this solenoid valve, both in terms of its physics model, as well as the data that it generates. And I fuse the physics model and the data from it, I now have a digital copy of that solenoid valve.

Every time the wall opens, closes, I get data here corresponding to open close, which means I am sensing and communicating this data to this virtual object. And now I can do a lot about working on this virtual object itself, I can perhaps find out how it deteriorates over time, because of these operations. Because I understand that in the digital world, I can do any kind of destructive activity out there, which will not really influence anything that is physically running.

So, all your experimentation, all your future predictions, all your future operations that you want to do on, can happen on the digital copy. So people are talking about, the community talks about digital twins, and having virtual copies of the physical object is a lot more beneficial. If time permits, we will spend time on how to build these digital twins. But I do not emphasize that;

But please do look up, you will get a wealth of information about how these digital copies can interact with the physical objects wise and vice versa. So this is an important thing, you should have bidirectional transfer of data between the physical and the virtual objects. So that is essentially what this definition is.

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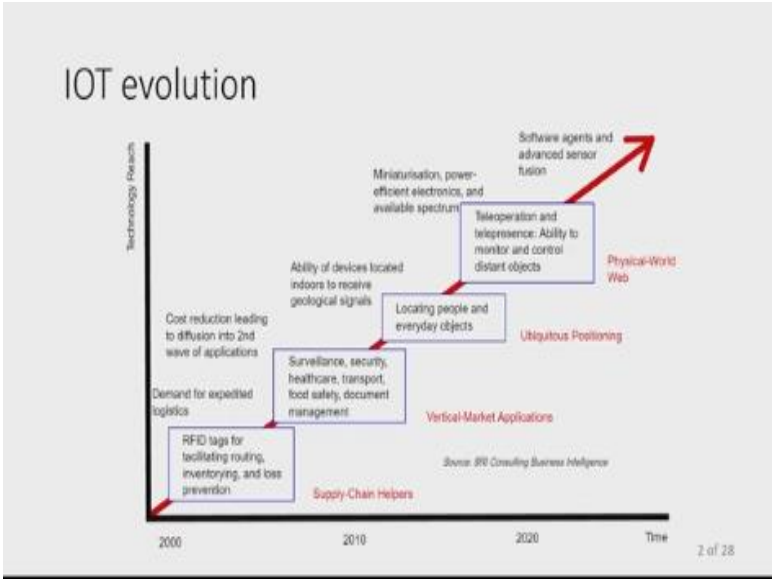

Now, if you look at the evolution of RFID, of this whole IoT evolution. On the X axis is the timeline, on the y axis is the technology. So look at what the very first bullet is and that is very nice to see that we already know a little bit about RFID. RFID tags for facilitating routing, inventing and loss prevention, everything can be done. See if you have a reader in front of the system, which is all the time, you know inventorying the tags, reading the tags.

Reading the tag is equal to inventorying the tags. So if you are inventorying it, moment an item is removed from that rack, or removed from there, the reader can quickly report and say, Hey, I do not see this item anymore. Maybe a customer has picked it from a shelf from a smart shelf call it. A smart shelf is a shelf which has an RFID reader which is attached to it and then the item was removed.

So you could essentially track systems in quick real time, and that is essentially what he is saying. This is all happened in the world of demand for expedited logistics. Now, the second as you go along in the 2010 kind of timeframe, surveillance, security, health, care transport, food safety, document management, these started becoming very, very important.

We do know about camera systems which are there in large cities, which are looking at intersections, which are looking at traffic management, which are looking at traffic intensity in busy junctions, looking at how to plan traffic to ease traffic in these congested cities. All of that is possible because IoT sensors are out there. A camera sensor is a fantastic IoT sensor, gives you a wealth of information about the amount of traffic.

The amount of pollution from air quality sensors will tell you that which are polluted areas, which are good for safe and which are areas you should avoid, so on and so forth. So, so many things are happening and all that happens in the time care. Even healthcare, personalized health care and Public health care have got revolutionized because of the fact that IoT was able to get applied there as well.

So, as you go on the Y axis, you will see that demand for expedited logistics, cost reduction leading to diffusion into second wave of applications, then ability of devices located indoors to receive geological signals, miniaturization of power efficient electronics, software agents and advanced sensor fusion, all these things are happening along the Y axis. Y and the X are moving together because you will see that it is like a line which is at 45 degrees.

You will see that the 2020 I mentioned to you, the most important thing that you can think of is locating people and everyday objects. And we must look at that also in some detail, then came all this issue of COVID-19 and doctors and hospitals and so on and so forth, where you want to maintain physical distancing. Important surgeries have to continue, but doctors can get infected.

So how do you ensure that these things are actually enabled? Well, the evolution, the era has come now where teleoperation has become a big thing.

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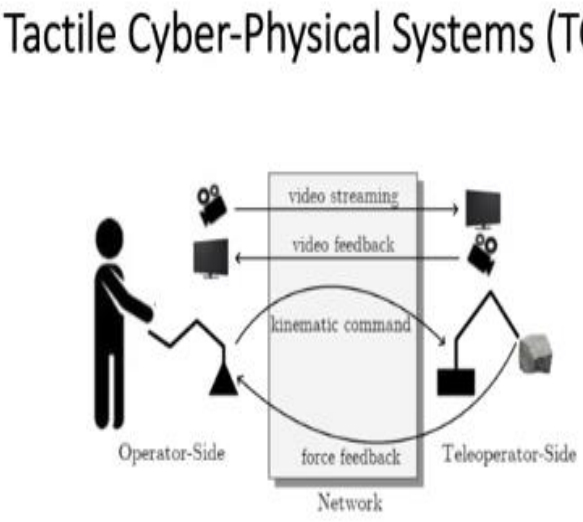

You will think about a doctor sitting wherever he or she is, performing a remote surgery. On the other side, a whole connection is IoT enabled. Lot of sensors on the robotic arm side

which is performing the surgery, for instance, which is giving tactile feedback to humans. And humans are who are essentially doctors are getting feedback.

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Maybe they wear a glove. And that glove will essentially have a feedback mechanism coming from the remote side via the Robot which is on the other side via internet. And once that feedback comes, the doctor knows what to do next. Now the opposite is also true. In fact, it all starts with the doctor performing a operation, type of a procedure, let us say he is doing the suturing procedure or he is doing a surgical procedure or something that action has to be translated to the remote side.

And the Robot has to actually do the surgical operation, has to perform the surgical operation and give feedback in real time. All this means tactile cyber physical systems have invaded us. It is their reality. Again, IoT comes in a big way because there are a lot of sensors. There is a lot of sensing and actuation happening in real time. And CPS systems essentially are full blown, where IoT plays an important role in this evolution of IoT.

Now, let us shift to the, I mentioned to you about the RFID systems. And I mentioned that if time permits, I mean if we know a little more about RFID you will actually know this part of the bullet which is down below here. This part of the bullet is known to you. You can look at RFID so let us spend a little more time connecting all the dots that we mentioned here. Thank you very much.