Introduction to Internet of Things
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Lecture - 10
Connectivity Technologies- Part-II

The next protocol that we are going to go through is also for offering connectivity between different devices forming the connectivity and this protocol is the 6LoWPAN protocol. So, this 6LoWPAN protocol is basically it runs over IPV6 that is from where this 6 figure comes. So, it is from IPV6. So, it runs over IPV6. So, it offers radio connectivity, radio linkages over IPV6 protocol. So, using IPV6 protocol and IPV6 as we know is for addressing, it is an addressing protocol and it is very popular for use for addressing in the case of IoT networks because of the large address space that is required for IoT. So, let us look at this 6LoWPAN protocol.

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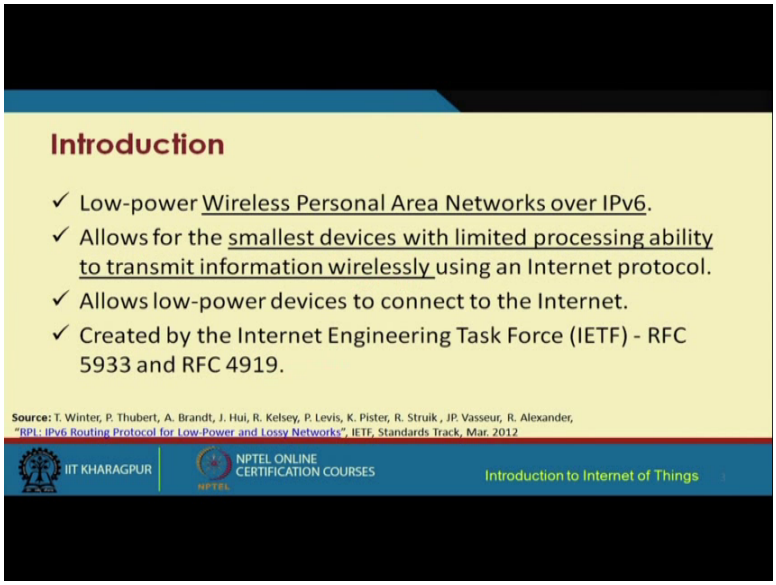

So, it stands for 6LoWPAN stands for Low Power Wireless Personal Area Network over IPV6 and it allows for the smallest devices and each of these devices having limited processing ability to transmit information wirelessly over the internet protocol.

So, we have low power small devices limited processing capability as is typical of IoT systems and wireless communication being present. So, it basically helps in establishing connectivity in this kind of networks. So, it basically helps this 6LoWPAN protocol, it

helps and allows to have this low power devices to connect over the internet because IPV6 is going to be used for addressing.

So, at the network layer, that is the reason why this protocol is useful for connecting this IoT network. These low power devices to the internet, it is basically created out of the IETF RFC 5933 and RFC 4911. So, these are two different RFC based on which this 6LoWPAN protocol is specified. So, this specification is available in these RFC's.

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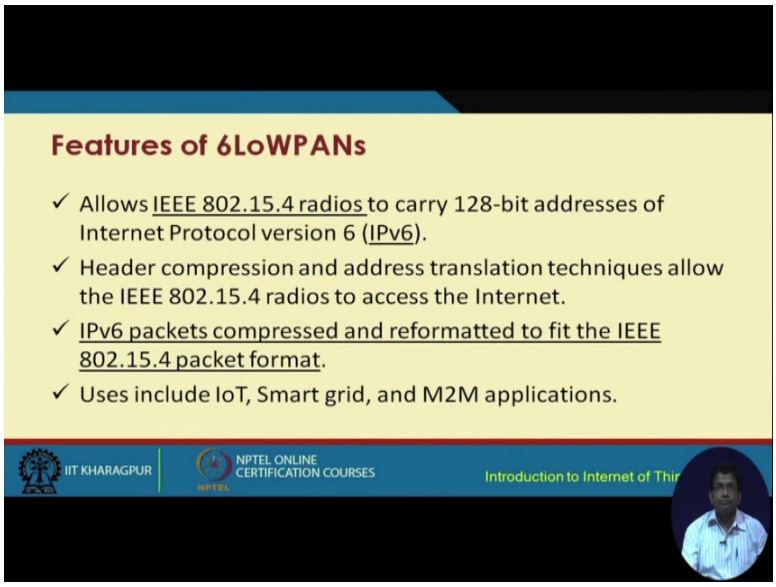

So, these are some of these features of 6LoWPAN and it allows IEEE 802.15.4 radios. That means, in the previous lecture we have gone through this particular protocol which is useful for setting up connectivity between the different nodes and it primarily operates at the physical and the MAC layers. So, the radios of the 802.15.4 are used to carry 128 bit addresses of the IPV6.

So, basically 6LoWPAN is an application or its joining you know conceptual joining of 802.15.4 radios with IPV6, but how it is made possible because you know 802.15.4, it is low powers in light weight protocol and IPV6 is not lightweight. So, how it is made possible? So, the header it is possible with the help of header compression and address translation techniques that basically helps to convert 802.15.4 radios to access the internet.

