Introduction to Internet of Things

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Lecture - 01
Introduction to IoT-Part – 1

So, the first lecture is going to be on the Basics of Internet of Things. So, in this lecture we are going to get introduced to the different fundamental concepts behind IoT and the basic technologies connectivity devices that are required and an overall understanding about how IoT's are made. So, we are going to have in this lecture an understanding about all of these concepts, but first let us get motivated about why IoT is required.

So, it has been anticipated that very soon all the different things that are going that we are seeing around us and that we have around us are all going to be internet worked. They are all going to be interconnected. So, at present what we enjoy as services, as internet based services is basically a connection of different computers and computing devices. So, basically this capital I internet that all of us use is basically a global network or an internet work of different computers and computing devices.

Now, what internet of things says is that the scope of this internet is going to be expanded. So, it is going to be expanded beyond computing and computer devices being connected. It is going to interconnect different things that physical objects that we see around us, the different objects such as the lighting system in a room, the lights, the fans, the air conditioners and anything and everything including things such as the toothbrush, the microwave oven, the refrigerator and so on so forth and not only in our homes, but also in our businesses such as internet working different machines, internet working different equipments and so on. So, each and everything that we see around us that we use at our home in businesses, in workplaces, everything being internet worked. So, this is the whole vision of internet work of things, internet of things.

Now, there are several challenges that are going to arise if we want to do it, but before that let us also discuss about why it is going to be required, why internet of things has become so popular, why it is going to be required? The reason is that IoT is envisaged to be able to provide advanced level of service to the society to the business and so on. So, advanced levels of services can be offered with the help of IoT based technology.

So, what is going to happen is, these different things, the chairs, the tables, these lighting system, you know the watch or anything and everything that you can think of, all of these are going to be fitted with embedded systems, embedded electronics and information technology, so that they have some basic computing platform in them, attached to them and then, they are going to be acting as different nodes of that particular internet, the IoT internet of things, right.

So, what is going to happen is these systems, these things are going to be all equipped with embedded systems and these embedded systems along with embedded electronics, embedded processor, embedded communication systems and so on. So, they are going to help in connecting different other things that are around them and depending on the application requirements, depending on the specific goals of the business and then, a big internet is going to be formed which is much bigger than the current internet of computers and that is the internet work internet of things IoT.

Now, IoT is one of the building blocks that is considered to be of use for developing smart homes and smart cities. So, at present not only in our country, but throughout the world there is a lot of interest on developing smart cities and smart homes. So, IoT is one of the enabling technologies to make the city smart, to mix make the home smart. So, how it is going to be done, that is going to be more evident as we proceed through the different lectures and the different intricacies that are going to be there in building this complex internet of things is going to be evident through different lectures that we are going to go through in this particular course.

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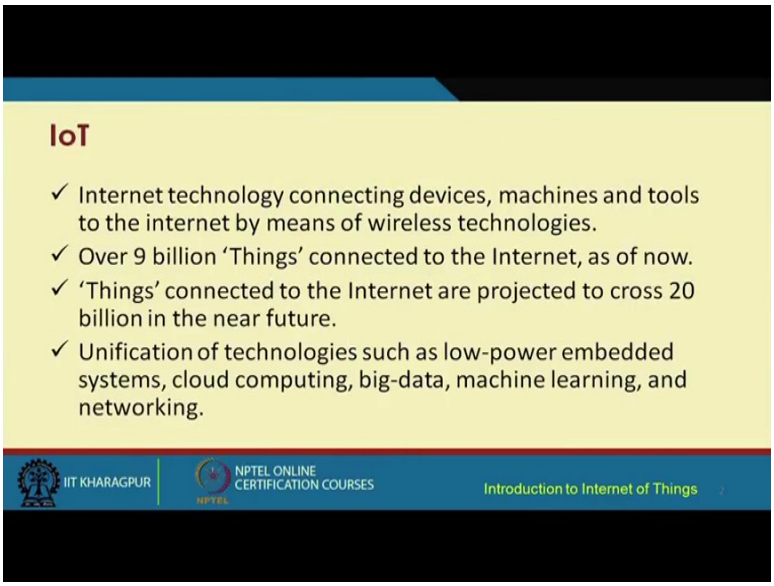

So, going forward Internet Technology that we have as I have already said it is going to expand beyond the connection of simple computers. So, we are going to connect or internet work different machines, different tools typically, but not necessarily using wireless technologies, such as Wi-Fi cellular technologies, Bluetooth Zigbee and different other wireless technologies that are available to us.

Now, in order to be able to do it, what is going to happen is because the number of things is very large, much larger than the number of computers that are available, so it is going to increase the number of nodes in this particular network. So, IoT in other words is going to have large number of nodes, the IoT internetwork is going to have large number of nodes and each node corresponding to the different distinct objects or different things that exist in the physical world.

So, the things basically are going to explode the number of connected things, are going to explode in time with time. So, the things that are connected to the internet are going to be projected to cross the 20 billion figure in the near future. This is what has been predicted. So, a large number of things, billions and in fact, billions and trillions of things are going to be connected to the internetwork of things.

So, at this point I should also mention one more thing that this internetwork of things can be construed to be built in two different ways. One way is to expand the scope of the current internet. That means, the internet of computers this is one way, so you expand.

So, essentially what is going to happened using this particular approach is all these different things are going to be connected to the existing internet.

So, this internet is going to be expanded further. It is going to become much bigger than what it is at present with only the computers connected. This is the first approach. The other approach is to build a separate internetwork of these physical objects from scratch. So, one is basically expanding the existing internet and the other one is a separate internetwork which is going to be built from scratch. So, irrespective of which one we adopt, each of these approaches has its own separate challenges that have to overcome.

So, going back we have the unification of different technologies that becomes very much mandatory we have. So, internetwork of things is not a single technology. Physical devices can be of different types of physical devices having different configurations, different specifications and so on. Each of these supported through different other systems such as cloud technology, big data machine, learning networking computer vision, you name it and all these different technologies from electrical sciences and some from even mechanical sciences are required in order to build IoT.

