E-Business.
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Lecture-42.
Sensors and IOT: Traceability Across The Supply Chain.

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Welcome back, next technology which helps in complete traceability of the supply chain which is beyond GPS, GIS and only RFID are sensors and IOT, Internet of things. In fact your RFIDs also come under IOT but we are talking them as a special case because they have become extremely important in case of supply chain. So now they are going to learn about these fundamental concepts related to sensors and IOT and their applications in supply chain traceability and why this traceability is important.

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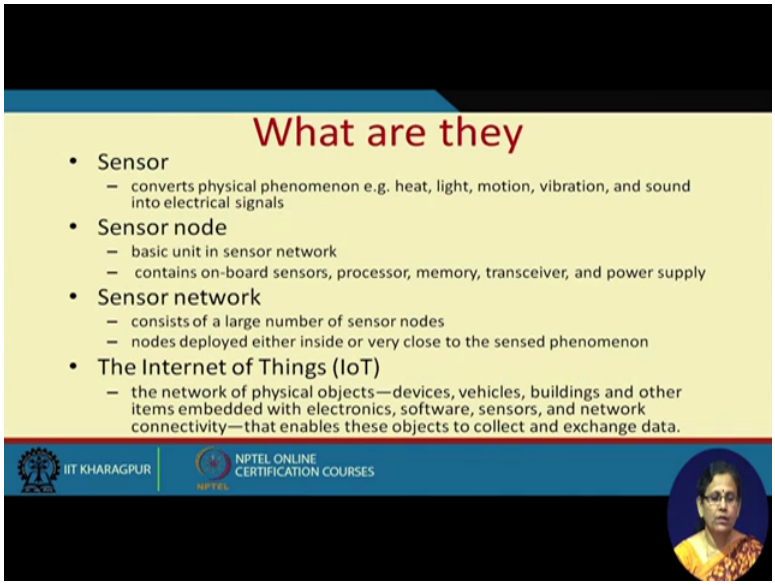

Now let us try to understand what the sensors are. The sensors convert the physical phenomena like heat, light, motion, vibration and sound into electric signals. And what is a sensor node, a sensor node is the basic unit in a sensor network, it contains on-board sensors, processors, memory, transceiver and power supply. And a sensor network consists of large number of sensor nodes, these nodes are deployed either inside or very close to the sensed phenomena. Next is the, next thing we need to know is the Internet of things, it is the network of physical objects, devices, vehicles, buildings and other items embedded with electronics, software, sensors and network connectivity that enable these objects to connect and exchange data.

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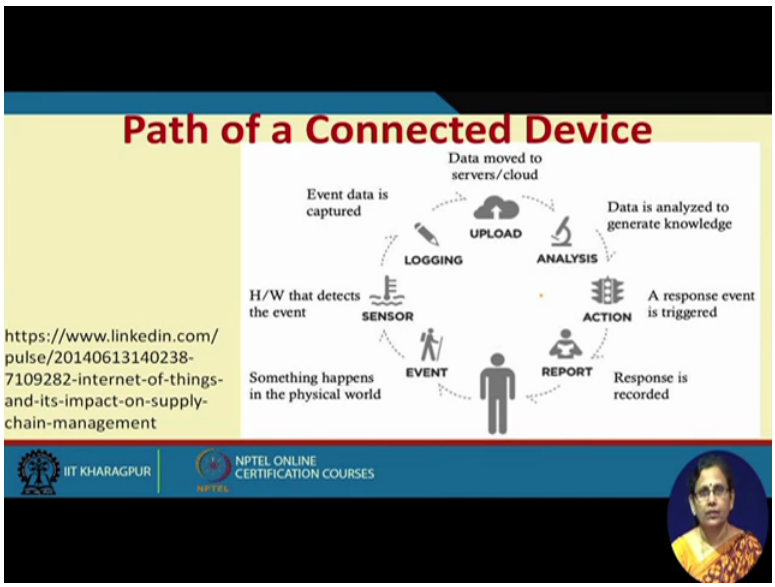

With these basic ideas on what sensors and Internet of things are, let us try to see how exactly these sensors and IOTs can connect the devices and make the machines communicate with humans. Think of this cycle, suppose a human is attached with a sensor which detects its weather, detects its lets say a hub, whether human is falling down or not. This data, these sensors will be now attached with some kind of Internet of things or IOT device which will be logging the data and uploading it into the cloud.

Next this data is analysed to generate some knowledge and finally based on that knowledge some response event can be tracked. For example somebody is running and had a fall, the response event would be, immediately send some assistance to the person. Let us say he is, the person is hiking, there is a group of people who are actually gone for hiking. So in case one of them had a fall, you should be immediately sending a helicopter for rescuing the person possibly. Then based on that it can also generate the report of those events which is in human readable form, this makes the whole cycle.

Now cycle of IOT and sensors and how they can help and how they can connect to physical world to Computerworld and back to the physical world, these are called cyber physical systems as well. Now we would like to see how exactly they help in the supply chain but before that let us try to formally see what IOT is, Internet of things is.

