

Introduction to Industry 4.0 and Industrial Internet of Things
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Lecture - 53
IHOT Applications: Facility Management

In this particular lecture, we are going to focus on the application of IIoT for inventory management and quality control. Conceptually, whatever we have discussed about the implementation of IIoT in the previous application domains, those concepts will not change. We are going to still borrow, those concepts that we have understood, the technologies that we have understood are core two IIoT. Those core IIoT technologies we are still going to borrow over here as well, but we are going to relook at it from the different angle from an inventory management and control viewpoint.

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Inventory Management

- Inventory
 - "a usable but idle resource having some economic value"*
 - [P. Vrat, Materials Management]
- Inventory Management
 - Activities entailing management of inventory such as:
 - Controlling, overseeing and ordering
 - Storage
 - Determine supply for sale

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So, think about what is inventory control? So, first of all we need to understand what is inventory? So, in inventory basically the dictionary meaning of it is that inventory is a usable, but idle resource having some economic value. So, it is basically some kind of resource having some economic value that is going to be managed in inventory management.

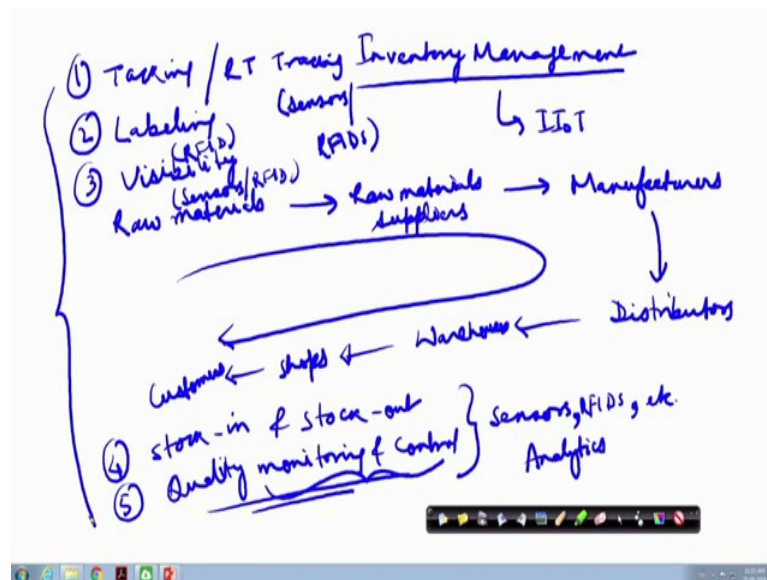
So, some resource typically in a manufacturing industry these manufacturing resources, so these are basically are going to be the inventories and these inventories are going to be

managed they are going to be used to have some value added products, value added services.

So, how you are going to manage this inventory? Inventory management is a huge thing in manufacturing plants is a huge thing there are separate teams which take care of inventory management and their control. So, activities that would entail the management of inventory would include controlling, overseeing, ordering, storage, and then determining the supply for sale.

So, because you do not want to sell anything that is out there right, you need to determine that based on your supply how much you are going to sell; how much you are going to sell? So, determining the optimum sale that can be achieved through the supply; you do not want to even stock the items, it is not like you procure everything stock it up and then you sell as and when it is required not like that, so everything has to be done optimally. So, that is where inventory management and the control of the inventory is required for the overall profitability of the business.

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So, let us look at the different activities in inventory management. So, for inventory management we are typically talking about let us say first starting with raw materials, these raw materials in the supply chain are going to be supplied to the raw materials suppliers, they are going to procure or they are going to get it through some other service party. So, suppliers which are going to be sent to the manufacturers.

So, basically this could be this manufacturing firm which are going to use the raw materials and are going to transform that into different products. So, from this manufacturing plant by the manufacturers these materials are going to be sent to the distributors, the manufactured products from the distributors are going to be may be sent to the warehouses and then to the different retail outlets or shops and finally to the end customers.