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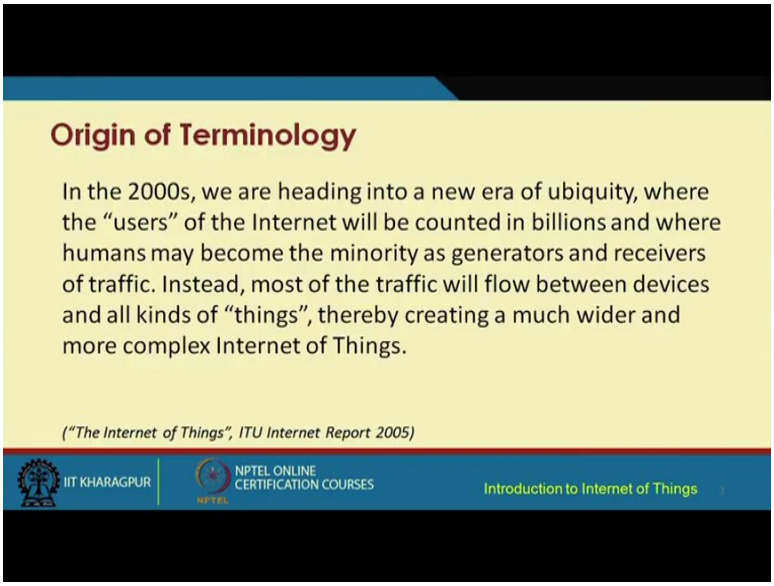

So, talking about the origin of IoT. So, in the 2000, what we are going to witness is a new era of ubiquity. So, in this era of ubiquity, what is going to happen is not only that we are going to have anywhere, any place, that means any place any time connectivity or services relating to connectivity. That means, internet or network connectivity of

different types, but also the service of connecting anything. So, anytime anyplace anything, connectivity is what is going to be observed in this new era of ubiquity. So, that is going to result in billions and trillions of things. Humans, everybody being connected and consequently what is going to happen is the number of humans that are on the earth that is going to this number, this figure is going to be outnumbered very soon with the number of things that are connected to the internetwork of things internet of things and consequently what is going to happen is, all these different devices, all these different things, they are going to send lot of data.

This data has to be handled properly, this data have to be analyzed and this is what we are going to cover in one of the next lectures. So, what is going to happen is this internetwork, the new internetwork that we are talking about, the internet of things is going to be very complex network with much wider scope than the current internet and with many more complexities and this is currently the vision of internet of things and all these lectures that we are going to go through in this particular course. All the other lectures that we are going to go through, they are going to cover the different challenges and how there are different tools that are available in order to, what are the different tools that are available in order to address these different challenges.

So, we are going to go and we are going to get introduced to all these different challenges and the different tools that are available in this particular course. We are going to mostly understand the different concepts that are behind them and typically because it is an introductory course, we are not going to go through each of these different technologies that are available to us in too much of detail, but at a level that will help us to understand the basic concepts for that are required for designing internet of things. So, there are different enabling technologies for internet of things.

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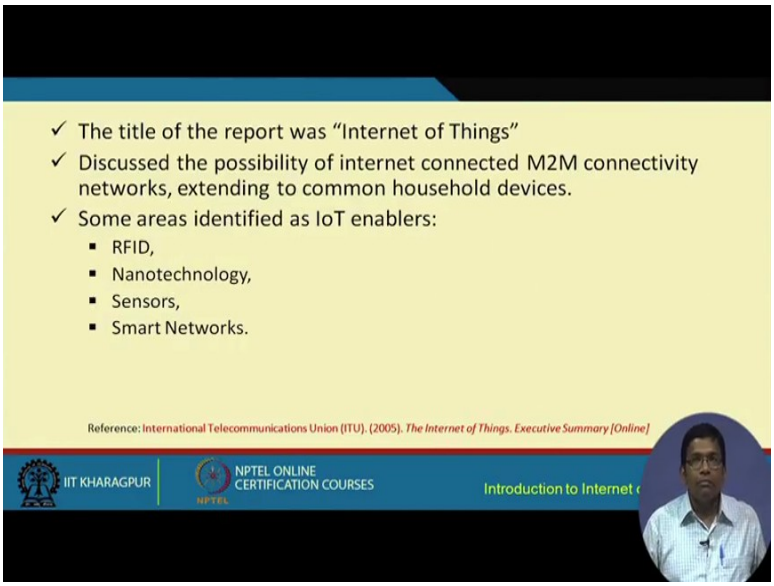

RFID is one we know at present in the market places and different places in the society you know and wherever we go, we see that RFID technology being used RFID tags, RFID readers are being used. So, RFID based devices are required for building internet of things.

Sensors is another one which is according to me one of the most important enabling device or enabling technology for building internet of things. Sensors and actuators are what we are going to cover in one of the next lectures very shortly and the other things are different networking devices, different connectivities, different communication paradigms and so on. So, these are also required in order to connect these different sensors, RFIDs and different other physical devices that have to be internetwork to form the IoT. Finally, I would like to mention that at present there is lot of interest in the nanotechnology domain. So, people are talking about building internet of nano things, internet of nano sensors and so on.

So, you know what is going to happen is there are going to be very small sized nano size nano in the order of nano sized devices that are going to be used for different purposes. For example, there could be these nano capsules which can be consumed and finally, which are going to be excreted after you know after they have performed their functions. So, these nano devices are going to be used, they are going to be swallowed and consumed and then you know once that is done in the form of capsules, they are going to

be internetwork. These different nano devices, these nano capsules are going to talk to each other. So, these nano devices, nano communication devices are being conceptualized. At present people are thinking about building these nano devices that can be used to form the internet of nano things. So, once we have this internet of nano things, the horizon of internet of things is going to be expanded much further.