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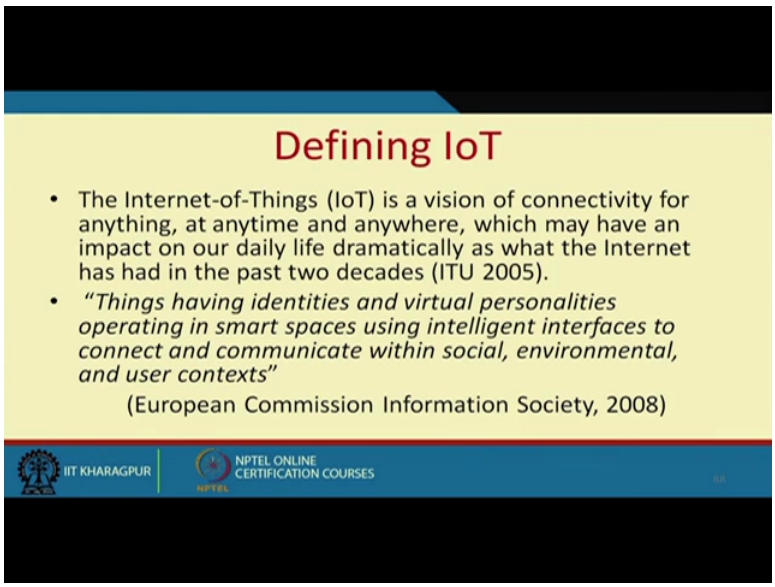

The Internet of things is a vision of connectivity for anything at anytime and anywhere, which may have an impact on our daily life dramatically as what the Internet has had in the past 2 decades. Again with another definition from European commission information society

says that things having identities and virtual personalities operating a smart spaces using intelligent interfaces to connect and communicate with social, environmental and user contexts. Very complex definition, and let us try to simplify it.

Internet of things, so which means anything having Internet connectivity. Typically you have Internet connectivity with your computer, your laptop, your mobile, etc. but now connectivity can be, so why do you have connectivity to them because all these devices have some IP address, so that the data packets with the corresponding IP address can be sent and they in turn can send back some packets, data packets. So in a network identifying uniquely each device is necessary. Now while talking about while talking about your Internet protocol and IP addresses, we were talking about that IP addresses, the older one is IPV 4 and the more recent one is IPV 6.

In IPV 4, we had four 8-bit codes but in case of IPV 6 we have 6 such 8-bit codes, with this, the number of IP addresses, with this new IPV 6, the number of IP addresses, the unique IP addresses have tremendously increased. As a result it is now possible, it has increased so much that within every square feet on the earth you can have at least one or 2 Internet connections and keep something for beyond the Earth as well. Keeping this thing aside, if you have so many Internet connections, which means so many unique IP's are now possible, what do you do with these unique IP's?

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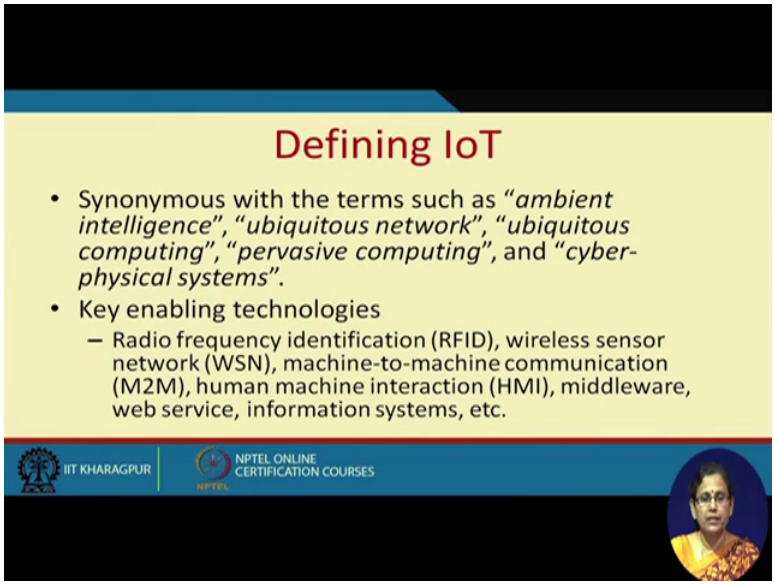

Now this concept of ubiquitous computing, pervasive computing, etc., which means computing everywhere are the phenomena resulting because of IOT. So these terms such as

ambient intelligence, ubiquitous network, ubiquitous computing, pervasive computing, cyber physical systems, all these are in fact outcomes, not outcomes, they are synonymous with IOT. And what are various enabling technologies for these, RFID where along with, let us say with active RFID has a port of its own.

Or in fact RF, you can have a better device where along with the RFID instead of only the passive tag, you should be able to get the data from the passive tag through the reader, reader has a port again IP, it has an IP address. So this RFID wireless sensor network, machine to machine communication, M2M, that is your cyber physical system, human machine interaction, middleware, Web services are, information systems of course are all the enabling technologies, key technologies for implementation of Internet of things.

