Computer Networks and Internet Protocol
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Lecture – 39
IP Routing-III (Autonomous System (AS), Path Vector Routing)

Hello. So, we will be this we will be discussing on routing protocols, we will be rather continuing our discussion on routing protocol in our course of computer networks and internet protocols. So, as we discussed that routing is a layer 3 phenomena, which connects networks, right and if the device is at least layer 3 enable. So, and also we know that every router maintains a routing table or sometimes called forwarding tables which is sort of a lookup table, by which any packet receive coming to that router look at that table and then get forwarded to the next hop.

And AS the overall internet is dynamic not maintained, so to say with a single administrative authority. So, this routing table are need to be updated so that the overall knowledge of the network, how need to be where the paths are need to be is known to the things. Now one beauty of the thing is that, that this routing protocols which helps in updating these routing tables updates the tables individually; that means, router a or router x has this table x which is updated and independent of the other things right.

So, it is only concerned about this the updating this table in such a way so, it gives it helps in providing the best possible route so, that is the basic objective. So, the routing protocols which is employed or deployed is basically in every router is basically to update the table with other co lateral informations. And also we have seen there is a concept of autonomous systems; that means, the whole internet it divided into several autonomous systems, with a autonomous system identifier; where there are 2 type of things one routing within the autonomous system and another across the autonomous system.

So, in a sense we have intra domain routing and inter domain routing type of things. As we understand that this whenever you have a more administrative control and a over a particular network and the resources you have a better way of manageability, but when you have a in a very large network, then you have to follow some sort of a what we say collaborative approach right.

Secondly there can be lot of other issues which come into play. It is not only finding the shortest path or the optimal path; it may so happen that I need to look at some policies. Like I can say, that I want to forward this packet, but I do not want to travel through this network right or I must travel through this network or these are the networks which I which are more friendly networks which my packet need to be travel etcetera, right. Other than other metric like congestion list time, RTT and a lot of other things, I can have some sort of a policy defined on the on the particular while pushing the packet across the network right.

So, today we will see the basic concept or basic components of autonomous a system and or as and the basic philosophy of the path vector routing or which the popular routing protocol BGP employs right. So, it is most of looking at the autonomous systems and the path vector routing is the thing along with definitely the BGP will come into play. So, just to repeat the same picture, we have broadly 2 things, intra domain and inter domain. And this path vector is a inter domain routing; that means, across the domain or across the autonomous systems and type of things.

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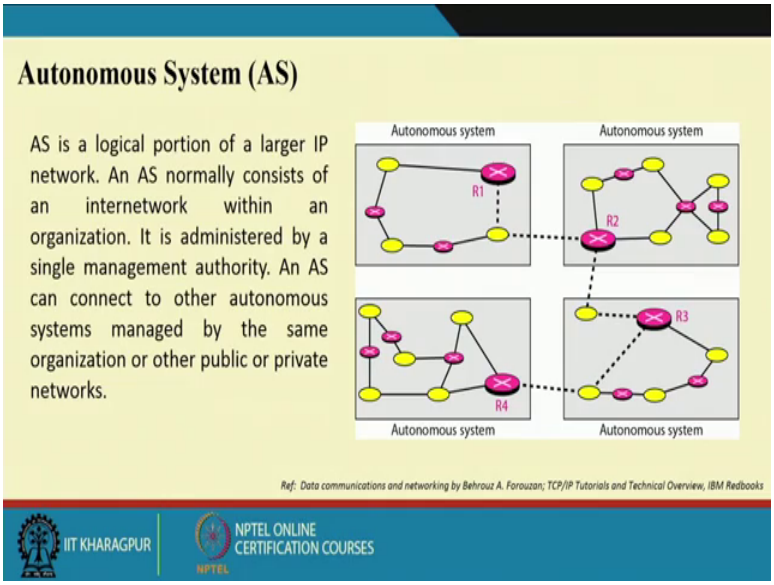

Now, what is a autonomous system? So, autonomous system or a, AS can be looked as a logical portion of a large IP network, right. So, it is a definitely, there are physical router etcetera, but it is a logically a large IP network. And AS normally consists of an internet to work within an organizations; that means, it is somewhat under one administrative

control or one administrative what we say policy right. It is administered by a single management authority and AS can connect to other autonomous systems, managed by the same organization or public or private and so and so forth right.

So, let us repeat so it is a so what we are saying that this whole internet, I take a group of things which are logically maintained by a organization or a administrative authority, and it can or it definitely it help to communicate with other autonomous systems; which are may be of the same organizations, may be of other organizations may be public may be private and type of things, right. So, what in a sense what we have like the figure shows that we have several such autonomous systems acquired the things.

And autonomous systems identify is identified by the by a unique number, what we get from the international regulatory or authority. And so, that we every autonomous system as a unified is a unique number to identify. Now within the autonomous systems there are routing are done by through inter domain right, intra domain right, within the domain routing and typically OSPF per reaper the popular things to be routed.