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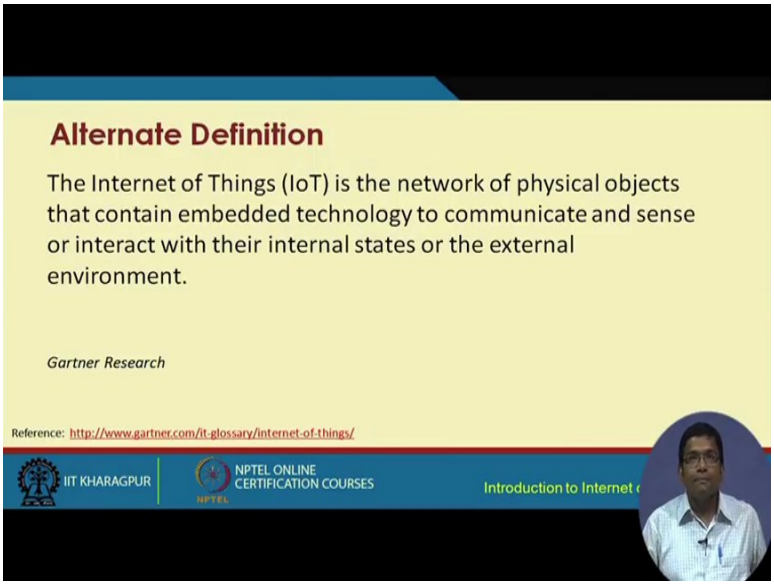

So, we already have seen that when we are talking about IoT, it is mostly about networking of physical objects and these physical objects are embedded with you know the different embedded electronics that communicate and sense and interact with the internal states or with the external environment in which they are operating. So, either they are interacting with each other, they change their different states or they are interacting with the inter external environment in which they are operating.

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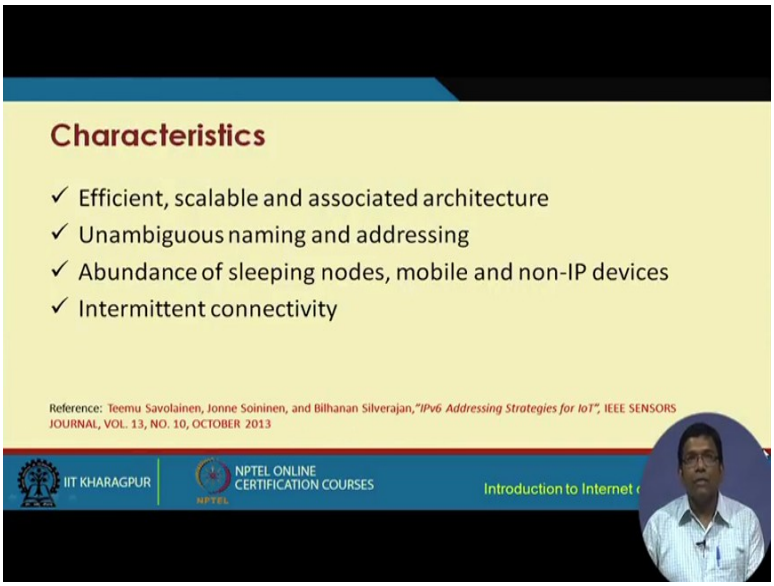

There are different characteristics, there are different characteristics of IoT. So, first of all this IoT that we develop that has to be efficient. It has to serve efficiently the requirements of the applications for which they are deployed. They have to be scalable because we have already seen that in IoT systems, we are talking about large number of things, we are talking about not simply millions of things, but in several billions and trillions, we are talking about the scalability is very important, consideration is very important issue that has to be addressed.

So, even if the number of sensors and the sensing devices IoT devices are going to increase, the overall network performance should not be compromised. So, you know this is challenge in terms of the network. So, from a networking perspective, it is a challenge that has to be worked on. There has to be unambiguous meaning and addressing architecture. So, this is very important. So, all these different devices already we have witnessed that addressing in the IPV4 context in the regular existing internet context is a big issue.

So, we are talking about naming and addressing different mechanisms of naming and addressing with the help of IP technology, DNS etcetera etcetera. We already have seen that these can be used in order to you know address these problems of addressing and naming in the context of the present internet and now, when we are expending this

internet in this large scale. So, what is going to happen is, we are going to run into a bigger problem with naming and addressing.

So, we need a new mechanism for naming and addressing of the different nodes, these physical nodes, the physical objects that are fitted with embedded systems. So, another thing is that in terms of the resource requirements, each of these nodes are typically very low power. They have very low resources and they have to be you know whenever they are not required, they have to be put to the sleeping mode, they have to go through a sleep cycle.

So, that means whenever they are not being used, they are not being active. They have to be put in a sleep state and whenever it is required, they have to be made active. These devices can be mobile, they can move. For example, a smartwatch you know whoever is wearing the smartwatch, when they move, this node also moves, the smartwatch also moves. So, mobility like this becomes a very important problem in the context of IoT networks. Mobility of the devices and the mobility of the sub networks also is possible.

So, part of the network becomes mobile and in extreme cases even larger network can also become mobile. So, IP based addressing may not be always very suitable in this sort of scenario. So, what are the different alternatives? There are different people, different researchers globally who are working on how IoT technology, how naming can be a different form of, naming can be designed in order to support this IoT technology and intermittent connectivity is another characteristic that is typical of IoT. These devices, they move, they get the network and the subnetworks get partitioned. One device which is in connectivity with another device at a later instant of time may not be connected.

So, this is another problem that has to be taken care of. So, for example there is this opportunistic mobile networks which is a topic which can help in addressing this particular problem, this technology. The Waymond technology can help in addressing this particular problem. So, opportunistic mobile networks are useful in order to address the problems of intermittent connectivity between the different nodes in the network.

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In terms of application domains, there are you know IoT is attractive in different applications, spheres application, domains spheres. For instance, manufacturing and business, healthcare, retail, security and so on. So, among all of these, it is estimated that most of the market share with IoT goes with the manufacturing at an business sector, so 40.2 percent approximately.