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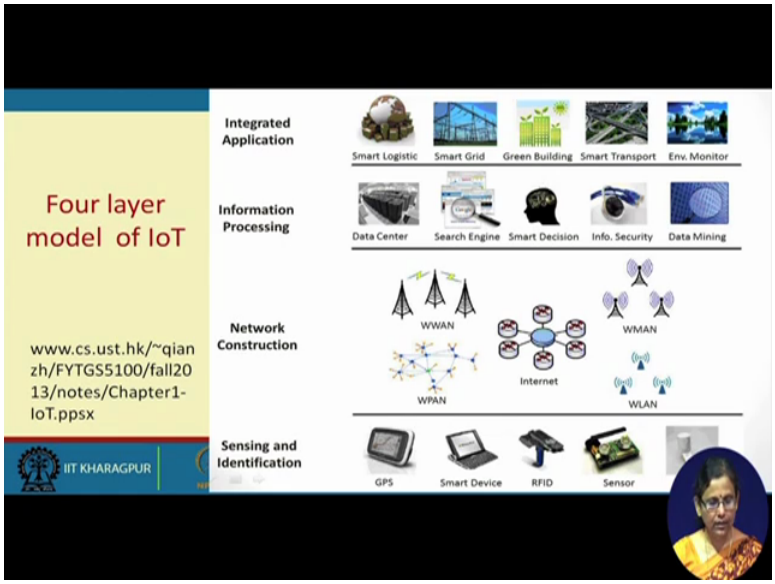

Now we look at the 4 layer models of IOT. Let us try to see the 4 layers of IOT infrastructure. The 1st layer you have the sensing and identification devices, you have sensors, you have RFID , tags and readers, then you have other smart devices and GPS devices and so on. So whatever we have studied so far are the lower level of sensing and identification. Then the signal has to be sent, once the signal is collected, objects are identified, it has to be sent, it has to be said over a network. So this network can be Internet, this can be wireless LAN, wireless WAN and so on, all these wireless networks.

After this, where this data will go? Data is generated, data is transmitted, where, where it is getting transmitted? It has to be transmitted to some place where it has to be stored. So the generic name for this is actually cloud. Once the data is stored in the cloud, in some

datacentre some information processing has to happen on this. Your search engines, various types of information security, data mining algorithms has to run on this to provide a solution to many integrated applications like that of smart logistics, smart grid, about green building, about smart transportations, about environmental monitoring and so on. So this is the whole framework of Internet of things.

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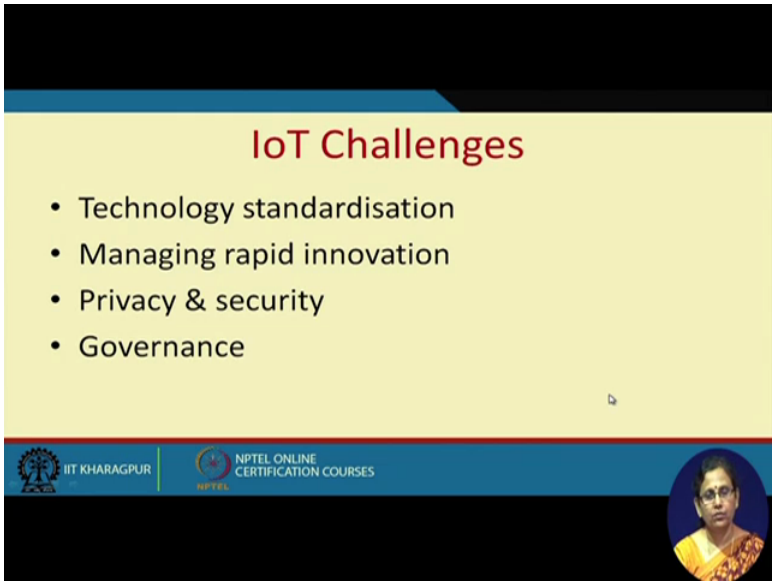

So there are many challenges for IOT, 1st of all is the technology standardisation which is yet to happen. Now because the technology is moving so fast, managing the, and IOT is almost now everywhere. We were discussing about the supply chain, transport chain, etc. but no, it is everywhere, it is in environment monitoring, it is in health care and so on. So to manage this rapid innovation, no framework is so far available. And now look this is what they are doing, these devices are collecting data, they are sending through wireless LAN, it is getting stored in the data centre.

What if this data is, let us say somebody's healthcare data is going, what if some intruder is getting this data, what if the datacentre misuses this data? So the next concerned is about the privacy and security of the data. Next there is no infrastructure from the government side to manage those devices. So there is lack of governance infrastructure. So with this let us move to the real topic of our discussion, that is how to use these technologies for supply chain tracking and traceability.