So, it will help this 802.15.4 radios to access the internet using header compression and address translation techniques. IPV6 packets are compressed and reformatted to fit the 802.15.4 packet structure. So, this is what is done. IPV6 packets large in size, they have to be compressed, they have to be reformatted and they have to be mapped with the packet format of 802.15.4 which is primarily meant for low power networks, small scale low power networks as is typical of IoT.

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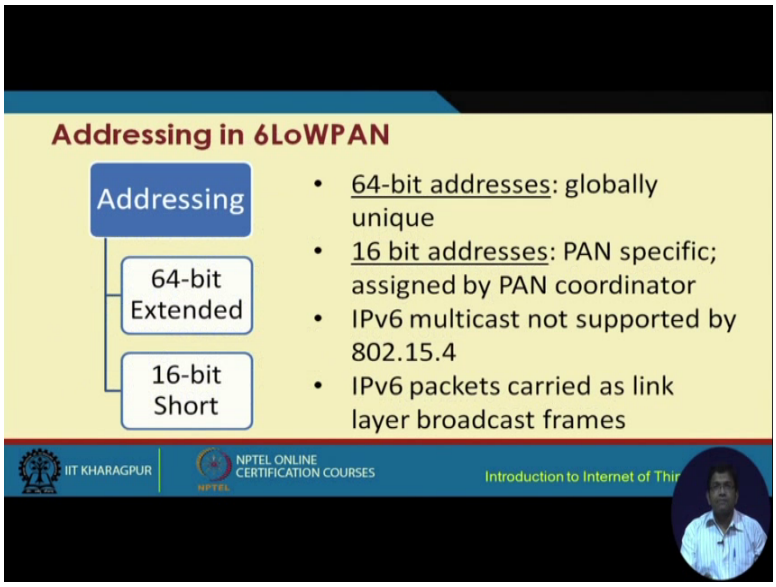

So, it can be used for, IoT 6LoWPAN can be used for IoT smart grid applications, smart home applications, M2M applications and many other different, similar applications. So, for addressing in 6LoWPAN, there are two types of addresses that are used i.e. 16 bit short address which is for pan specific communication. That means, it is assigned by the pan coordinator for communicating within the pan, the personal area network and 64 bit extended address which is used for global unique connectivity, global unique addressing throughout the network.

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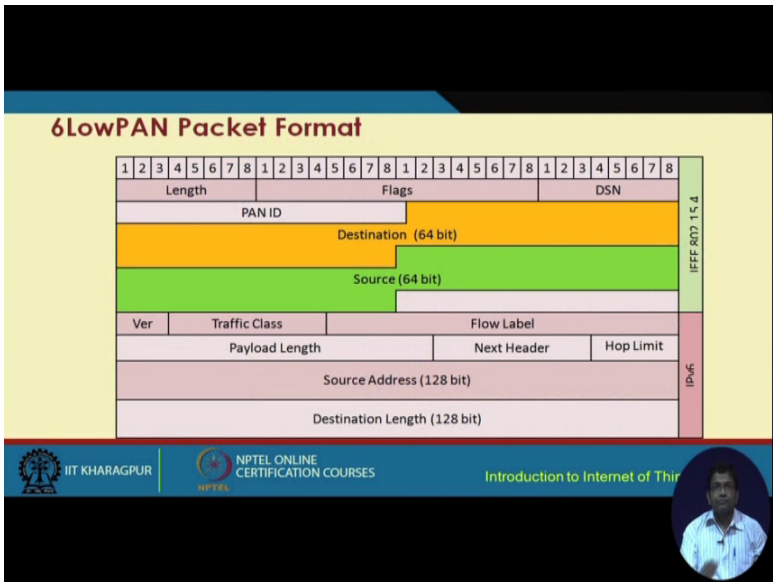

So, IPV6 multicast is not supported by 802.15.4 and IPV6 packets are carried as link layer broadcast frames in the case of 6LoWPAN. So, we have in front of us the packet format of 6LoWPAN. So, as we can see over here if you look very closely, we have 802.15.4 and IPV6 club together 802.15.4 radio and IPV6 for addressing over the internet and these corresponding fields are also shown over here.

So, what we have for corresponding to IPV6? We have the source address, the destination address and these different other IPV6 fills that are typical in this particular protocol IPV6 protocol and for 802.15.4 as well, there is this source, the destination both of which are 64 bits. That means, source and destination together will become 128 bits.

Then, we have this pan id because you know when we are talking about 15.4 networking mode go to personal area network. So, the pan id is basically stored in this particular field. So, this is how the 6LoWPAN packet format looks like.