Next is the healthcare and third is the retail sector and fourth is the security, surveillance, safety surveillance and so on with the help of IoT based systems.

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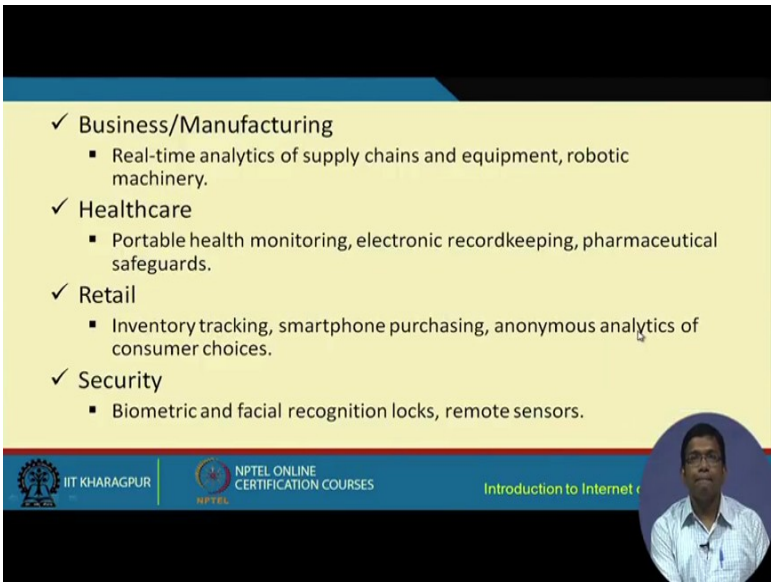

So, when we talk about business and manufacturing, we are talking about how to improve the overall supply chain, what are the different equipments that have to be introduced and different sensors and actuators can be fitted to them, the different robotic machinery can be used in order to improve the business processes.

Second is the healthcare. We are talking about portable healthcare monitoring telemedicine in a much more bigger way. That means, much remote areas can also be connected the different healthcare facilities, hospitals, nursing homes, doctors, nurses. Irrespective of where they are, they can still monitor the healthcare condition, the health condition of the patients that they are treating.

So, portable health monitoring electronic recordkeeping is another. So, automatically because you know in medical domain record keeping is a very important concern. So, electronic record keeping automatically things are the records, medical records are going to be archived. They are going to be stored, they are going to be you know maybe they can be even further analyzed to grow some meaningful conclusions from them and so on and different pharmaceutical set safeguards can had in using the IoT technology.

In the case of retail sector as well tasks, such as inventory tracking, smartphone purchasing, anonymous analytics of consumer choices, these are the different things that can be done efficiently through the use of IoT technology. Security is another biometric and facial recognition looks, then the remote sensors and so on. You know fingerprinting based or face recognition based or different eye rays recognition based you know, so these technologies can be connected and used with the help of IoT and you know this sort of security mechanisms can be developed.

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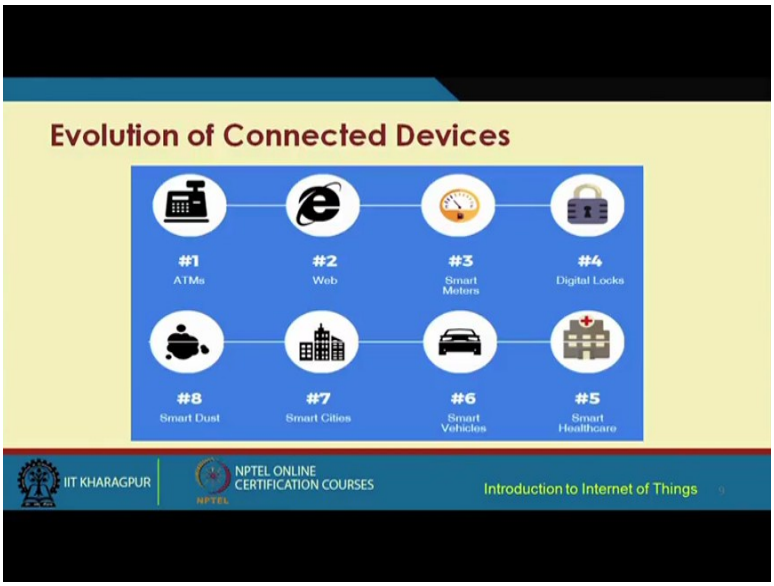

Now, when we talk about this interconnectivity of different devices, we see that this interconnection or connectivity between the different devices has evolved over the years. First it started with these individual cash machines or the ATMs being internetworked. The web became very popular.

So, you know everybody connects to the internet or the web in order to get access to different information, send emails and so on and so forth. Many different things are performed by different web users. At present smart picker meters then became popular. So, smart meters are used at different homes in a city. These smart meters, they can be programmable and they can record different things.

Even you can program the smart meters at your homes in order to do different things like load balancing, electrical load balancing, efficient use of electricity you know using electricity during non-peak hours, pricing, accordingly in the pricing mechanic choosing different options for service of electricity that is provided by the service provider and so on and then, we have digital locks. Biometric based digital locks are very popular.

We have smart healthcare, smart vehicles, smart cities and smart dusts. So, these are the different technologies that have evolved, these are different connected you know device based technologies that have evolved over the years.