So, as you can see this is the whole supply chain; it starts with the raw materials, procurement supply use being delivered to the manufacturers, the manufacturers use those raw materials to produce the goods, then the manufactured goods are then distributed sent to the warehouses finally, to the little shops and then are basically purchased by the customers.

So, in this entire process what are the things that are important? Number 1 is tracking and I would say ideally it should be real time tracking. So, real time tracking if we can have this would be a good feature. Labeling; labeling of these raw materials, labeling of the manufactured goods etc.

So, labeling is important then we can have you know it is very important to have visibility through the entire process visibility of the products, their expiration dates, the item locations where they are stored, where they are stocked forecasting their demands etcetera., so visibility. Then number 4, optimally stocking in and stocking out.

And then it would also be nice to have in this kind of supply chain or inventory management process it would be also nice to have some kind of quality monitoring and control mechanism and like that there are different things that could be achieved.

So, you see that for tracking and particularly real time tracking we can use different sensors or RFIDs, we could use those different devices, for labeling, RFID-based labeling would be attractive then for visibility again this different sensors and even the RFIDs could also be used. Then similarly, for the stocking in and stocking out and also for quality monitoring and control.

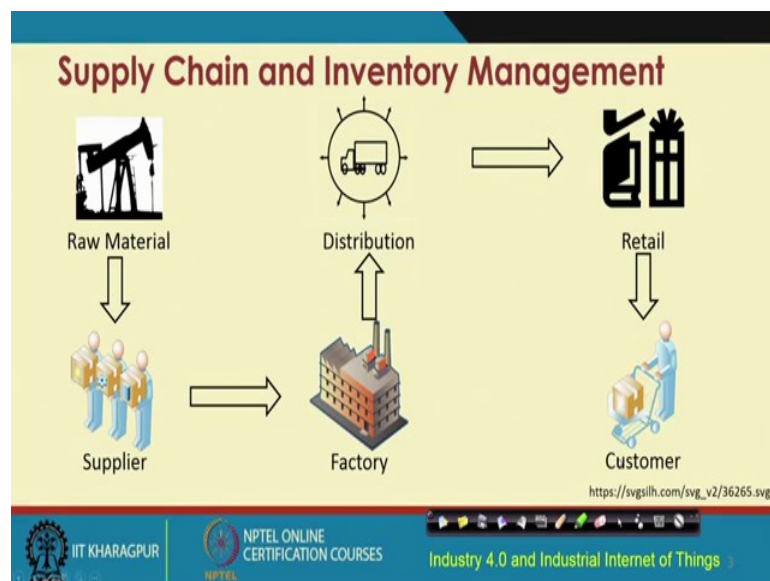
So, stocking in and stocking out and quality monitoring and control here also you could use the sensors RFIDs etcetera, but additionally you should also have particularly for the

monitoring and control part of quality, you should also have the implementation of different analytics, so different analytics engines should be implemented.

So, as you can see this entire process we can automate we can make efficient through the implementation of these different concepts that we have learnt over time through different lectures on IIoT such as sensor, sensor networks, RFIDs, different connectivity technologies because ultimately you need to have this connected system holistic connected system which is going to retrieve the data and this data has to be sent through the network, to the cloud for analytics right.