So, in this case we have you see we have 4 autonomous systems. There is a designated router called border router autonomous border router; which keeps the informations of the network within the autonomous systems. So, in other sense, it gets updated by the OSPF or reap protocol inter domain routing protocols which updates the things, right. If this interns helps in these routers helps in finding the path between one autonomous system to a another autonomous system.

So, we try to emphasize there is a concept of path between one autonomous system to another in autonomous system; that means, when the packet is routed it, it try to find out that in order to reach the destination which are the set of up ordered set of autonomous system need to be covered, all right. And this gives us we will see this gives us a lot of flexibility in policy based routing right. I can say that I do not want to touch that autonomous system or I want to go through this autonomous system provided there are connectivity's available and so and so forth.

Now, these autonomous systems need goes on updating their information using these border routers right. So, if we look at the routing protocols at the autonomous systems as we have discussed.

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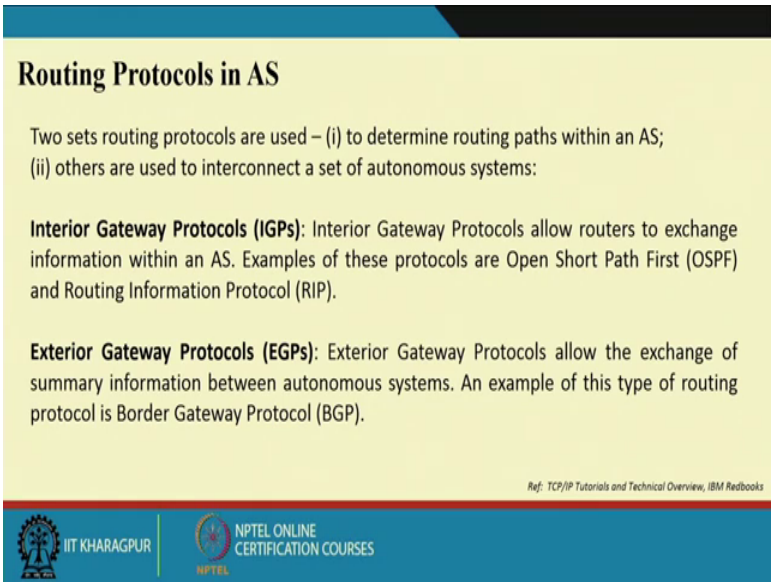

So, 2 sets of routing protocols are used to determine the routing paths within the AS. One is to determine the routing paths within the AS; others are used to interconnect a set of autonomous systems right.

So, one is within the AS; that means, the routing which will be done within the AS, as we are saying these are these autonomous systems individually are with one organization or one administrative control; that means, what sort of routing has to be done is based on that the total discretion of that particular organization which may be influenced by the type of organization or type of traffic flow it is having and a nature of the organizations, or nature of the network they want to envisaged and type of things.

It is nothing to do with the other autonomous system. Only the autonomous system looks at the informations by these border routers etcetera. And secondly, what we like to have the others are like the protocols which are used to interconnect a set of autonomous systems. So, I need a protocol which allows us to connect to the other autonomous systems. So, interior gateway protocol IGPs, interior gateway protocols allows routers to exchange information within the AS right.

So, examples are open shortest path first or OSPF and routing information protocol or RIP. So, these are the popular protocols which we all already we have seen. So, these are 2 popular protocol; one is based on distance vector, another is based on a link state protocol right. There is other set of protocols which are based on routing across the

autonomous system or what we say inter domain routing, and those are exterior gateway protocol. So, allow exchange of a summary information between the autonomous systems. The example one best example is the border gateway protocol or BGP.

So, that means, the border router of every autonomous system have a summarized information of the whole autonomous systems. Now this summarized information are been exchanged with the other border routers right. So, based on this, but this information they exchanged they find out the path between the source which is generated from one autonomous system and destination; which is at the other and some other autonomous systems and how the things will follow.

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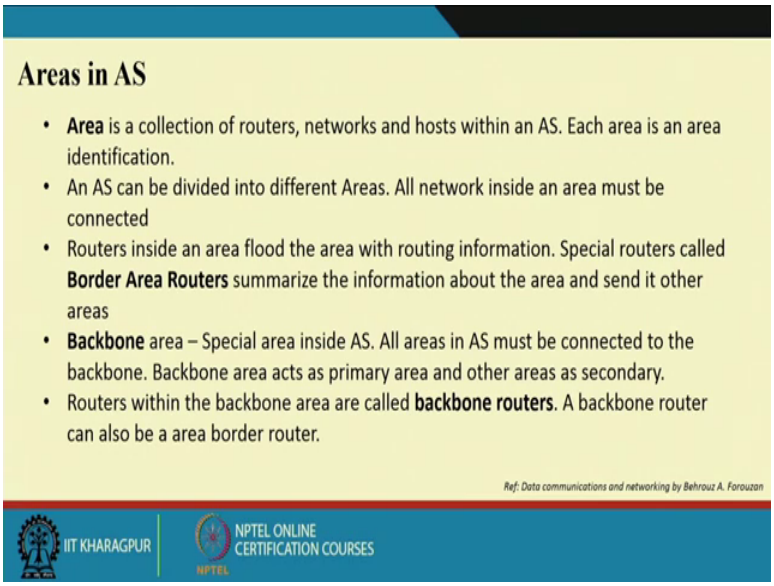

So, there is a concept of area in autonomous system. So, in so, one what we have seen? The internetworking is divided into several autonomous systems. Given a autonomous systems, it is divided into different areas. So, area is a collection of routers network and host within an autonomous systems. Each area has a area identification number or area ID right. So, an AS can be divided into different areas. All network inside the area must be connected right. So, the all the network within the area should be connected; that means, area is a connected network scenario; where there are routers networks host etcetera.