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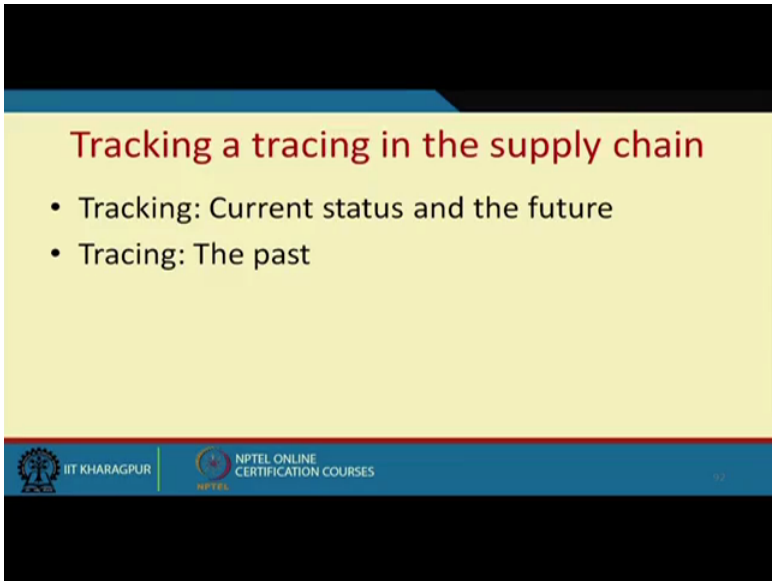

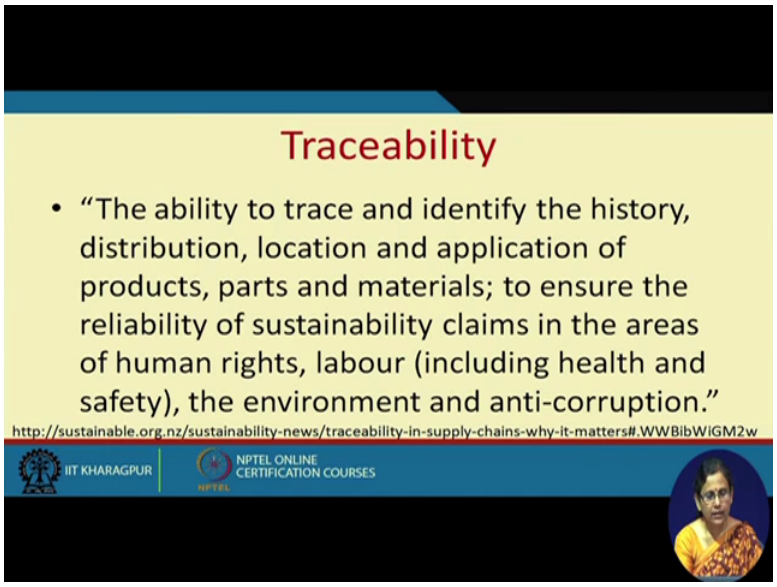

In fact so far we have been talking about the tracking part. What is tracking, it is knowing about the current status or the future. Where is my vehicle right now, where are my items in the store, when I am going to get I am in the stockouts, when the stock out is going to happen based on the current it and so on. But knowing these events currently and what will happen in the future by forecasting or so, solve one set of problem, but what happens if you get a product.

Recall what happened in the food supply chain, you got a complaint that the item which are in your store have already become stale in spite of their expiry date being there, you need to trace back to look at the past what has happened to that item. So while tracking is about knowing the current status and somewhat predicting about the future, tracing is about

knowing the past. So what is traceability in the context of supply chain? It is the ability to trace and identify the history, distribution, location and application of products, parts and materials; to ensure the reliability of sustainability claims in the areas of human rights, labour including health and safety, the environment and anticorruption.

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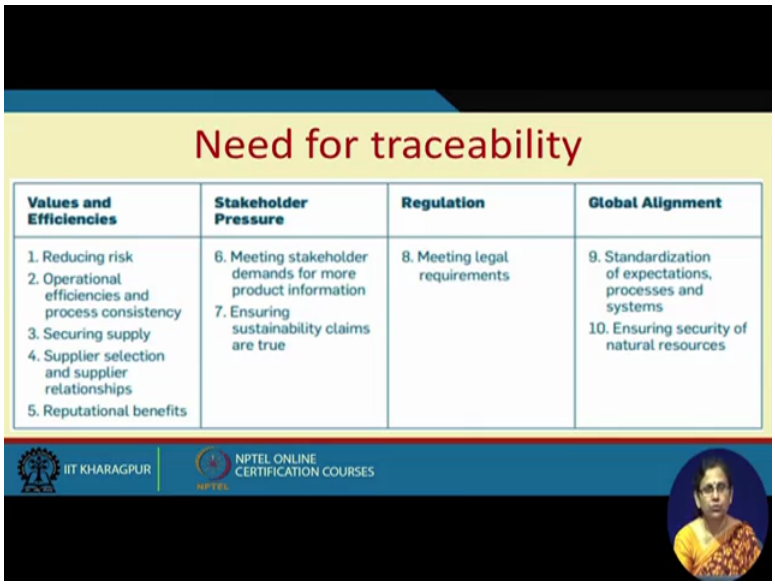

So knowing about the past data, what has happened to your product in the past is also extremely important. So these are few a few points which goes for traceability, it is for creating value and improving efficiency in your process, it reduces risk, it increases operational efficiency and brings in process consistency, it makes sure that your supply is secure and supply selection and supply relationship is fair, it helps in keeping your reputation intact.

In fact you can tell that what happened to your product, what has, what is the past of your, how exactly are product has come to your customer, you may get customer's loyalty, because they know that you care for them. Then there is a need for the traceability because of stakeholders' pressure. These consumers, they can, if they do not have enough information about the products they are using, they may take legal action. So meeting customer demand for more product information, ensuring accessibility claims that you are doing are true are some of the results for having traceability.