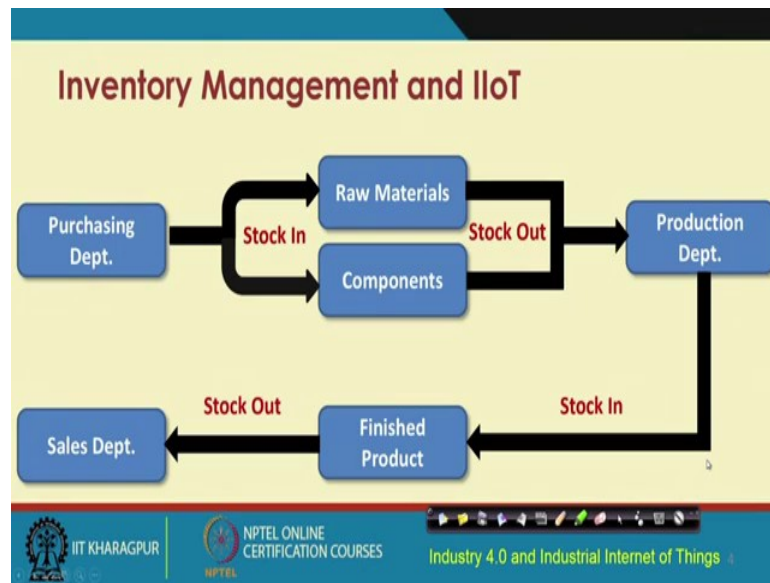
So, this is this inventory management and how we can make it much more efficient through the implementation of IIoT. So, IIoT based inventory management this is what we are going to achieve if we can you know implement it using suitable technologies.

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So, going forward, the supply chain once again is going to take the raw materials, send it to the supplier, goes to the factory, to the distribution centers, to the retailers, the distribution centers basically are going to send the finished goods, that are produced by the factories to the retailers and finally, the customers are going to use it this is this whole supply chain that we have already seen in the inventory management process.

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So, with IIoT all these different things the components that are involved in this inventory management such as, the purchasing department, the raw materials procurement, different other components getting involved there they are stock in of those components etcetera, sending to the production department, finished product, sales department etcetera everything can become connected.

So, the stocking in and stocking out over here, stocking in of the finished goods and stocking out over here of the finished goods. So, all of these things can be done efficiently with the incorporation of IIoT in the inventory management process.

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Functions of Inventory Management

- Meet anticipated demand
- Smoothen the production requirement procedure
- Decouple components of the production-distribution system
- Protection against stock outs
- Proper order cycles
- Hedge against price increases or to take advantage of quantity discounts
- Smoothen the flow of operations

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So, now let us quickly go through some of the functions of inventory management I am not going to elaborate this because these are quite self explanatory. So, the first one is meeting the anticipated demand, smoothing the production requirement procedure, decoupling components of the production distribution system, protecting against stock outs, properly ordering the cycles, hedging against price increases or taking advantage of quantity discounts, smoothing the flow of operations, so all of these are different functions of inventory management. And if we go little deeper down, so with the incorporation of IIoT we can have efficient inventory management through the implementation of all these IIoT devices and systems and applications.

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Requirements for Effective Inventory Management

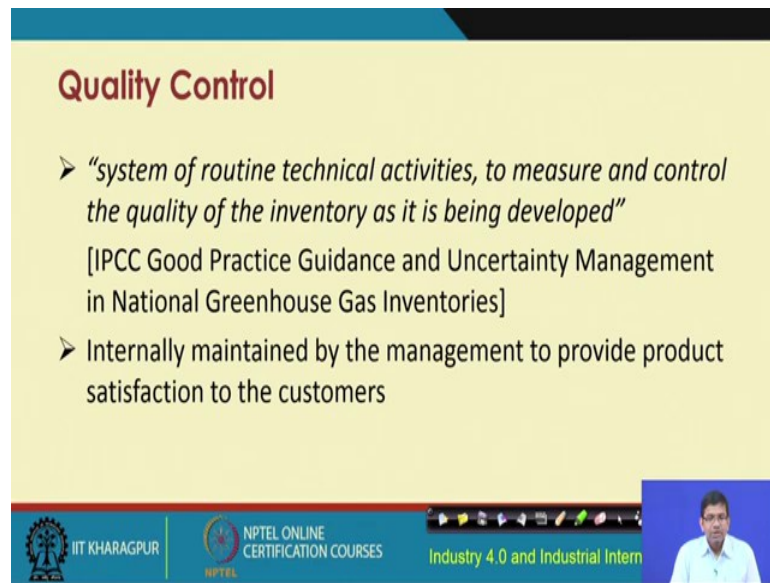
- Keep track of the inventory
- Forecast of demand
- Manage lead times and lead time variability
 - Time between order placement and delivery
- Estimate inventory holding costs, ordering costs, and shortage costs
- Classification of inventories