So, routers inside an area flood with the flood the area with routing information. So, so what we see? That the whole internetwork autonomous, autonomous into different area

routers within the area basically shear information or a flood information inside that areas. So, all so, there is a special router called border area routers summarize the information about the areas and send it to other areas, right.

So, there are border area router. So, every router every area often particular operator of autonomous systems as a border area routers, we summarize the information about the about that particular area. One of the area or sometimes referred to as area 0 is the backbone area. Special area inside autonomous system, all areas in as must be connected to this backbone area. The backbone acts as a primary area other as secondary.

So, in a autonomous system what we see, that there is a area called backbone area or at times the area with identity ID is 0; which basically takes care us or summarizes the information of the all the areas of the autonomous systems, and all areas must be connected to the backbone area, and backbone area acts as a primary area and other areas as secondary right. Routers within the backbone area are called backbone routers. A backbone router can also be a area border router, right.

So, as backbone is also area. So, area border router can be a backbone router. So, this backbone router acts as the information hub for the whole autonomous system. This connecting to the backbone does not mean that the area the routers in the area cannot connect to the routers in the other area. For that matter it also does not mean, that a router in particular autonomous system cannot connect to a routers in the other autonomous system. It is more of a information summarizations which comes into play right.

If I want to get information and try to find a routing path across of the inter domain routing. So, from to whom I should concentrate right. So, these are the constituents of information things, but that does not restrict that a particular area router to connect to a particular another area router of another area, or even the area a router in a autonomous system in area router of the autonomous system connected to another router of another autonomous systems and the type of things, right.

So, that is more of a network connectivity which we may not a which we cannot dictate per say right. So, those connectivity's are there, but the overall summarization or custodian of a informations we require this type of backbone routers.

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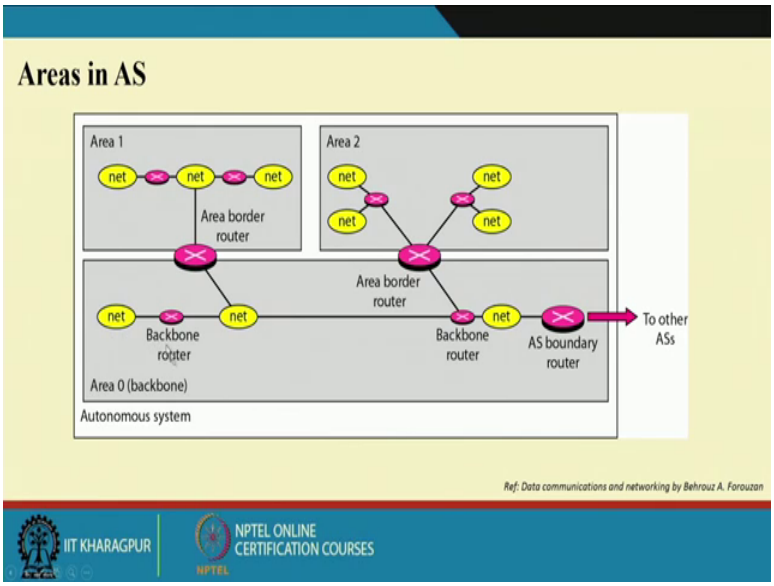

So, if we try to see say there are area 1, area 2 and a backbone of area 0 and there are different different routers. So, area border routers, and there are backbone routers, one router in this particular backbone is designated at as boundary routers, right.

We shares or informations or based on the policy of the autonomous systems with the other autonomous systems right. So, we have this sort of structure. So, there is so, I just to repeat there is a area 0 or backbone router, we have area 1 area 2 dot dot dot area N. And there are area border routers, which allows to connect to these backbone routers and in the backbone area or area 0 there is a AS boundary router designated router which summarize keeps the summarized information and share with the other autonomous systems based on the standard and the policy of the autonomous system right.

So, this is the overall structure wise right.