Now regulation, meeting the legal requirement, if the government wants your product to be traceable, you have to maintain a traceability infrastructure. Global alignment, in order to have your export import possible, you have to be going by the global standardisation, so if it

is required, if there is an expectation from your business partner about the traceability, so you have to maintain. So the standardisation of expectations and processes and systems is another reason. Then traceability as the consumers are becoming more more concerned about the natural resources, traceability information assures them that natural resources are secure because of your product.

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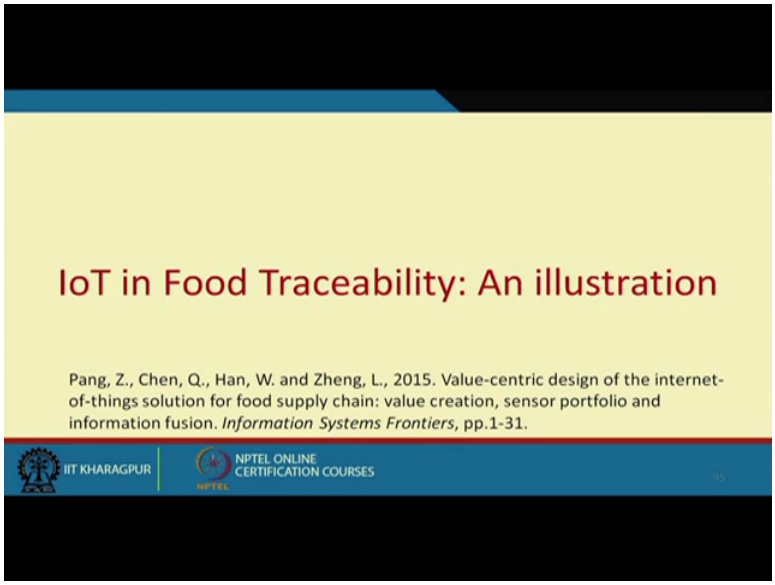

Now we will be looking at one example problem which illustrates this use of IOT in food traceability. In fact most of this will be taking up from this Pang's et al's paper. In fact throughout this lecture we have discussed, I have referred many Internet material as well as research papers which very lucidly explains the idea and which of course I am trying to give at a very high-level without going into details of the technologies and the analytical things explaining much, because this course is about knowing the technology and how to use the technologies. I am not going into analysis part but if you refer those materials that I have discussed in the past, you can get better insights.

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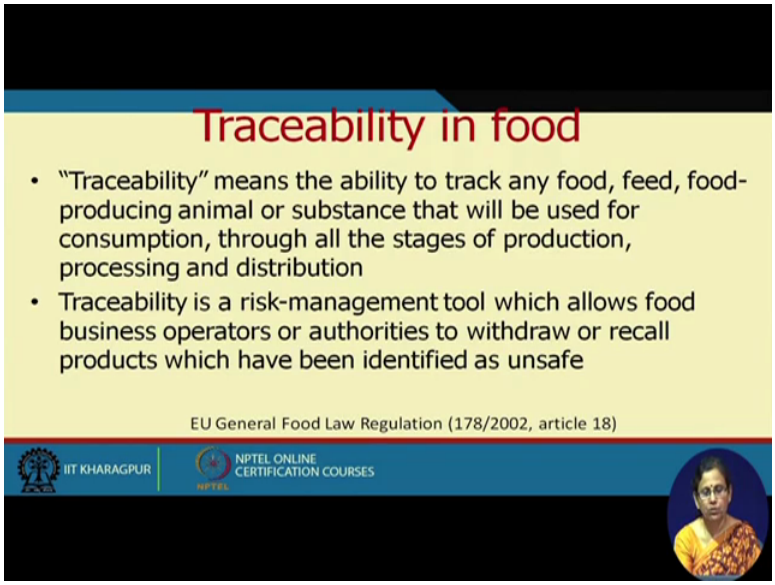

Now coming to traceability in food supply chain, traceability means the ability to track any food, feed, food producing animal or substance that will be used for consumption, through all the stages of production, processing and distribution. Traceability in fact is a risk management tool which allows food business operators or authorities to withdraw or recall products which have been identified as unsafe. This is the definition by European Union general food law regulation. In fact throughout the world, now people are very concerned about the traceability of food supply chain.

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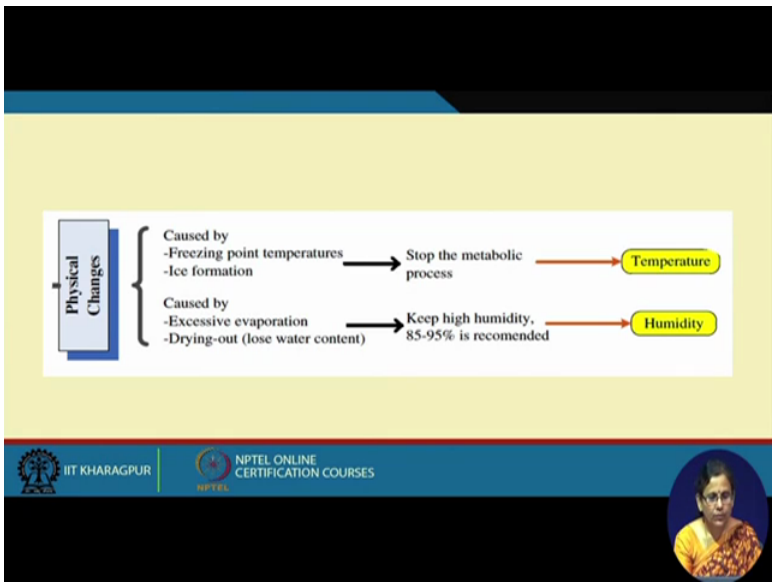