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So, for effective inventory management it is required to keep track of the inventory, to forecast the demand, to manage the lead times and the lead time variability. So, what is this lead time? So, basically this is this latency that the lag between the placement of the order and the delivery of the order. So, basically managing that particular latency, that particular delay and the variability of that delay is what concerns the lead time.

So, effective inventory management should have effective lead time management, estimating the inventory holding costs, ordering costs, shortage costs etc. and classification of inventories these are the requirements for effective inventory management.

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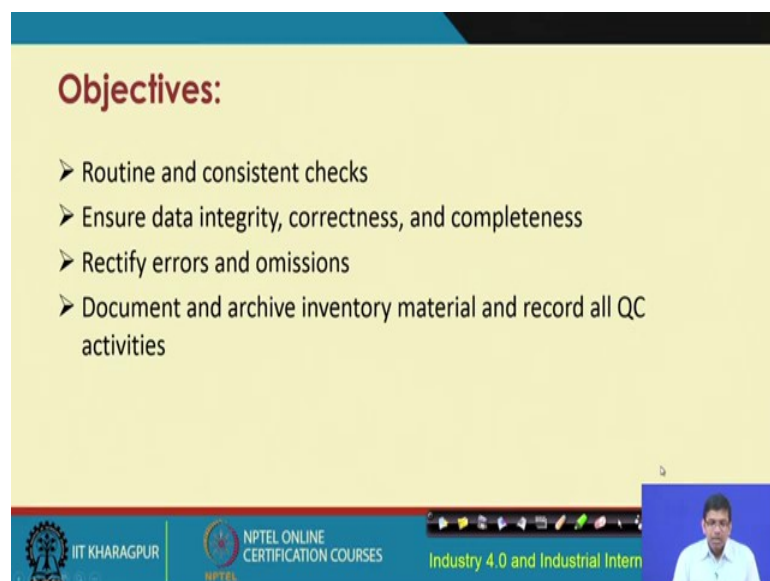
Quality Control

- *“system of routine technical activities, to measure and control the quality of the inventory as it is being developed”*
[IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories]
- Internally maintained by the management to provide product satisfaction to the customers

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Now, let us switch our gear and come to quality control. So, quality is very important; quality of the product quality of the services. So, this quality is important because ultimately we are talking about purchase by the customers and if the customers purchase, but then the customers are not satisfied, then that basically results in the failure of the product that is made, that is manufactured and is delivered. So, quality control of the products quality control of the services is what is very important.

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Objectives:

- Routine and consistent checks
- Ensure data integrity, correctness, and completeness
- Rectify errors and omissions
- Document and archive inventory material and record all QC activities

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So, the objective in quality control is to routinely and consistently make different checks about the standard of the products that are being manufactured or the services that are being offered. Ensuring integrity of the data, correctness of the data, and completeness of the data that is also part of quality control. Rectifying any kind of error any omission incompleteness etcetera these are also part of the objectives of quality control.

And documenting and archiving inventory material and recording all the quality control activities, this documentation recording archiving and so on. These are also very important objectives of quality control; it is not just performing the quality control, but also the proper documentation and archiving of all these different activities data and so on that is also an important objective of quality control.