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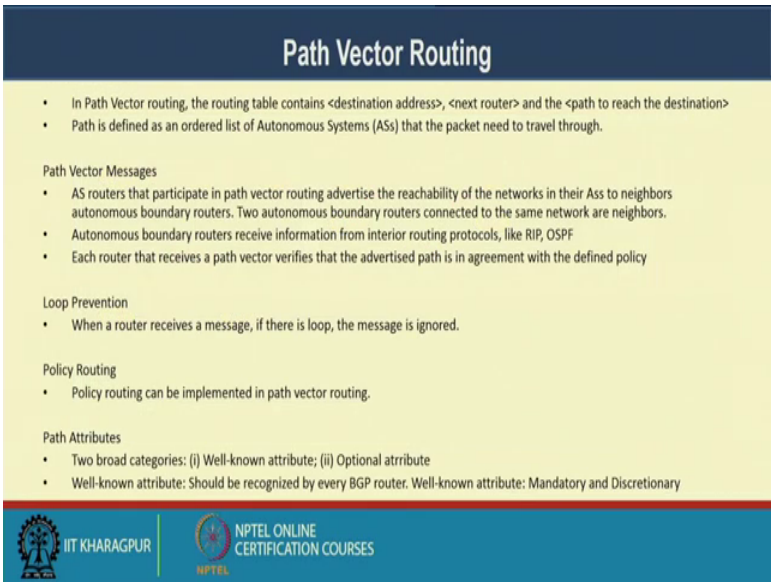

Now, if we look at that path vector routing right. So, in path vector routing, routing table contains destination address, next route and the path to reach the destination, right. Unlike if you look at OSPF and reap or distance vector and link state. In this case, we have the destination address, next router to be hit and the path to reach the destination.

Now, this path is a ordered set or ordered list of autonomous systems that the packet need to travel through, right. So, the path is defined as a ordered set of routers or autonomous systems that the packet needs to travel through. The path vector messages so, there are different what we say what need to say the different characteristics or different components of the things, one is path vector messages. AS routers that participant in the path vector advertise the reachability of the networks in their autonomous systems or ASs to the neighbors autonomous auto neighbor autonomous boundary routers using this messages right.

Two autonomous boundary routers connected to the same network are neighbors right. So, if it is on the same network or it is connected by the networks, they are neighbor and this path vector messages are the message which are exchanged between the things. So, as we see that that has there should be some format, not only that the your autonomous system this boundary routers and border routers, need to be updated by the OSPF or reap; that means, distance either this way or this your distance vector or link state

protocol again using some messaging right there should be a structure to do that by which it updates right.

So, each router that receives a path vector verifies the advertise path is in the agreement with defined policy or not. So, once a router receives a path vector, it checks that whether it is a agreement with the with the defined policies right. So, it is policy based routing, right also supports policy based routing. You know, that means, it says that whether in it is policy it is allowed or not. Suppose it is say that you cannot cause AS 13 right. If the path says that AS 13, that is not a feasible path for this or acceptable path based on the policy for this particular router.

So, there is a problem because there is a issue of loop right. If there are different autonomous systems, there are several autonomous systems, every autonomous system such boundary routers or back board router boundary routers are updating the paths; that means, a set of or a ordered set of AS numbers now in doing so, it may so happen that there can generate a loop based on that the routing algorithms etcetera type of things are following like in BGP and type of things, it may end up in a loop.

So, how to identify a loop? If there is a repetition of the as like if I give AS 1, AS 2, AS 6, AS 9, AS 12, AS 13, again AS 6, AS 49 etcetera. So, there is a loop into the path. If there is a loop it identifies and discard the thing. So, when a router receives a message, if there is a loop or if you can identify the loop it ignored the thing. There is a there is a way of policy based routing, or policy routing as we are discussing, policy routing can be implemented a in path vector routing, that I can always say that with path if say a particular as need not to be trust or need not to be in my path of forward in for forwarding my particular packets of a AS of a AS then it can checks, and if it is there it can discard that particular path.

Also when we talk about paths so, it comes with attributes right. How do you it is not only the as along with the attributes. So, there are 2 broad attributes, one is the well-known attributes. So, there are a few attributes which are well known attributes, and there are few attributes which are optional attribute; which can be followed or not, right. Well known attributes like I can have a origin of the particular message and type of things and be a well-known attributor.

So, well known attribute should be recognized by these routers; that is, inter domain routers right, popularly that or in other sense that BGP routers. So, if we look at the well-known attributes, some of the attributes are mandatory and some of the attribute are disc discretionary. So, this is different set of attributes helps in defining that particular path right. So, not only that it may so happen that some of the attributes need to be updated when there is a update to the other routers right.

And so, those if some so; that means, there is a mandatory to update that particular attributes to the next router. So, using this attribute, we can more finely defined the paths to along with the packet will move.