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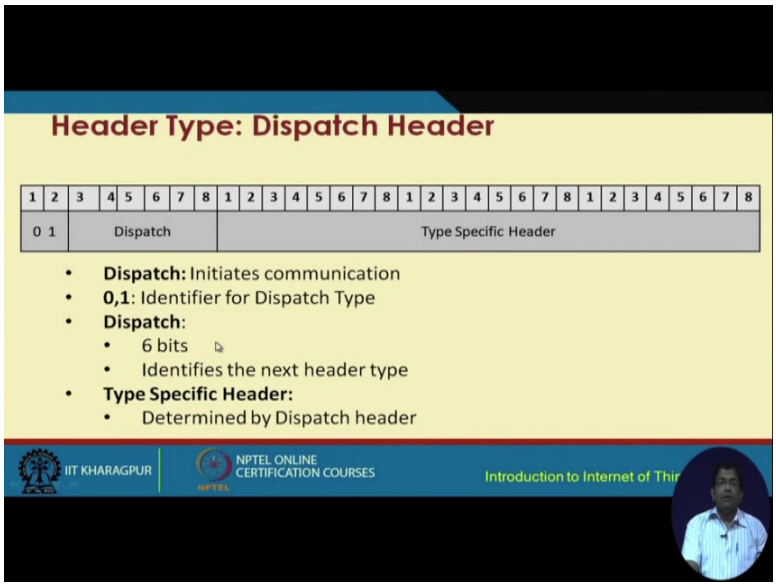

So, that is the packet format. Now, what about the header? There are three different types of headers. One is known as the dispatch header, the second one is known as mesh addressing header and the third one is known as fragmentation header.

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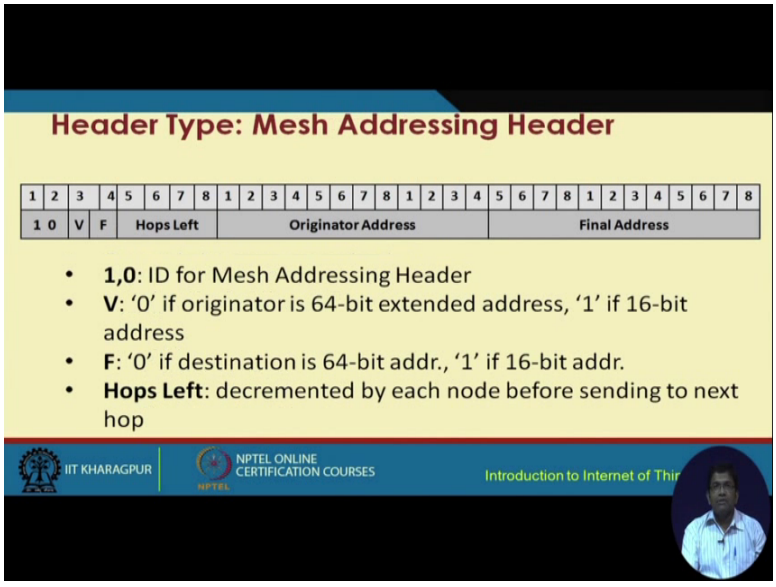

So, let us look at these three different headers. The format of these headers is given over here. So, how many bits we have? We have 8, 16, 24, and 32. So, the header is 32 bits long, out of which the first two bits are used to identify the dispatch type and this

dispatch type basically helps in the dispatch communication initiating the resetting the communication.

Now, this dispatch field has 6 bits. So, it is 6 bits long field and these basically identifies the next header type and there after the next list of the bits are used to specify the type specific header and that is determined by the dispatch header. So, then we have the mesh addressing header and here basically the first two bits are used to store the id of the mesh addressing header.

The next field, the V field is 0. If the originator is 64 bit extended address and we have seen that both of these are possible to have 16 bit as well as 64 bit address. The F field is 0 if the destination is 64 bit address and 1 if it is 16 bit address and hops left are decremented by each node before sending to the next hop.

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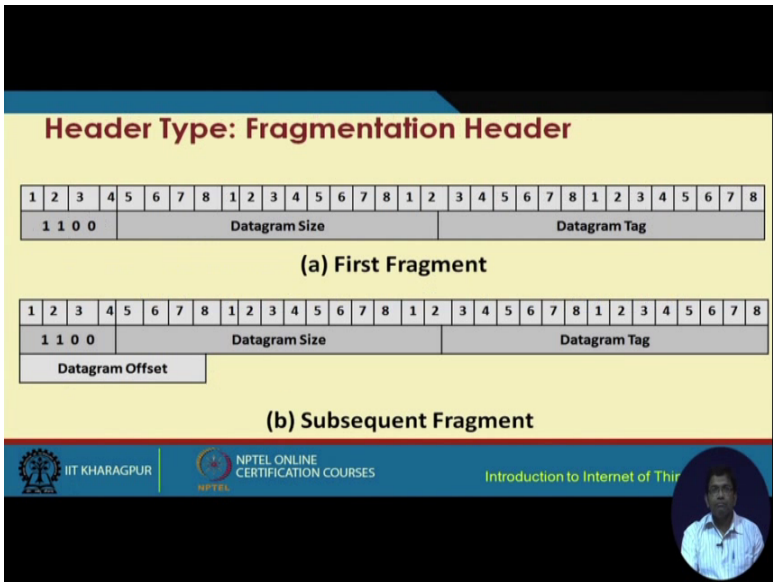

So, how many hops are left until the final destination node? This is basically stored in this particular field and is decremented as I said hop by hop when one hop is over, it is complete, that field the value is decremented by 1 and third in a type is a fragmentation header and the corresponding fields are shown over here. So, in this case, the first fragment has this structure, the header has this structure as shown over here and the subsequent fragments have this particular structure.