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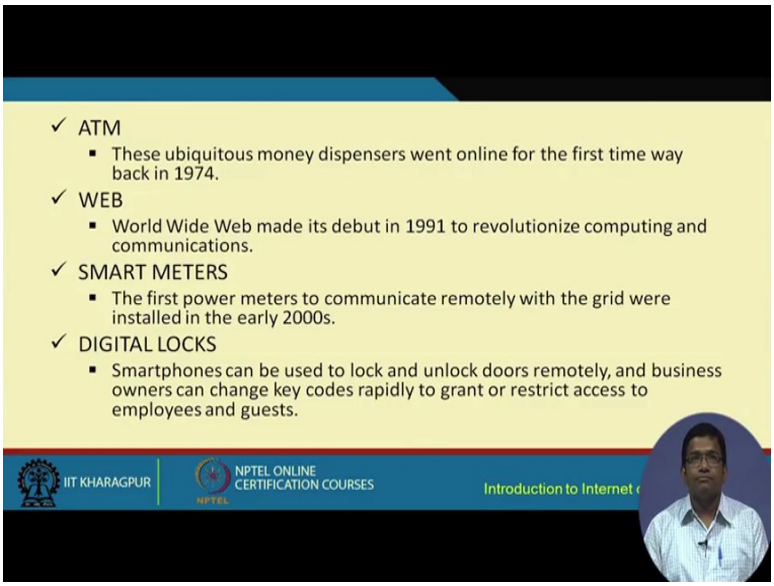

So, ATM and web are relatively old by now. One comes from 1970s and the other one from 1990s, but smart meters became very popular in the 2000s. Digital locks are very popular at present.

So, smartphones can be used as locks to lock and unlock the doors remotely at your homes or at your businesses and these locked keys and so on. They can be easily changed and one can be granted access to a particular facility. One means in a business, the employees or the different guests, they can be granted access to different facilities through the digital locks much more easily than the conventional locks.

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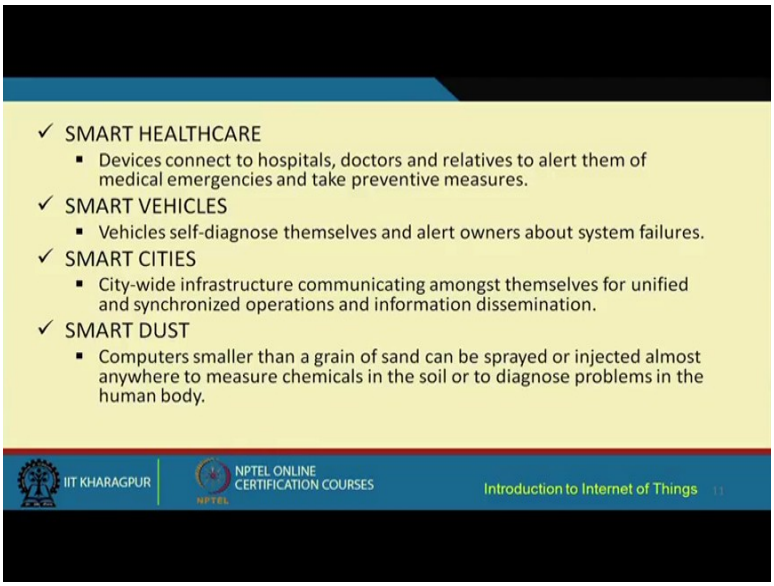

Smart healthcare connected vehicle, smart vehicles you know these are quite common smart cities as I was telling you is very popular at present not only in India, but throughout the globe. So, in smart city, people are talking about deploying smart different infrastructure. These infrastructure which can communicate with each other, they can be used by different owners and the different operations in a city and different functions of the different offices, etcetera you know.

So, all these things, offices and different other public places, all these things can be monitored and the operations can be improved much more easily and also, the information dissemination because you know all these different devices, they are typically fitted with sensors. So, these sensors are going to throw in lot of data. So, dissemination of this particular data is very important, handling of this particular data is very important. In the context of smart cities, smart dust is another thing where the computers that are smaller than a grain of sand can be spread or injected almost anywhere to measure chemicals in the soil or to diagnose problems in the human body.

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So, in the modern day IoT people are talking about different applications such as smart parking, structural health monitoring noise urban maps; that means, noise maps in a particular city or an urban environment smartphone detection traffic condition, smart lighting systems, waste management, smart roads river flood monitoring, smart grid tank monitoring, water tanks etcetera, tank level monitoring, photovoltaic installations, water flow monitoring, stock calculations, access control presence of different liquids hazardous materials and so on and so forth.

Large number of applications are envisaged. In fact, you know there are many IoT oriented systems have been built already. They have been prototyped. Some have been much more advanced than in that than a simple prototype and these can be used for serving not only these applications that I just mentioned, but also a large number of different other types of applications. For example, healthcare, space applications and so and so forth.

The number is many and you know anywhere that you see there is a problem IoT is quite likely can be used in order to improve the efficiency of the solution to that particular problem.

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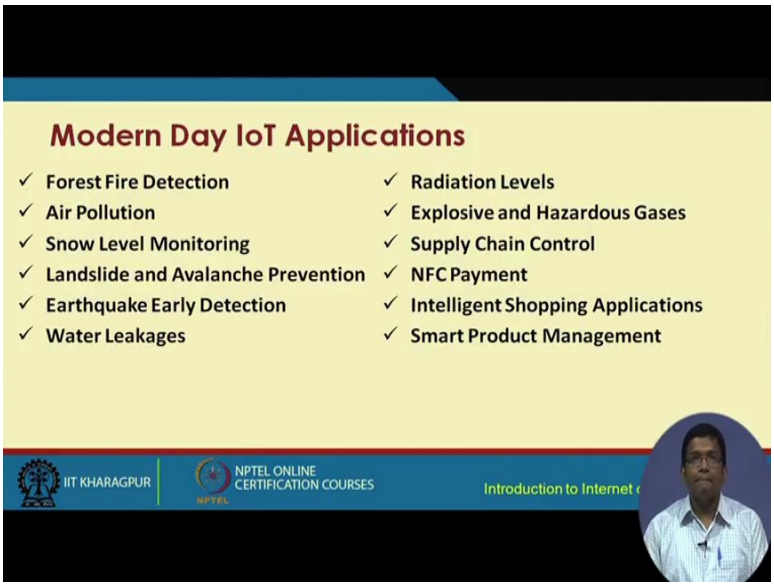

Different other applications such as forest fire detection, air pollution monitoring, snow level monitoring, landslide monitoring and avalanche prevention actually landslide monitoring in our country, there have been different institutions that have already developed systems for landslide monitoring. So, without getting into the details of it, let me proceed further.