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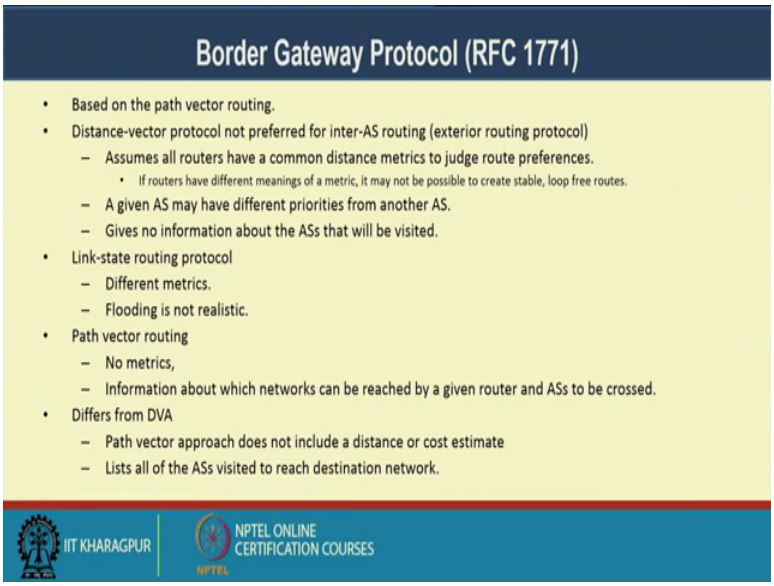

So, one of the popular protocol or the protocol you can say there is a BGP protocol, or border gateway protocol based on the path vector routing distance vector protocol not preferred as the inter as routing, right.

So, it is exterior routing protocol so that we distance vector or even link state protocols are not very popularized. So, it assumes all routers have a common distance metric to that router routing preferences; that means, while we do a distance vector, I take care that the whatever the cost or the distance metric we are using, this is agreed upon metric, everybody is doing like that. So, if routers have different meaning of a metric, it may not be possible to create a stable loop free things, right.

So, in distance vector the distances are caused what we think that all are same. So, a given as may have different priorities from another as or based on the matrix gives no information about the as that will be visited, right. So, it is no information about the as there is no summarized information about the AS. So, that is not preferred even in case of a link state protocol that is different metric. Flooding is not realistic in such a large internetworking scenario.

So, it will it have a lot of bandwidth and finally, the convergence will be a major problem. Every router if it wants to keep a keep a track of the whole network topology on it is things ideally find, but it is not physically or even theoretically it means practically feasible right.

Because it is not possible to converge on the whole network and take a call based on the things. So, there will be a huge traffic problem, even the router may not be able to handle such a network and do run a algorithms or with his own resources to do that. So, this is also not realistic for practical implementation of a in case of a inter domain routing, right.

In path vector there is no such ideally matrix. So, you have a sequence of sequence of paths which is looked into. So, information about which network can be reached by a given router or AS can to be crossed is the only thing right. And it is somewhat differ from this distant vector algo by in the sense the path vector approach does not include distance or cost estimation right. It is more of the path which sequentially is given and based on the attributes and other.

List all the as visited to reach to be visited to reach the destination network. So, it basically gives a ordered set of list. So, it is not ideally it goes on calculating the distance etcetera right. So, this makes more sense in a large internetworking scenario.

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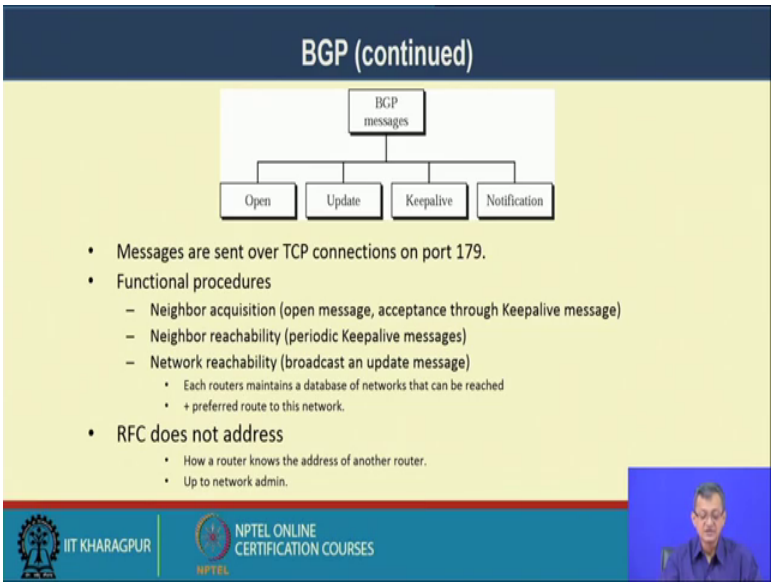

And if we look at the BGP or this which is based on path vector, there are several messaging. One is open; one is update, keep alive notification. So, open message is sends to whenever we want to send a message or send a communication with the other BGP protocol.

There is a important for update like means that BGP also can basically update; in a sense, remove create a already advertised some path a particular router or border router can update the things, right. And in case of a keep alive is basically saying that the router is ready for receiving messages. So, it is sort of a beckoning a keep alive type of messages, and there are if there are some erroneous or certain conditions which need to be alerted is using the notification.

So, messages are typically send over TCP connection on port 179, function procedure neighbor acquisition. So, when we do is a open message, acceptance through keep alive messages. Neighbor reachability, periodic keep alive messages. Network reachability using broadcast and update message right. So, each router maintains a database network that can be reached right, plus the preferred route to this particular network right.