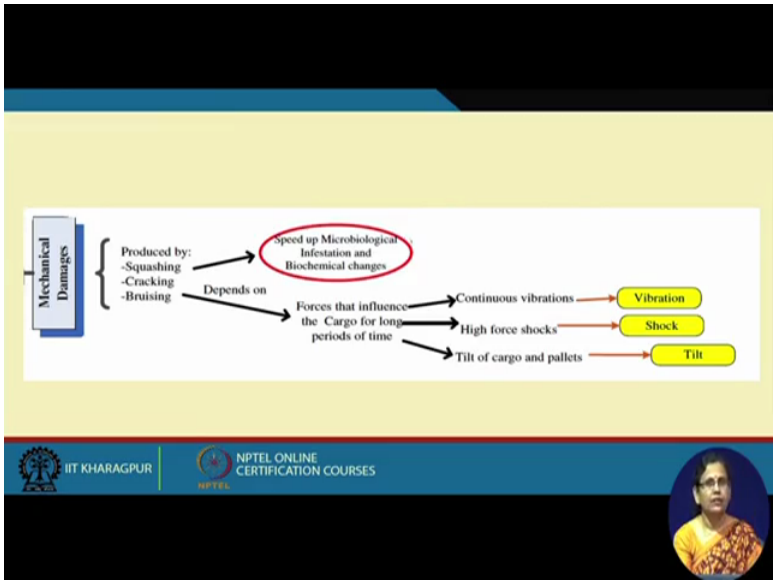

In fact in the food, the contamination can happen at any stage. There can be physical changes which are caused by, in fact we are going to discuss about a cold chain, we were discussing about a cold chain, traceability in a gold chain that I forgot to tell you earlier. So about the freezing point temperature, ice formation which stops the metabolic process, so you need to monitor temperature. The physical changes can be caused by excessive evaporation, drying out, so which means you have to keep hide the humidity.

So which means if you will not in this food chain, you are trying to keep track of the physical changes that has happened to the food item, you need to collect temperature and humidity data. How will you collect? You have to now attach sensors to the items which are travelling through the supply chain to monitor this temperature and humidity over the Internet. What other changes can happen? Now the food supplies are coming through different vehicles, during transportation, many things can, many mechanical damages can happen.

It can be produced by squashing, cracking or bruising the item, which in turn speeds up the microbiological infestations and biochemical changes. It also depends upon the forces that influence the cargo for long period of time continuous vibration, high force, shocks, tilt of cargo or pallets. So you need again this allowance, you need a vibration measurement sensor, a shock sensor, tilt sensor and so on. So if the food is spoiled at the end, by understanding the readings of this, past readings of these sensors, you can actually trace out what is the exact problem because of which the spoilage has happened.

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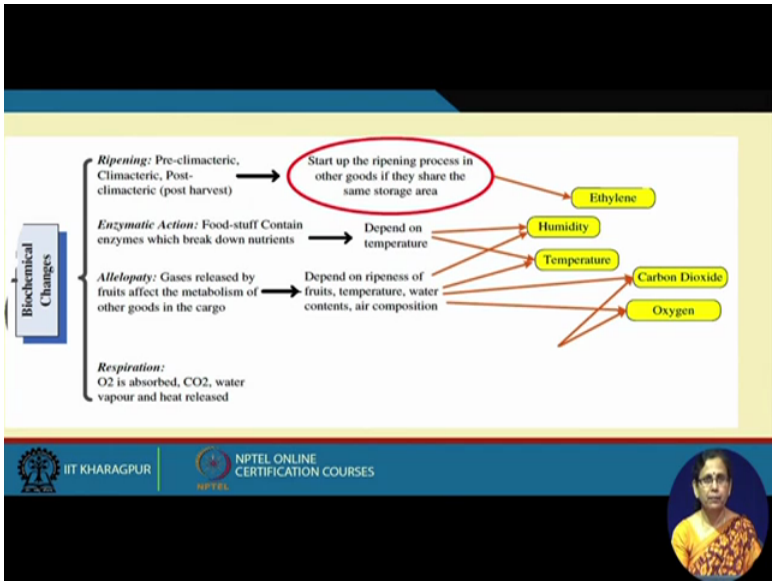