So, we have earthquake early detection and monitoring seismic system. Seismic sensors have been developed. They can be connected, they can be internet worked and so on. Water leakage monitoring in a water delivery system, water transmission system in a city, radiation level monitoring, explosive exclusive monitoring and hazardous gas monitoring, supply chain control, NFC payment, intelligent shopping applications and smart product management.

As I was telling you before you can in fact think of IoT applications in almost any sphere of the society, any sphere of life.

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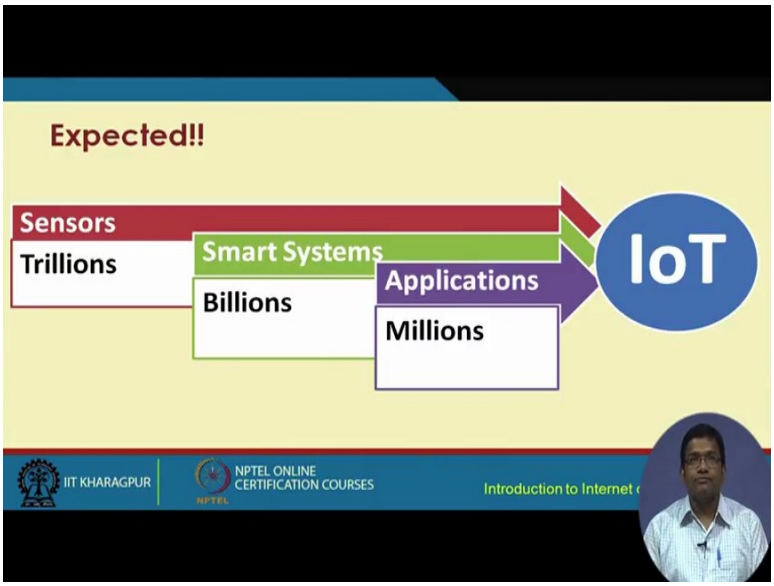

So, what is expected in order to build IoT is to have trillions of sensors, billions of smart systems, millions of applications, all of which are going to be internetwork. They are going to be made synchronously operated in order to form, in order to build IoT.

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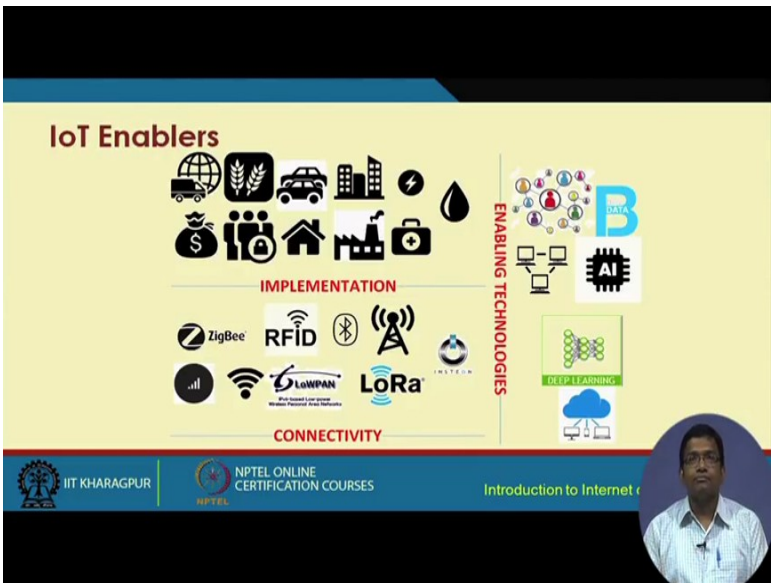

Different enablers of IoT in terms of, in terms of enabling technologies, we have from implementations perspective different technologies, such as you know smart homes, smart factories, and so on. Different sensors can be fitted and then, we also have

different connectivity offering devices such as RFIDs, Zigbee, Wifi, Cellular connectivity, 6 Lowpan, Lora and so on and so forth.

So, different connectivity offering technologies are required and in terms of implementation as I was telling you, factories homes you know banks and transportation sector, agriculture, you know healthcare and so on and so forth, all of these different technologies are required and the other enabling technology is things like big data, deep learning, artificial intelligence, sensor network, regular network, the regular wireless and wired networks. So, all of these are different enablers for buildings IoT.

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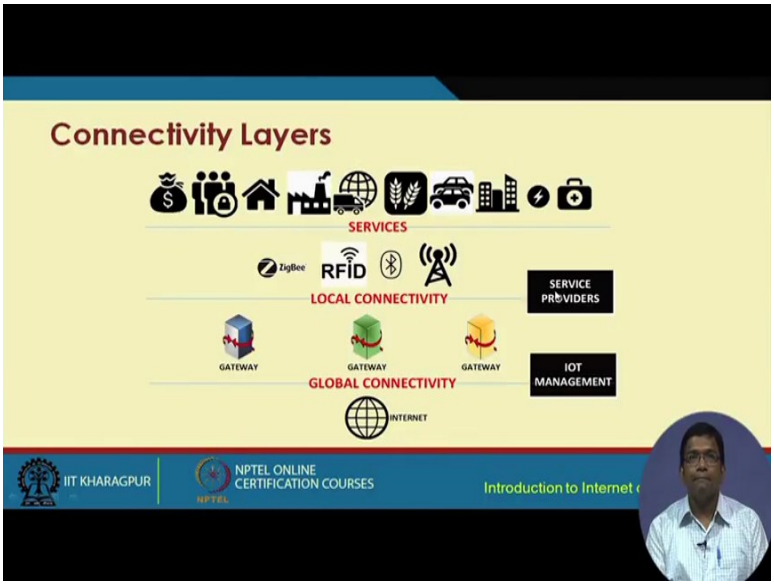

In terms of connectivity, typically there are three layers of connectivity service; service layer, local connectivity and global connectivity. For global connectivity we have the internet, for local connectivity we have components such as the gateway and for service level using different communication technologies, such as these you know different services can be offered to different application areas, such as health care agriculture you know businesses, factories, plants, banks and so on.