So, it can have a policy of the things. So, that means, using this 4 category of messages BGP protocol tries or basically finds that the or in other sense update that routing table to find out the paths right. So, that that particular RFC does not include or address that how a router knows the address of another router and so and so forth. It is up to the network

administrator to have that type of things that how the router informations can be collected that which are the how to get the router address and type of things.

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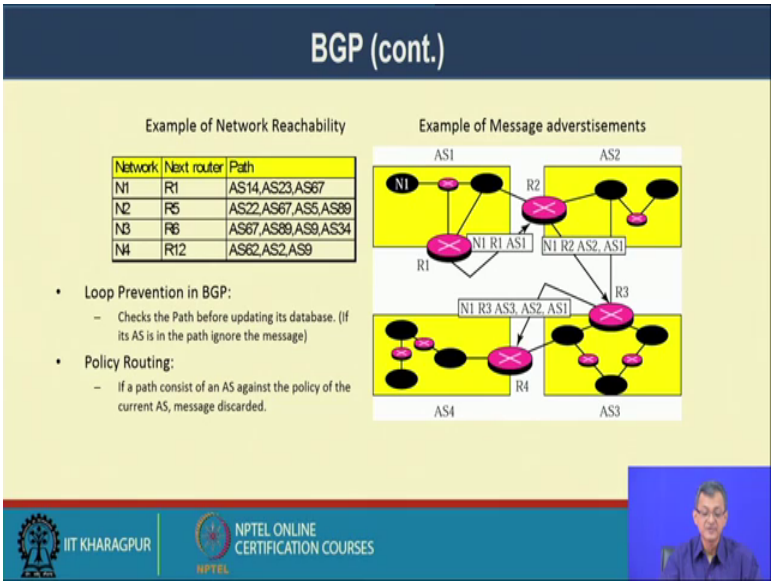

Now, if we look at that what we are discussing; so, if it is that router N 1 for net network N 1, a next router is R 1 for this AS. And the path is as to reach there is AS 14 AS 23, AS 67 right. So, this way it is defined. So, in order to reach N 2, the next order is now try to try to directly a match with this figure. So, the table is example of network reachability of the things right.

So, in order to reach N 1, this next router is R 1 and the path to be follows is 14 23 to 67, in order to reach N 2 next router is R 5 when the path is followed to be so and so forth and like this. So, what we see that by unlike other our link state or your distance vector, here the ordered set of AS or AS IDs are given.

So, loop prevention in BGP checks the path before updating the database. If it is as in the path ignored the message right. So, there will be loop if it is the same AS is there in the path. Policy routing if the path consists of AS against the policy of the current AS message is discarded right. So, these are the messaging format where while updating right. It is saying that in order to N 1 within the as R 1 and AS 1 is there; so, router 2 gets the things right. And router 2 when it is advertising that in order to reach N 1, you next router will be R 2 As is AS 2 next As is AS 1.

So, that means, from here anything goes 2 looking for N 1, it knows that the next router will be R 2 right. And it has to travel by AS 2 and AS 3. Similarly, here if you see anything goes to N 1, it next router is R 3 and it goes to a AS 3, AS 2 and AS 1 right. So, the path is defined in this way.

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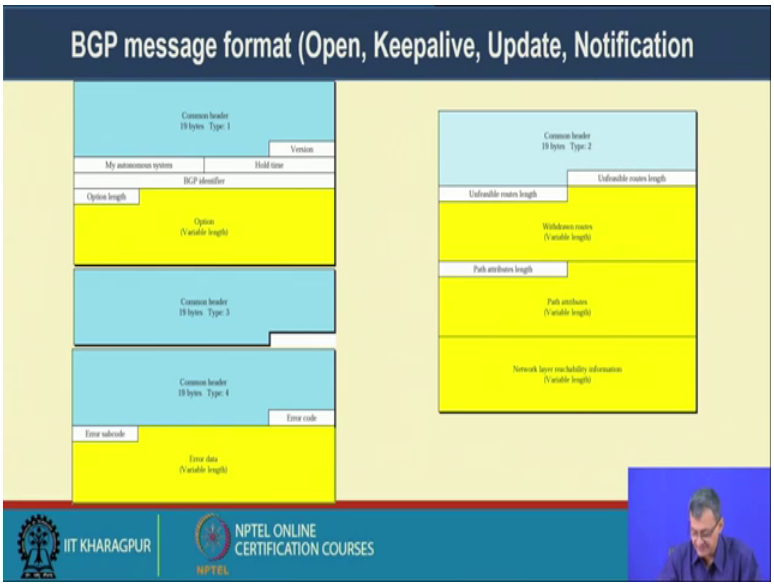

And these are different formats of the BGP messages open, keep alive, update and notification so that it can exchange information across different AS.