So, as you can see over here, the main difference between the first fragment and the subsequent fragments is the inclusion of the datagram offset.

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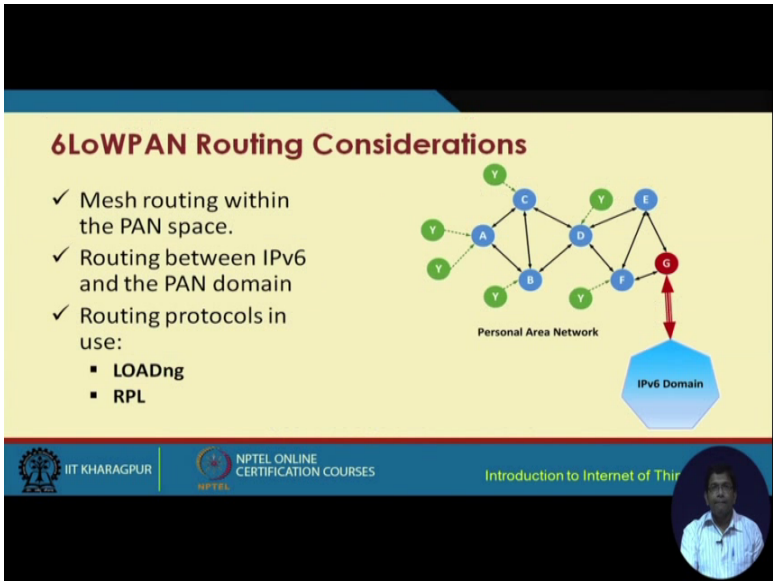

So this datagram offset basically shows that it will give the value of what are the subsequent frames that are there. So, this will basically help to connect with the first frames; so 6LoWPAN because it involves a strong network layer component and it takes care of routing.

So, the most important type of routing is a mesh based routing and this mesh based routing is used in the context of a pan topology, Personal Area Network Topology. So, routing is used, routing basically is based on the IPV6 protocol in the personal area network domain and there are two protocols that are used in 6LoWPAN for routing.

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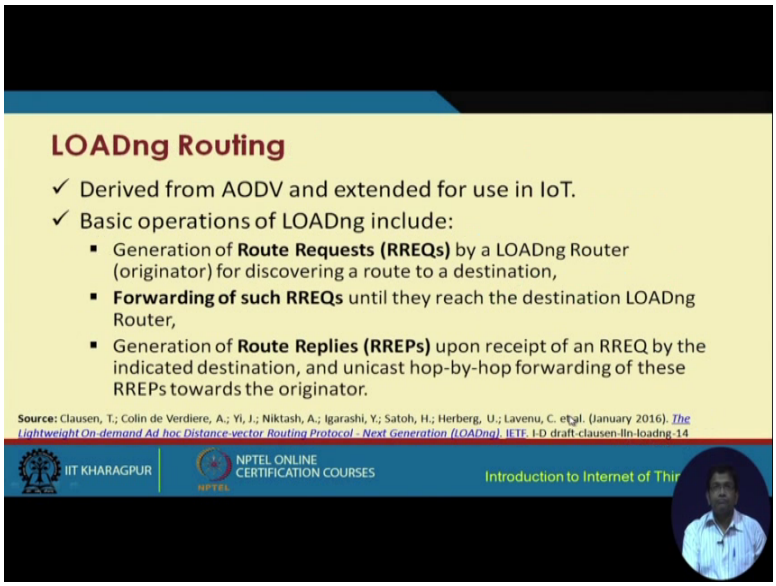

One is the LOADng protocol and the other one is RPL protocol and as you can see over here from this particular figure, we have this IPV6 domain and we have this personal area network PAN and with the help of this coordinator of the gateway, it connects to the IPV6 network. That means, the IPV6 based internet, the LOADng routing protocol, it is primarily a derivation from the AODV protocol that is available and was proposed for ad hoc networks and this has been used and extended for IoT networks.

So, this LOADng protocol has few different PDOs. The first one is the load request PDOs and it is generated by a LOADng router, the originator for discovering a route to the destination. So, the forwarding of such route requests take place until they reach the destination LOADng router, then comes the route replies which is generated upon receipt of the route request by the indicated destination and unicast hop by hop forwarding of these route replies towards the originator.