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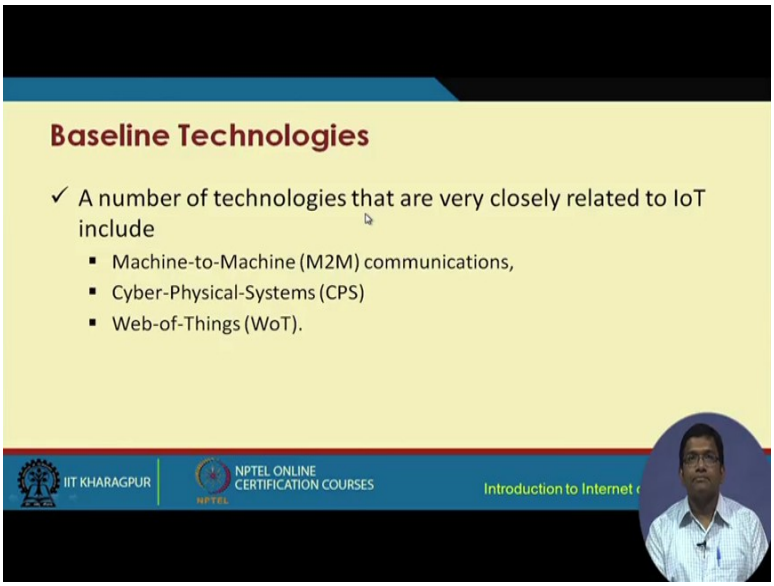

In terms of the baseline technologies, there are quite a few baseline technologies that can be used. Machine to machine communication is one. In machine to machine communication, one machine directly talks to another machine, communicates with another machine without any human intervention. We have the cyber physical systems where the cyber, the physical systems are basically equipped with computer and connectivity computational and connectivity mechanisms.

So, we have a cyber physical system which works hand in hand. Cyber 1, the cyber component of the system works hand in hand with the physical component of the system. So, we have the cyber physical system, we have web of things which is sort of like the web person of the internet of things.

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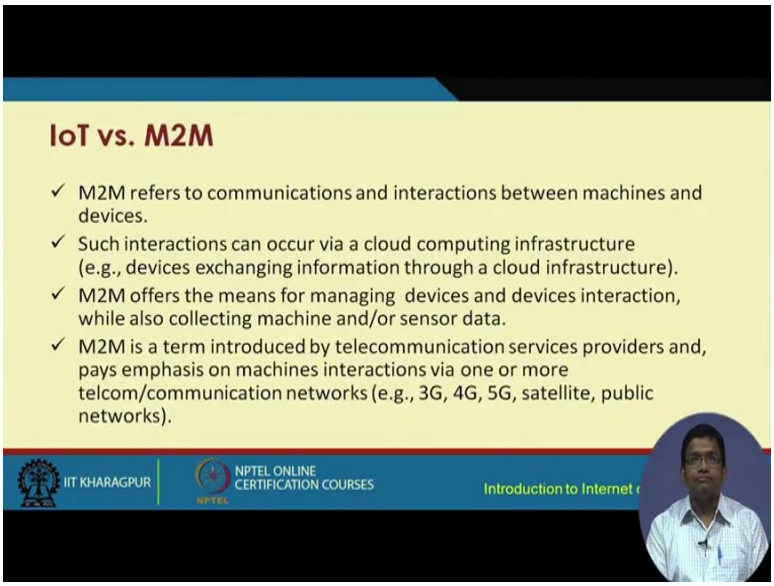

So, IoT and M2M, these go almost hand in hand, but there is a distinction whereas, M2M is just concerned about communication and interaction between two machines or two devices using technologies such as cloud regular internet and so on.

In the case of IoT, IoT the scope is much bigger. So, in IoT we are talking about not only machine to machine communication, but different other things as well.

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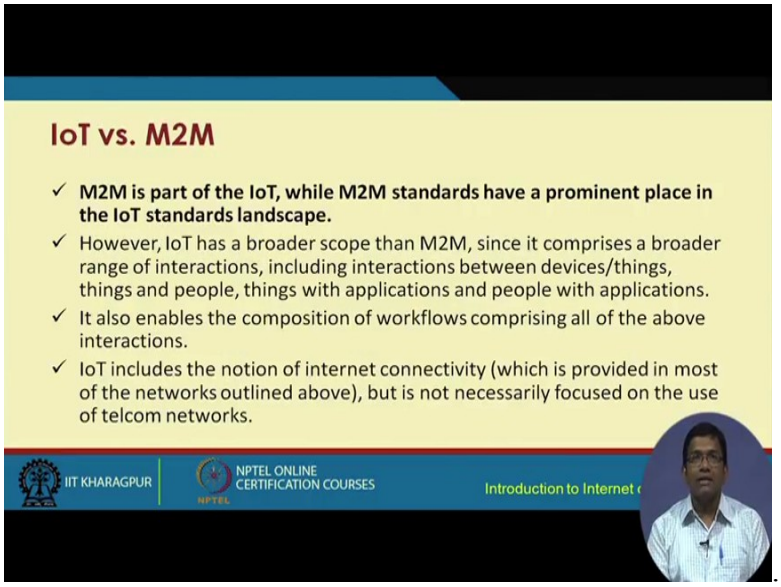

So, M2M can be construed to be a part of IoT while M2M standards have a prominent place in the IoT standard landscape, however IoT has a broader scope than M2M. So, there can be broader range of interactions and not simply machine to machine interaction. They can be interactions between not only machines and machines things and things, but also things and people, things and applications and people with applications.