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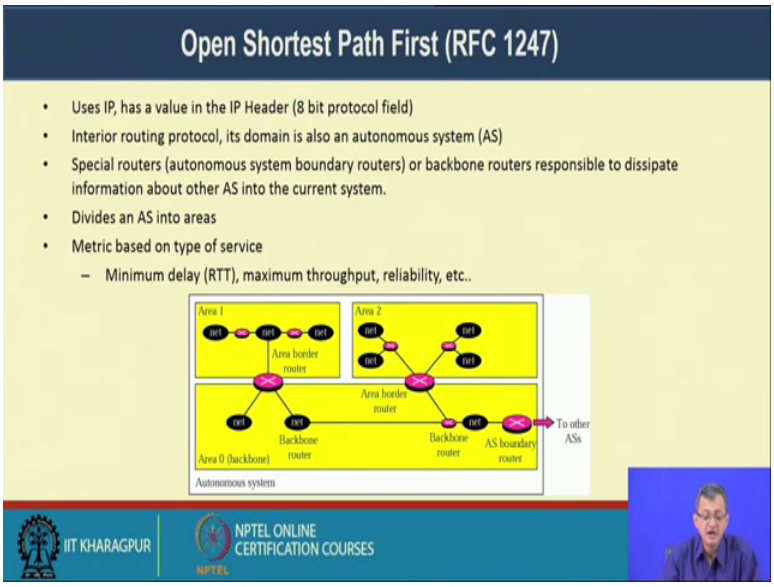

Similarly, for OSPF which is within the border area network; which we have already discussed. So, that is within that particular within the AS. So, it uses the IP and a has a value of the IP header, if you remember there is a 8-bit protocol field. Interior routing protocols, it is domain is also an autonomous system. Special router autonomous system boundary routers, as we have discussed backbone routers responsible for dissipate information across layers in the current system, divides the AS into areas, and metric to be used minimum delay or RTT, maximum throughput and so and so forth.

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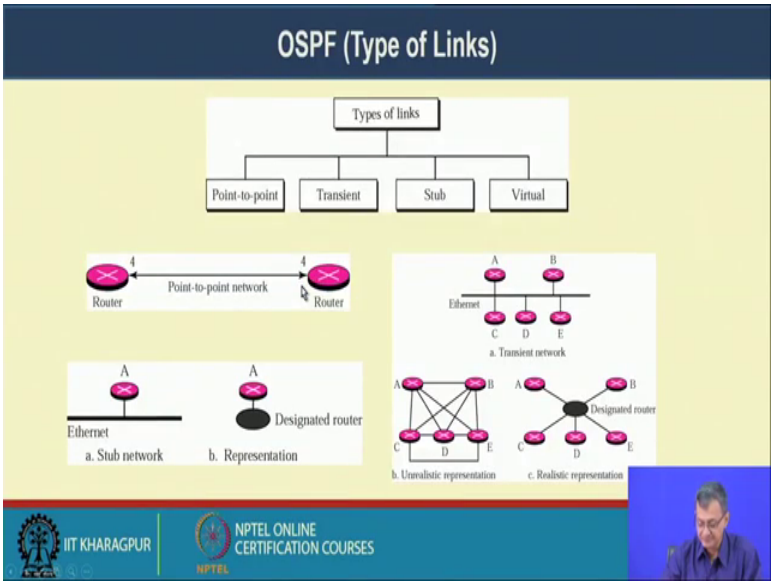

And for OSPF which is based on link state advertisement is there.

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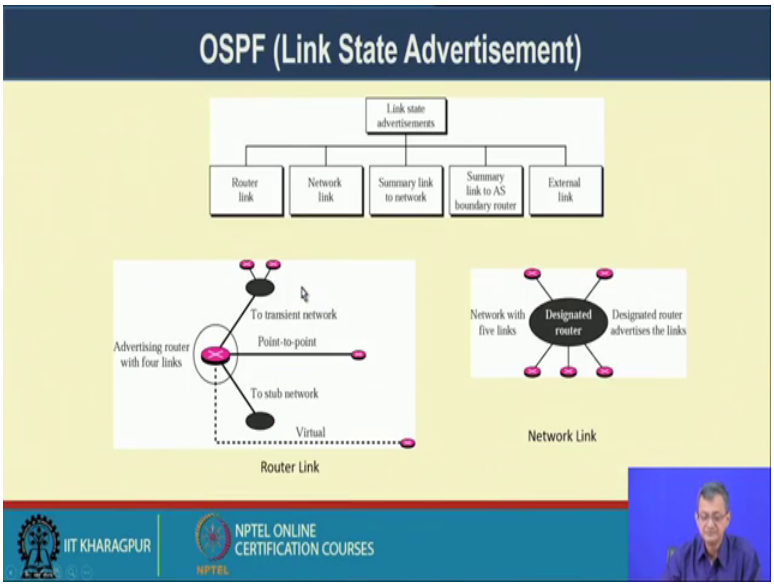

And there are several messages. So, link state advertisement like, router link, network link, summary link to the network, summary link to as boundary router and external link. So, these are the different category of link in the LSS and similarly LSA or OSPF when it is within the router.