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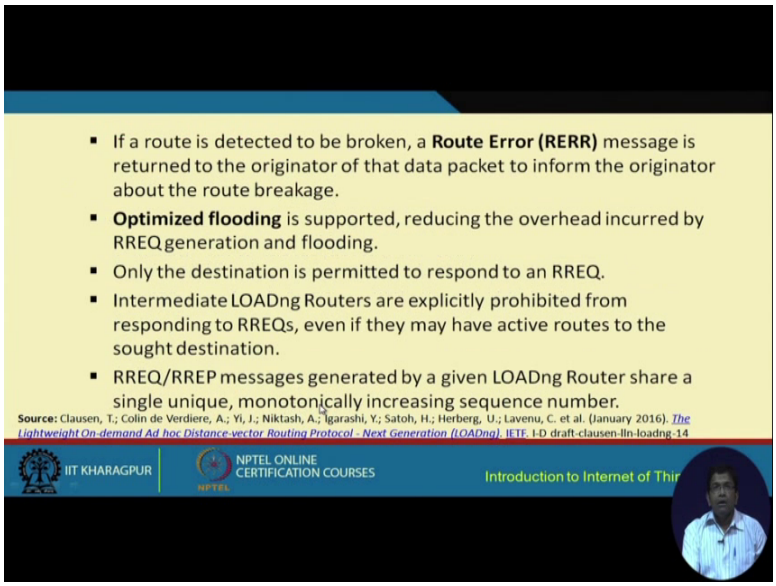

There is also this route error message that is used to return errors to the originator of the data in the event that there is some route breakage that take place. So, optimized routing is supported reducing the overhead that is in cut by the route request generation and flooding only the generation is permitted, sorry only the destination is permitted to respond to the route request. Intermediate routers of LOADng are explicitly prohibited from responding to the route request even if they have been very active in terms of seeking routes and generating routes in the network.

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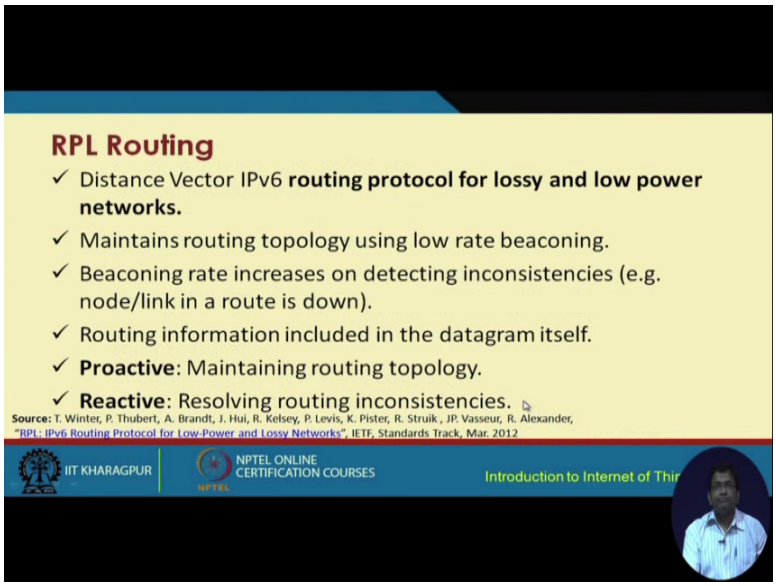

The route request and route reply messages are generated by a given LOADng router and this share a single unique monotonically increasing sequence number. Next comes RPL, Routing Protocol which is based on the distance vector routing for lossy and low power networks. So, this is where this l comes from this lossy. So, it is used for lossy networks as well as low power networks for routing.

So, it maintains routing topology using low rate beaconing. Beaconing rate over here increases on detecting inconsistencies with respect to situation such as load failure or link failure. Routing information is included in the datagram itself. It uses two types of routing proactive i.e. routing for maintaining, routing topology and reactive for dissolving routing inconsistencies.

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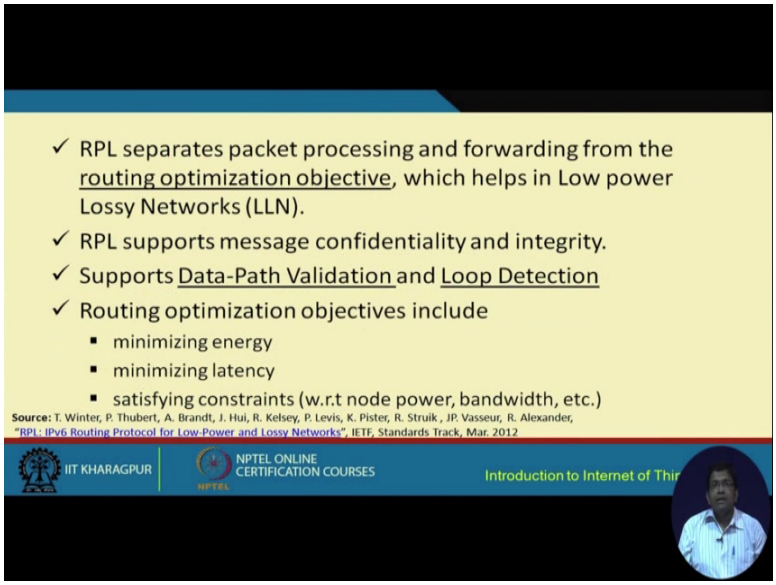

RPL basically separates the packet processing and forwarding from the routing optimization objective which helps in Low Power Lossy Networks, LLN.