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Radio Frequency Identification Devices (RFID) tags

- Used in an identification system
- Uses Radio waves for communication
- RFID Tagging system consists of:
 - The RFID tag
 - Read/write device
 - Host System
- Two types:
 - Active RFID tags
 - Passive RFID tags
- Finds scope in data collection, processing, and transmission applications

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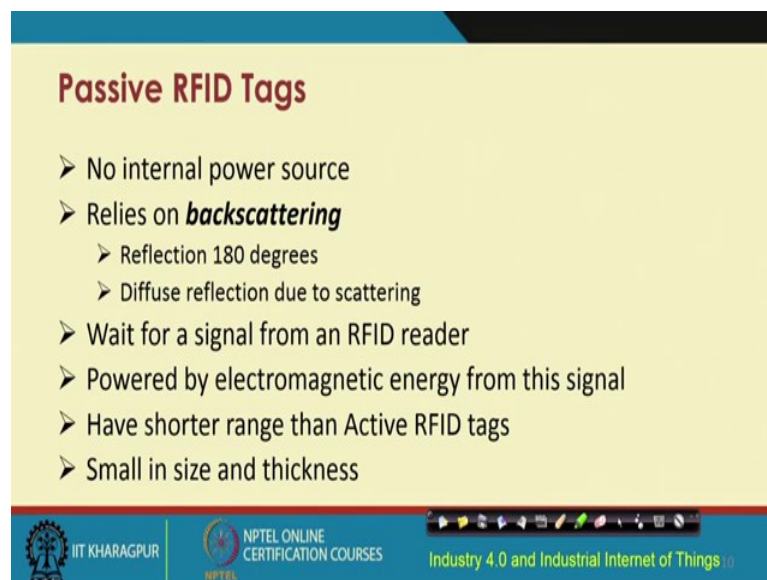
So, now very quickly we will go through as a recap of the technologies that are involved primarily in inventory management and quality control. We have talked about a lot about sensors, connected sensors, networked sensors, and sensor networks. We have talked about a lot in the previous lectures. We have also discussed briefly about the RFIDs. So, RFIDs basically are used heavily in the industry; in the industry for inventory management and control.

So, RFIDs basically will have two components and this is something that we have looked at in a previous lecture on RFIDs in detail. So, there are primarily two components one is the RFID tag which will have different data that are basically embedded or stored in

them and the RFID reader which will come in the close proximity of the RFID tag and would be able to extract out the information that is stored in the RFID device or the RFID tag.

So, RFID uses radio waves for communication. So, in RFID the technology is radio communication technology, so there are radio waves that are communicating and this RFID tagging system will have these different components the RFID tag, the reading or the writing device and the system on which the RFID tagging system is deployed. So, there are two types of RFID tags, the active tag and the passive tag. So, there are two types and these different tags would be able to collect the data which will be further processed and would be sent to the applications that need the processed data.

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Passive RFID Tags

- No internal power source
- Relies on **backscattering**
 - Reflection 180 degrees
 - Diffuse reflection due to scattering
- Wait for a signal from an RFID reader
- Powered by electromagnetic energy from this signal
- Have shorter range than Active RFID tags
- Small in size and thickness

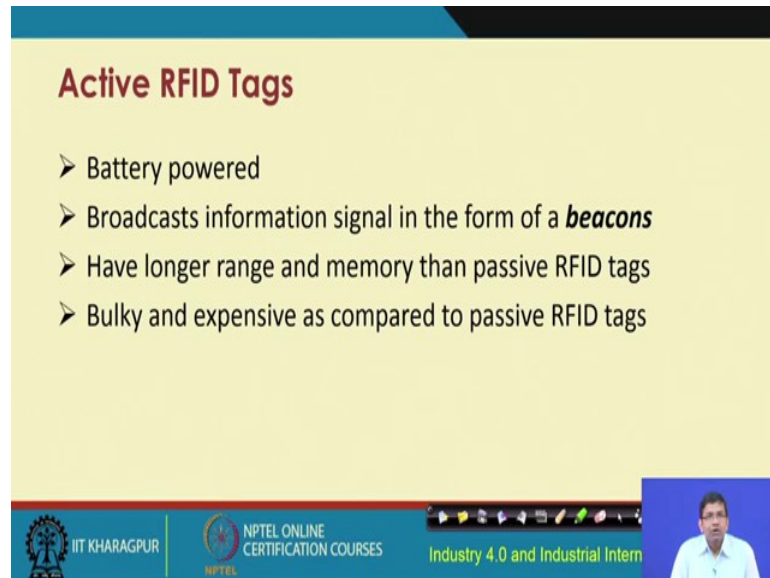
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So, passive RFID tags do not require any internal power source, these tags basically work on the principle of backscattering. So, backscattering in communication basically talks about getting certain signals on the rays or the electromagnetic waves and these waves are going to get reflected back 180 degrees. So, basically what is happening is some kind of diffuse reflection that is going to happen due to the scattering and the back scattering.