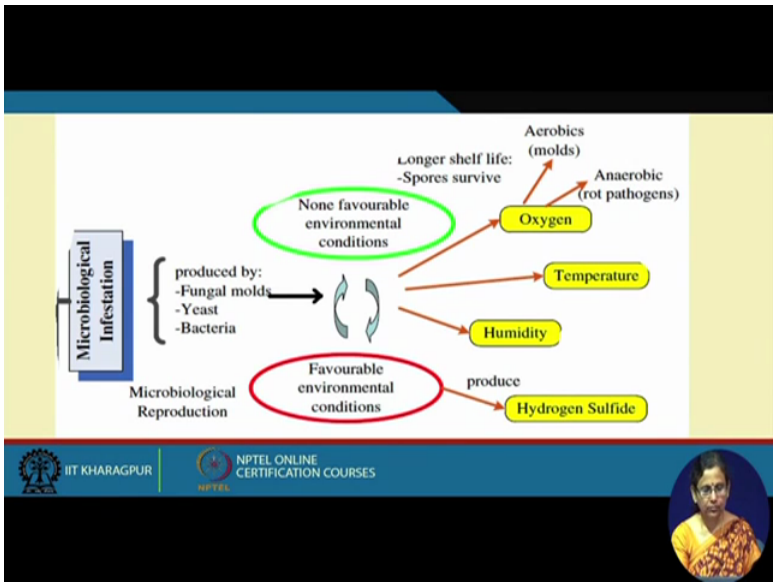

It can be because of biochemical changes like ripening, enzymatic actions, Allelopathy, respiration and so on. We are not going into the details of all this, you can read it out, but here again you need to monitor oxygen level, carbon dioxide level, ethylene level, humidity and temperature. For everything, all these you can have sensors to monitor. The change can happen at microbiological infestation, because of microbiological infestation like because of fungal molds, yeast and bacteria. And to observe that, again you need various kinds of sensors like oxygen sensor, temperature sensor, humidity sensor, hydrogen sulphide sensor and so on.

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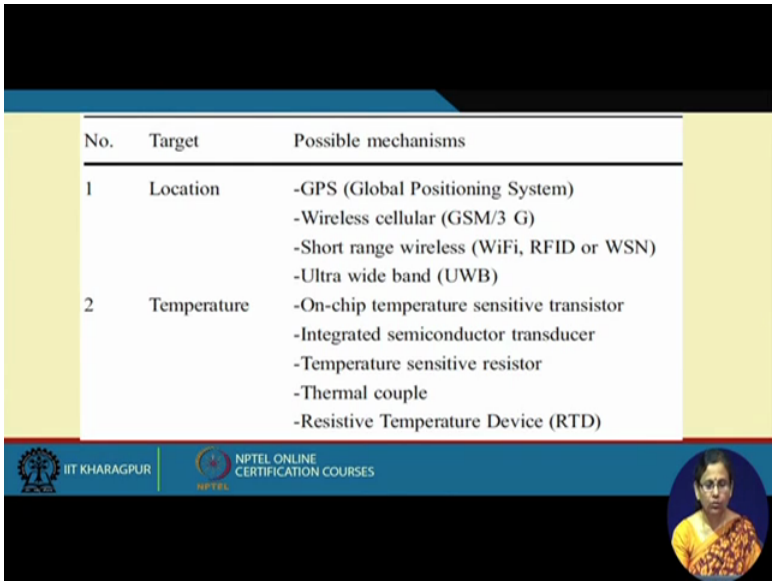

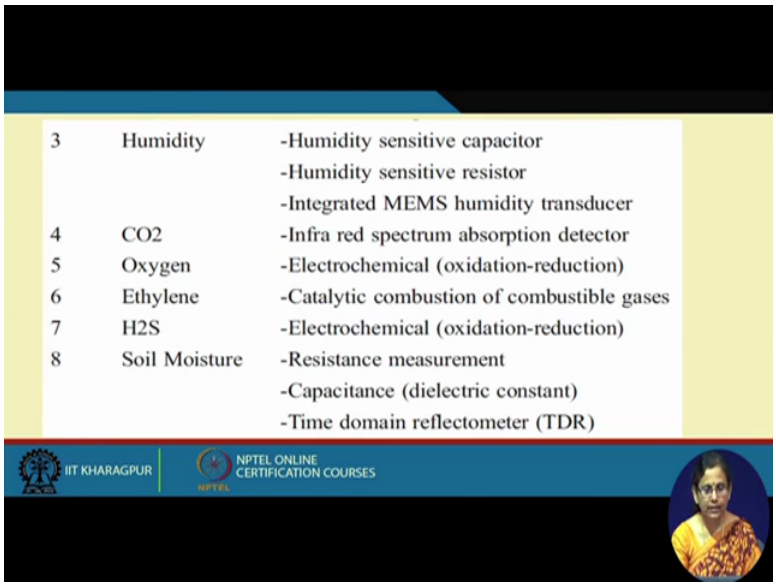

Now look, here is a list of the mechanisms by which you can collect the data, you can collect the data by GPS, Wireless cellular network, and within a short small area like that of warehouse etc., you can use RFID, Wi-Fi and wireless sensor network in combination and Ultra wideband can give you that. Then temperature, you can have on-chip temperature sensitive transistors, you can integrate the semiconductor transducers, temperature sensitive resistors, thermal couple, resistive temperature device and so on.