So, this particular protocol, it supports features such as confidentiality, integrity, ensuring integrity, validating data paths and detecting the presence of loops. The overall optimization objectives of routing include minimizing the energy minimizing.

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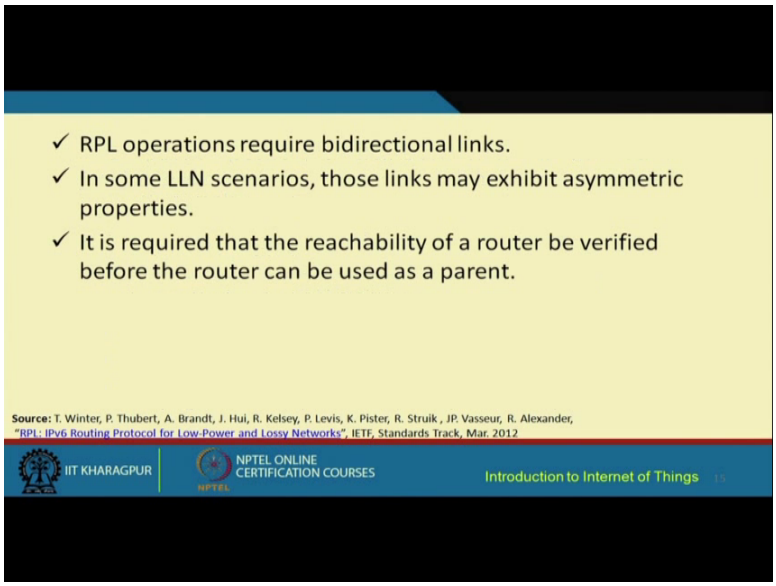

The latency and satisfying the constants with respect to node power bandwidth etcetera, this RPL protocol operates using bi-directional links. So, there is bi-directional flow of communication of messages.

So, in some LLN scenarios, that mean the lossy scenarios, these links may exhibit asymmetric properties, right. So, basically asymmetric property means that while the message is sent from the source to the recipient, it flows through one route may be directly, but because of all these environmental situations or whatever the response or the flow of message in the other direction does not take place through the same route. Maybe it comes back through another route. So, it is asymmetric. So, it is required that the reachability of a router is verified before the router can be used as a parent.

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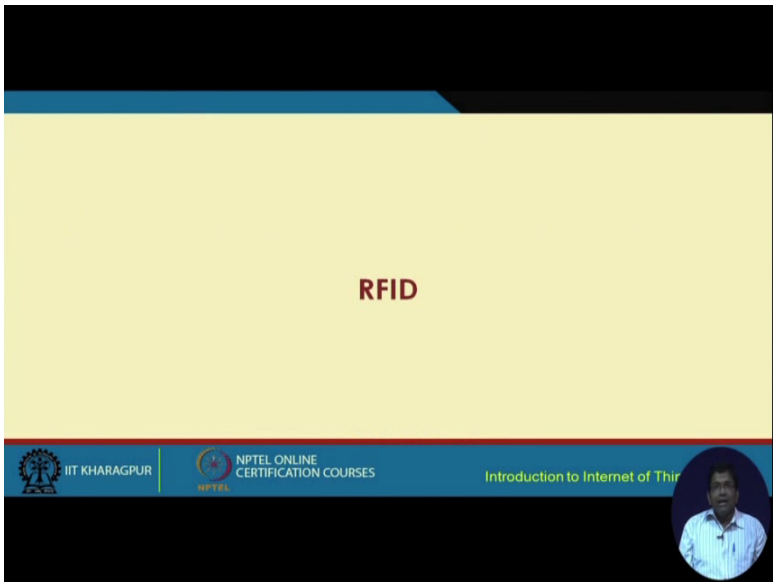

Finally for this particular lecture, we are going to go through the protocol RFID. RFID is very popular. It is commonly used. It has been in use for long, it is still used in shopping malls. What places you know? For example, the id cards are fitted with RFID tags. RFID tags can be scanned in the RFID readers. Similar things happen in the shopping malls like when we go for purchase in certain items, for example, clothing sensors these also are fitted with these RFID tags and these RFID id tags can be used to scan against RFID readers to get further information and so on.

So, how does RFID work? RFID is we have to remember that sensor networks and RFID sensor networks we have not yet covered. We will cover in a subsequent lecture, but RFIDs and sensor networks and also other technologies, such as zigbee, 802.15.4, for w PAN, NFC also which is very similar to RFID. These are different other connectivity offering mechanisms that are popularly used for IoT applications. So, these are the core for establishing connectivity in IoT networks.