So, the reader basically will wait for a signal from these tags and basically as I said that these tags do not have any internal power source and they are basically powered by electromagnetic energy from this backscattered signal. So, they are small in size and also

very thin in terms of thickness. So, basically it's the chip that is embedded in these tags that makes the entire mechanism function.

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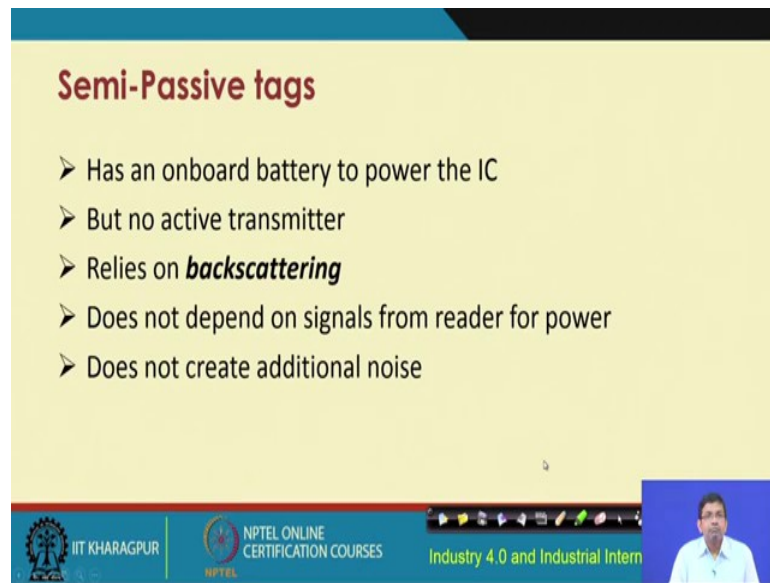
Active RFID Tags

- Battery powered
- Broadcasts information signal in the form of a *beacons*
- Have longer range and memory than passive RFID tags
- Bulky and expensive as compared to passive RFID tags

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In active RFID tags on the contrary we have separate battery units, power units that can power these tags. So, these active tags would broadcast the information signal in the form of beacons and they have longer range and memory than the passive RFID tags that I discussed previously. So, these active RFID tags compared to the passive ones are much more expensive, much more bulky and are not as much portable as the passive RFID tags.

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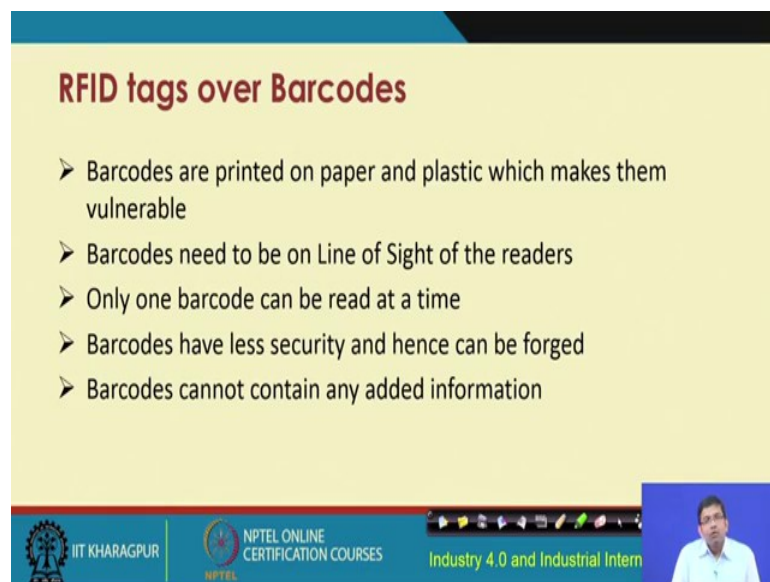
Semi-Passive tags