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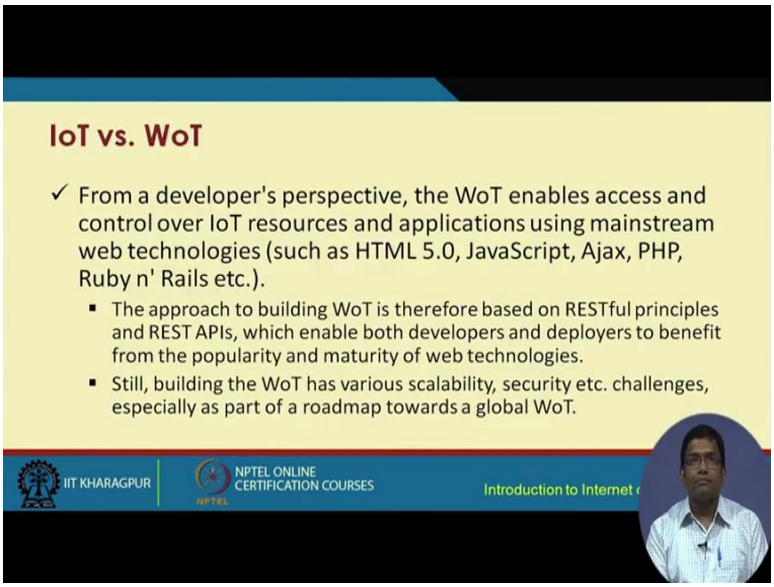

IoT and web of things, internet of things and web of things are often confused to be one and the same, but there is a distinction. The web of things basically focuses more on the use of web based technologies, such as HTML5, JavaScript, Ajax, PHP and so on and so forth.

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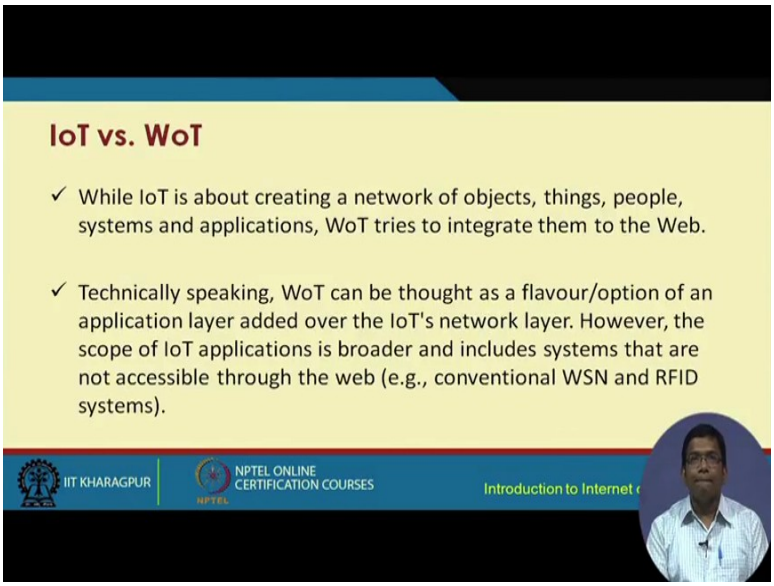

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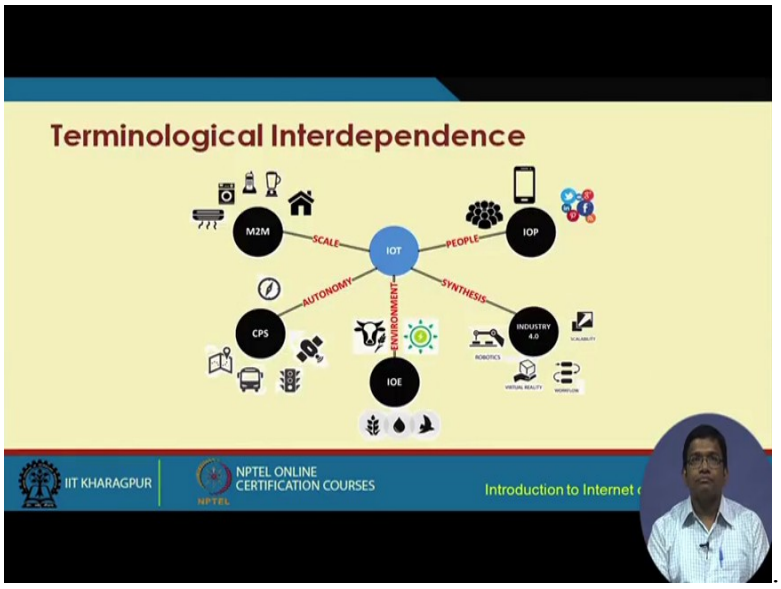

Over the regular IoT to make IoT smarter and web accessible, there are a lot of terminological interdependence when we talk about IoT.

IoT has similarity with internet of people which has a people focus IOP from IoT different using IoT different industry oriented machines and so on can be controlled. So, we have smart factories, you know smart factories using a robots virtual reality and so on. One can have industry 4.0 which is an approach to the modern day mechanization or improvement of the current day plans and industries.

Internet of environment is another. We have CPS which is basically the Cyber Physical Systems, where these systems basically autonomously they operate and they can in fact in an IoT world what can happen is these CPS systems, these different CPS systems, they can be internetwork together in this particular internet. That means, the internet of things we have M2M machine to machine communication.

I already mentioned to you maybe what can happen in a smart home machines, such as the lighting system can talk to the cooling system directly, the cooling system can talk to, can communicate with the fans directly, the fans can communicate with a mobile phone directly or the mobile phone can communicate with a fan directly. So, as you can see that between two different machines, without any human intervention, you know communication can take place and this is known as M2M.

So, with this we come to an end of this particular lecture and we are going to continue with the introduction in the next part of the lecture as well. So far what we have understood are the basics of internet of things, the motivation behind internet of things, the different application areas, the different main points, the challenges that are involved and what we are envisioning when we are talking about building internet of things in the future.

Thank you.