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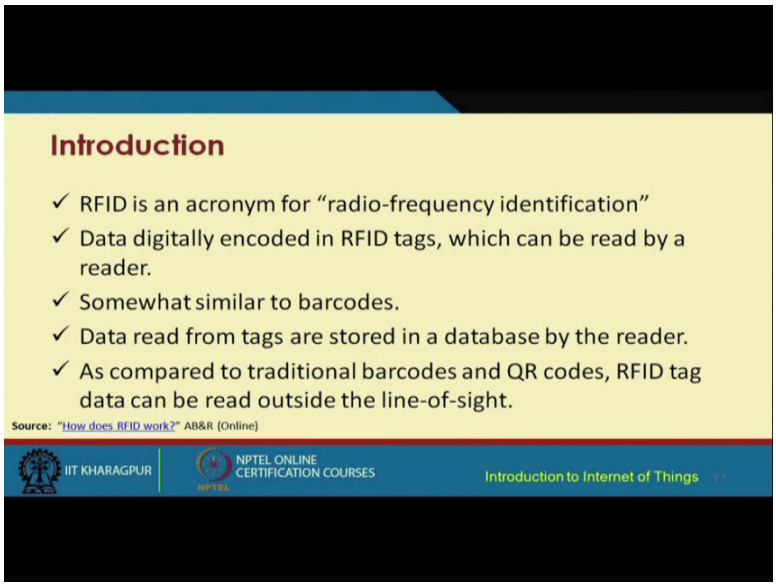

So, going back to RFID, first of all RFID, its an acronym for Radio Frequency Identification, where the data is digitally encoded in these RFID tags and these data can be read from the RFID tags. So, RFID tags are encoding the data and these data can be scanned from RFID tags by the RFID reader. So, these are very similar to the bar coding schemes and QR coding schemes.

So, in a barcode what happens in a barcode like in libraries ecetera, in a bar, bar coding schemes are typically used to store information about the books and you know having the identifiers for the books. So, the barcode basically are like vertical lines, right. So, there is a barcode reader which can read those vertical lines. Similarly there is QR code which is sort of like that square square kind of thing which is used for scanning the data, right. So, these are the QR codes.

So, there is that reader which can take that image and it can basically process that image to identify the data that is embedded in that particular code. So, RFID tags are also very similar in operation to the barcodes and QR codes, but the functionality or the way these operate are vastly different. So, let us now try to understand how RFID tags, the RFID principle works.

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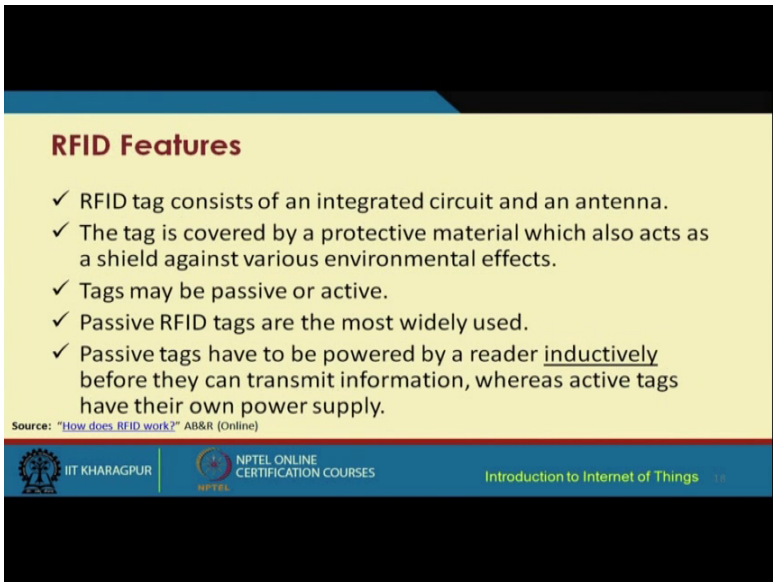

So, every RFID tag consists of an integrated circuit and an antenna. So, basically it is a very small tag. So, tag inside the tag, there is some circuitry that is there and a small antenna which is embedded into it, inside it. So, this antenna, it is going to be used for communication with the outside world. That means, outside the tag and the circuitry basically does number of things including storing the information in that particular tag, may be the RFID tag could be for a smart card that can be used for storing employee information.

So, you know employees in an organization have different identification for different identifiers and those identifiers, the different data can be stored in electronic form inside the chip that is built into this RFID tags. So, the RFID tag consists of integrated circuit and an antenna. The tag is covered by a protective material. So, outside the tag is some kind of a shield protective material which can also act as a shield against various environmental effects.

The tags can be of two types. One is the passive tag; the other one is the active tag. So, passive tags are more common and the way these passive tags are operated are through the process of inductivity. So, inductively when these passive tags, when these tags come in proximity to the RFID reader, there is some inductive effect, some magnetic force fields are created due to which the information is transferred from the tag to the reader or vice versa. So, it is from the tag to the reader and vice versa. Those are the passive tags.