Similarly for a military there are certain sensors carbon dioxide, oxygen, ethylene, hydrogen sulphide, soil moisture, for everything, sensors exist. It is not important to know what will happen but it is important to know here as information scientist that information can be collected through sensors and sensors do exist.

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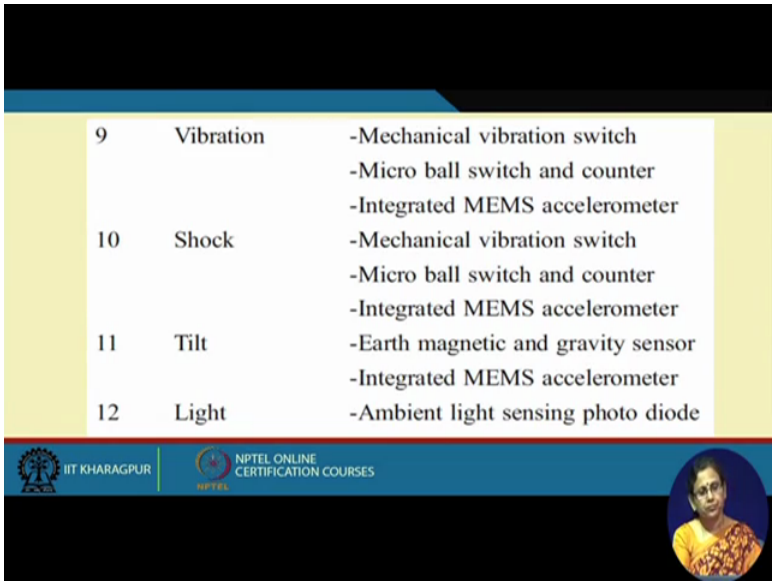

So therefore it includes also vibration, shock, tilt, light, etc. So therefore across the supply chain if you take help of these sensors and you have IOT devices with sensors, you will be able to collect this data. Sensors change the physical phenomena to electrical signal, that is fine, but sending this electric signal to a common data repository is equally important. Not equally important, it is the important thing for traceability.

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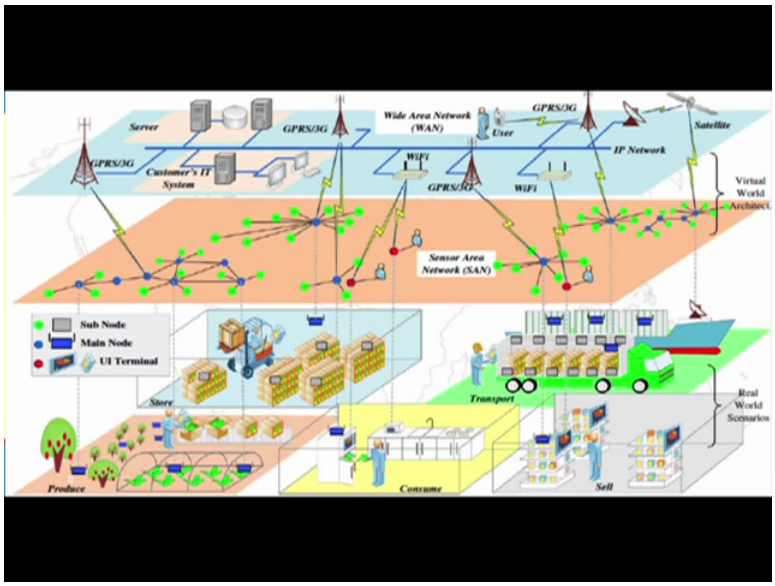

Now look at this world, here the authors have beautifully made a translation of physical world scenario to virtual world architecture. In fact in the physical world you have starting from your, we are talking about the food chain, right, tracking, at the time of your production, starting from soil, health, etc., you can have the sensor data. Okay. This sensor data can be

collected through IOT devices, sent over the Wireless network through some through GPRS technology and stored in some centralised server and centralised cloud in the cloud.

So also during transportation, after production it is stored, what is happening in the store, how temperature variation is happening, etc., can also be, that data also goes. Then transportation happens, vibration, tilting, everything, whatever happens, there will be sensors, data will be collected and sent back. And finally at the selling point, again there can be temperature variation and so on. So when a consumer comes to your store, if this entire traceability data is available, not only he will depend on, if at all he has any doubt about the expiry of the product, about the condition of the product, he himself can visualize the whole thing.

In fact supply chain visualisation is a very important phenomena. The, all the data that you collect, at the end of the day, what happens to this data? Data is in such huge amount, they come in such huge amount, without proper visualisation tool, it is extremely difficult to know, to understand what this data tells. Then again for using this data, you need to have right infrastructure because the data is huge, sensors, these IOT devices, every millisecond, your RFID tags, every milliseconds they will be, your GPS, every milliseconds they will be sending the signal.

How do you keep this signal, where do you keep this signal, how do you use this signal, that itself is a big challenge. However this data from every entity is collected through some network and sent over some GPRS or some kind of 3G network to some centralised server. Some data even comes from satellite when you transport the items, every data will be stored together. Now the fusion of this data and creating some understandable, generating knowledge of it and using it for decision-making is the next challenge of business decisions. So with this we finish this lecture and next class we are going to look more on various types of data and how to use them. Thank you very much.