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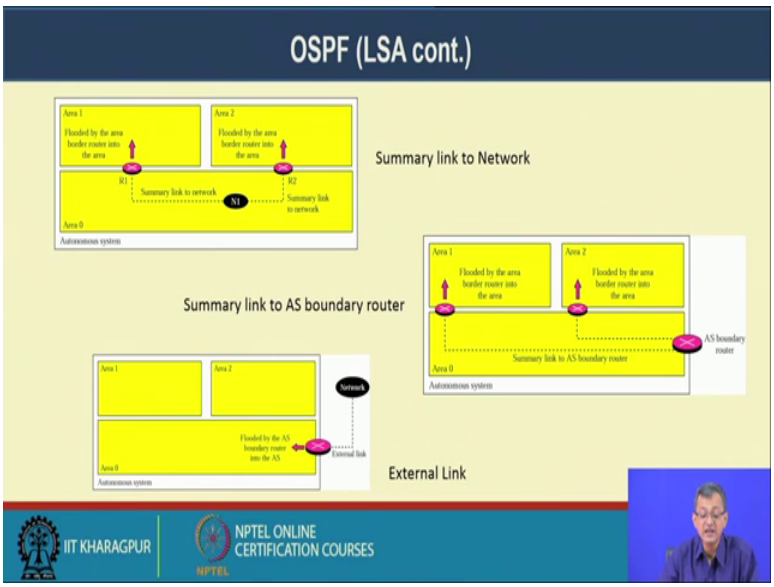

So, summary link it is summary link to the network.

Similarly, for external link it is a for the external network. And this is a summary link to the as boundary routers right. So, there are different summarization or information about the about the autonomous systems are being pumped into the things.

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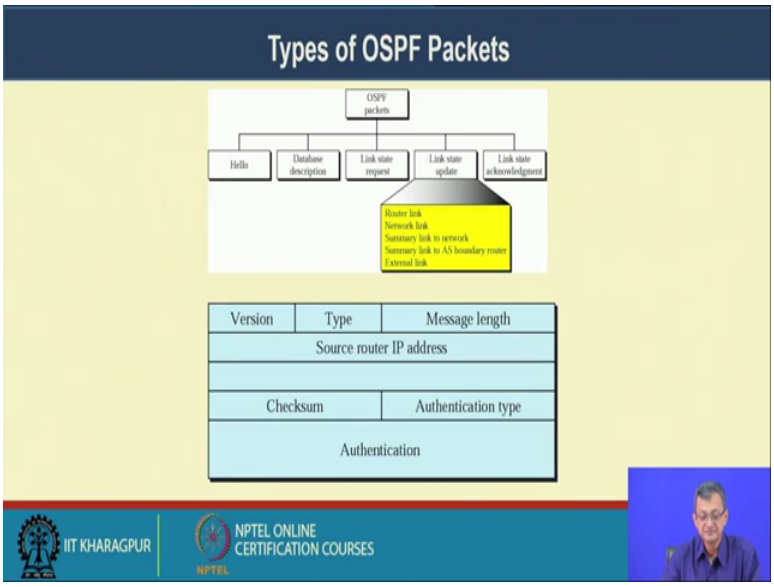

And this is also that what are the different type of OSPF packets. And specially the link state update we require that router link network links summary link to the network summary link to AS, boundary routers which takes care of that summarization of the whole autonomous systems and share with the things, and external links.

And this is the typical format of the OSPF packet.

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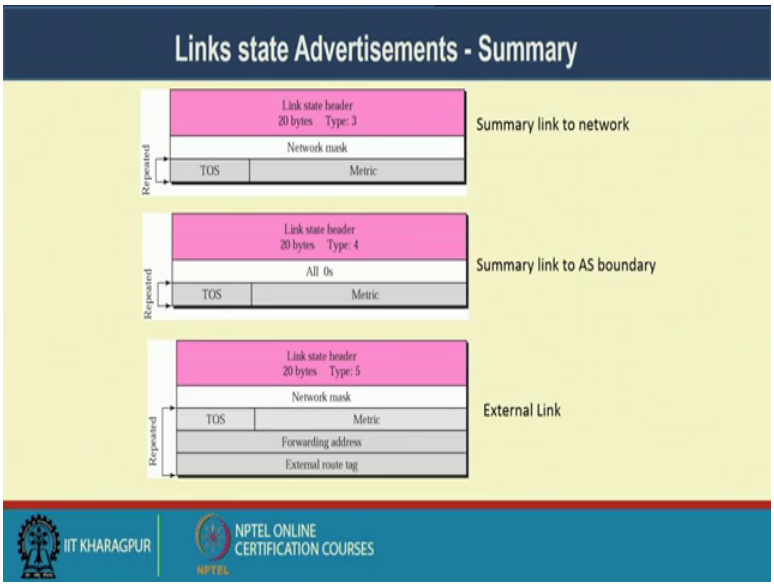

Similarly, we have a link state advertisement or LSA summary, not that that formats or the packet formats; that how it is how the different things the summary linked to network format summary link to AS boundary external link format. So, these are defined formats what he tries to emphasize. So, there is a standardized way of communication between with the messages, and it also helps in talking with several autonomous systems without any with standard messages without any hindrance.

So, with this we let us end our discussion today. In the next talk, we will discuss little more into this BGP protocol to see that how this BGP protocol works and how this overall routing is feasible.

Thank you.