- Has an onboard battery to power the IC
- But no active transmitter
- Relies on **backscattering**
- Does not depend on signals from reader for power
- Does not create additional noise

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So, there are semi passive tags as well which has an onboard battery to power the IC, that is inside these tags and there is no active transmitter, but this mechanism also relies on backscattering concept that I discussed previously for the passive RFID tags.

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RFID tags over Barcodes

- Barcodes are printed on paper and plastic which makes them vulnerable
- Barcodes need to be on Line of Sight of the readers
- Only one barcode can be read at a time
- Barcodes have less security and hence can be forged
- Barcodes cannot contain any added information

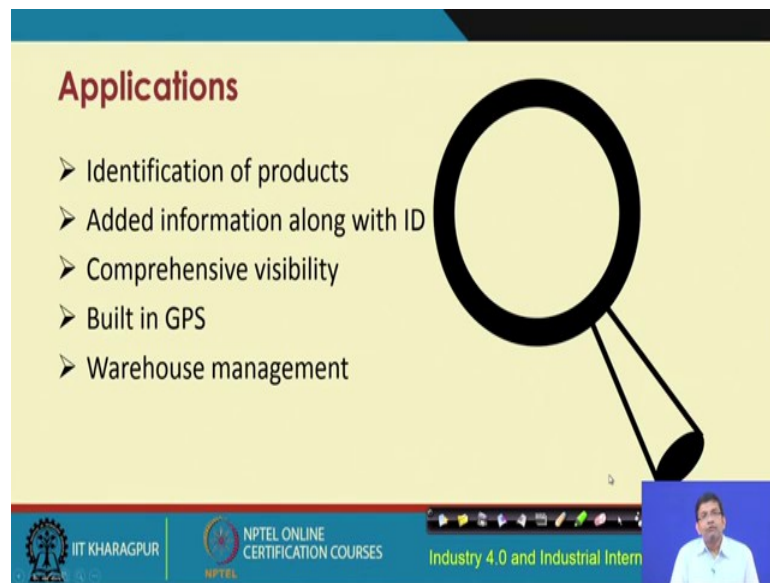
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So, compared to RFIDs, bar coding mechanisms could also be used, both RFID tags and barcodes they could also be used but RFID tags over barcodes is something that is very interesting. These barcodes are basically printed on some device some goods may be paper or whatever paper or plastic and etc. So, barcodes need to be on the line of sight of

these RFID readers and only one barcode at a time can be read and these barcodes have less security and hence can be forced.

So, barcodes cannot contain any added information beyond what is actually encoded in these codes. So, RFID tags over barcodes is a mechanism that is popularly used, but is not the only mechanic; this is an alternative way of basically using these RFIDs.

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Applications

- Identification of products
- Added information along with ID
- Comprehensive visibility
- Built in GPS
- Warehouse management

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There are different applications of RFIDs in the inventory management and control process. So, basically identification of the products; products that are shelved in the warehouses, in the management of the warehouses, then adding information along with the ID, then having comprehensive visibility of the different products that different stocked items, shelved items and so on. These are some of these different applications of the use of RFIDs in inventory management and control.

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Applications (contd.)