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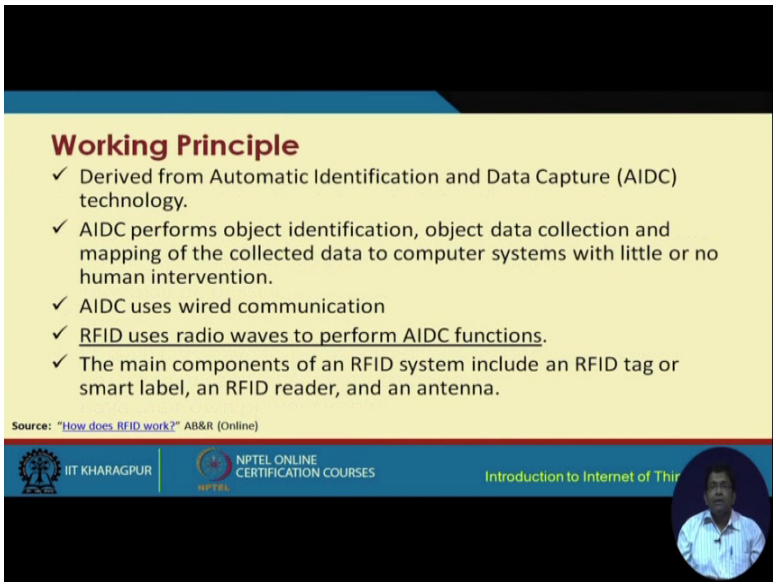

On the other hand, the active tags, they have their own little source of power supply. The working principle of RFID is similar to its predecessor which is called AIDC. The AIDC full form is Automatic Identification and Data Capture Technology. So, it performs object identification, object data collection and mapping of the collected data to computer systems with little or no human intervention.

So, the concept of RFID is basically adopted from AIDC which is its predecessor. So, AIDC is no longer very common, however the difference is RFID is mostly wireless, not mostly it is fully wireless. On the other hand, AIDC uses wired communication. So, RFID basically uses radio waves that mean wireless communication to perform different functions which are also performed by AIDC.

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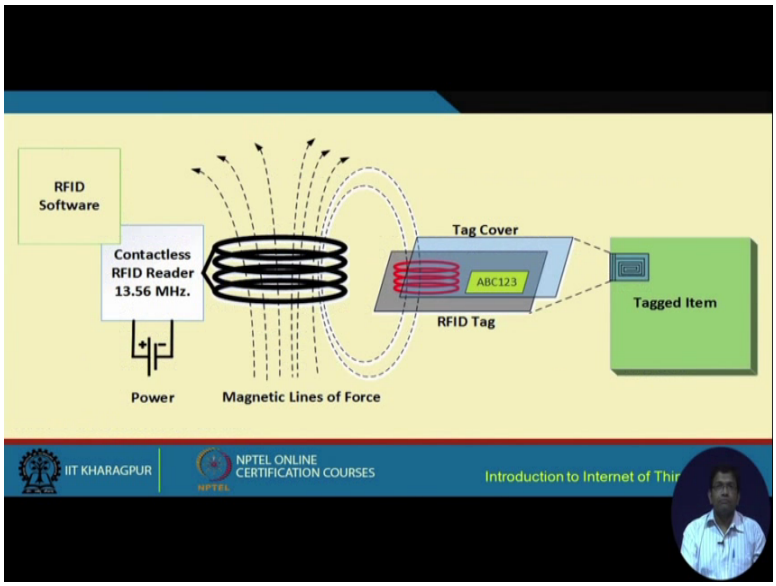

So, let us try to understand how RFID works. Let us say that there is a tagged item like clothing or something in a shopping mall, some kind of a cloth. So, this cloth is tagged with this RFID reader, no sorry RFID tag. It is tagged with this RFID tag; it is attached to the RFID tag. This RFID tag consists of the circuitry some kind of a quailing mechanism and the cover.

This cover is some kind of a polymer, some plastic or some other polymer and the circuitry is basically stored inside this particular tag. Then, we have this one if we look over here. So, we have this part, we have this part which basically is for the reader. So, this part is for the RFID tag and this part is for the RFID reader. As we can see over here, this RFID reader has a software and a source of power supply and it also has a coil and when you bring that reader which has a coil inside some magnetic coil, then there is this magnetic inductive effect producing this magnetic lines of force are created.

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So, this is how the data that is there in that small chip inside the RFID tag is transferred to the RFID reader with the help of this force field magnetic force, field RFID tags. RFIDs in general are useful for supporting different IoT applications such as inventory management, asset tracking in an organization, personal tracking you know who is coming when, who is living when in an organization, what is the attendance.

So, attendance tracking systems for example, controlling access to restricted areas. So, you know whoever is authorized will be having an RFID tag and they can bring it in close proximity to the RFID reader and if it is a valid tag, then the door is going to open for that person and the person can get in. So, it is used for controlling access to the restricted areas.

Id badging as basically you know identity badges, smart cards in an organization, it is used for that supply chain management counterfeit prevention particularly in the pharmaceutical industry. So, these are different applications of the RFID tags.

So, with this we come to an end of this particular lecture and there are few other protocols that are also very much useful, and we are going to go through them in the next lectures.

Thank you.