- Added information along with ID:
 - Current storage temperature
 - Weather condition
 - Damage (if any)
 - etc

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There are other different applications such as, weather condition monitoring, damage assessment, storage temperature monitoring and control; these are also the different other applications of use of IIoT applications in inventory management and control application.

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Applications (contd.)

- Comprehensive Visibility
 - Inventory levels
 - Expiration dates
 - Item location
 - Forecast demand
 - etc

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Getting comprehensive visibility, inventory levels, getting idea about the expiration dates, item locations, then about the demand forecasting. So, basically if in the future if you are going to get some more demands than what how much is the stock? So, demand

forecasting, so these are some of these different other applications of the use of IIoT in the inventory management and control sector and particularly using RFIDs.

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Applications (contd.)

- Warehouse management
 - Shrink, Shortage, Overstock of commodities
 - Identification of efficient areas based on demand

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Similarly, warehouse management, shrinking of the stocked items, shortage overstock of commodities, and identification of efficient areas based on demand. So, these are also the different other applications of use of RFIDs for IIoT implementation in an inventory management application in a smart factory.

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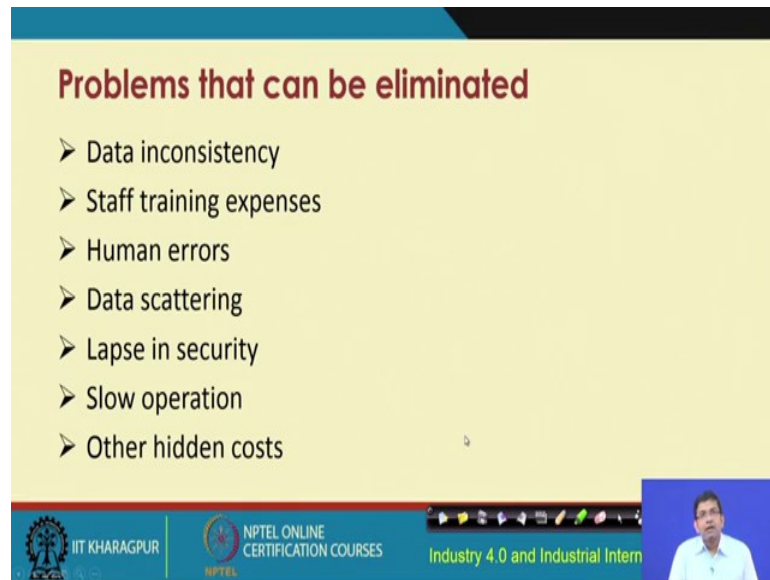
Applications (contd.)

- Similarly in transportation modes
 - Track time and place of congestion
 - Compute delay and alternate routes
 - Commute with efficient time and mode

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So, different other applications such as in the transportation sector basically tracking the time and place of congestion, computing the delay, and finding out alternate routes, commuting with efficient time and mode.

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Problems that can be eliminated

- Data inconsistency
- Staff training expenses
- Human errors
- Data scattering
- Lapse in security
- Slow operation
- Other hidden costs

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There are different problems that can occur through this IIoT implementation in inventory management and control. Problem such as data inconsistency, staff training, the expenses behind this kind of training, human errors, data scattering, lapse in security, slowing of operations and other hidden costs and incurring those hidden costs. So, these are some of these challenges that have to be overcome.

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References

- [1] Vrat, P. (2014). Materials Management. Springer.
- [2] Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories. (2000). 16th IPCC Plenary, Montreal.
- [3] Stevenson, W. J. (2001) Operations Management, 7th Edition. McGraw-Hill Irwin.

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So, in this particular lecture I have given you an overview of the incorporation of IIoT and the infuse meant of IIoT devices such as RFID sensors and the network RFIDs and sensors for making the inventory management and control process much more efficient and smarter. These are some of these different other differences that I have given you as usual, for your further reading in case you are interested to know further about the implementation of IIoT in the inventory management and control process in manufacturing sector.

Thank you.