Communication Networks
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Module - 12
Network and Transport Layer
Lecture - 56
Subnet and ARP

So, we have started discussing this IP addressing, IP header, and what is the way easily we can see the IP address, ok? So, we will continue on that. So, basically, what we will try to do today, we will try to see what different kinds of IP addresses are possible and with that, we will be introducing another concept of subnetting; that is available in IP routing, basically facilitate routing, we will see what that is.

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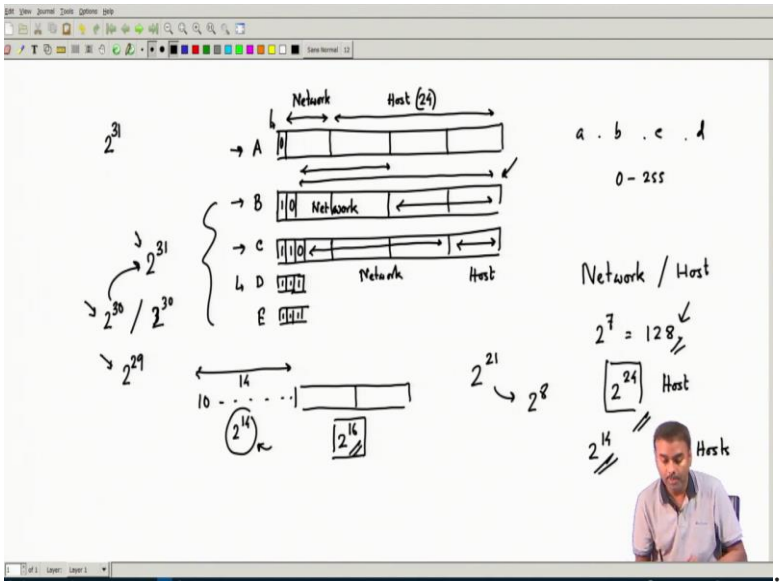

So, basically, we have seen already that IP addresses are generally 32 bits, and out of that 32 bits, we have given this 8-bit, 8-bit demarcation and we put with a three-dot and four decimal a, b, c, d, where each of this a, b, c, d can go between 0 to 255. So, this is something we have already seen. So, this is how IP address addresses are being generally identified; it is easier to identify that way, of course, it will be a 32-bit long binary stream.

But let us try to see now how we can classify IP addresses. So, there are generally if you see there are in fact five classes of IP addresses A, B, C, D, and E; out of them we will be mostly talking about A, B, C, and the others are used for other purpose. So, we will not be discussing them; but A, B, and C we would like to see what it is. So, basically all of them; I will just first draw this 32-bit thing, it is generally each class must be identified separately. What is the method of identifying?

So, it is it starts with one by one bit. So, the first bit if that is 0, then it is always a class A address remember if it starts with 0, then it is always a class A address. If it starts anything other than 0, then it might be class B, class C, class D, class E something like that, ok. So, therefore, the first bit for all others will be 1. Now, B and C will be differentiated with respect to B and others will be differentiated with respect to the second bit. If the second bit is 0, then that is class B.

And if the second bit is 1, that is class C, class D as well as class E; class D also will have both the bits 1, and class E similarly both the bits 1 ok, but anyway class D, E we will not be discussing them. And then, so basically as you can see we are actually from the first bits, we are trying to create a unique pattern. So, the first bit we will resolve; if it is 1, sorry if it is 0, then we know that it is class A and the rest of the bits are free to be allocated, ok? So, the rest of the bits can be allocated in any manner.

So, how many class A addresses can be addressed can be there? So, it is like this, all other 31 bits are free to be allocated. So, 2 to the power 31 total class A address can be generated rest other 2 to the power 31, ok. Among them, if the second bit is 0, immediately it becomes class B. So, how many class B addresses can be generated? So, all the other 30 bits. So, 2 to the power 30 class B, rest 2 to the power 30, sorry 2 to the power 30 can be class C, class D, class E combined.

So, like this, the classifications are being done. So, of course, there are many class A addresses, ok? So, as you can see double the class B address there are class B addresses available and like this, there is a binary reduction. So, class B addresses 2 to the power 30; class C definitely the next one should be 0, and if all others are there that should be 1, ok. So, immediately you can see the rest of the bits.

So, 2 to the power 29 will be class C, and so on. So, basically, as many class A addresses are there, which is 2 to the power 31; half of those there will be class B addresses, half of

that there will be class C addresses and this will continue like this. So, class D will have half of that, class E will have even half of that. So, like this, it continues, ok. So, each of these classes will also have two different fields; one is called the network, and the other one is called the host.

So, why we are trying to do this? It is like this that we will probably identify a particular network; let us say it might be, it might be from a state or from a country or it might be from a particular organization. So, identify a network and all the host IDs will be under that. So, there will be a unique network ID for that.

So, let us say if it is some company, let us say QUALCOMM; then QUALCOMM will have a network ID and then they will buy this network ID. Under this one, once you are buying a network ID; that means the entire possibilities of host under this you are free to allocate them.

So, basically, you are buying that many host IDs. So, how we will generally do it? So, it is like this, over here generally these 7 bits are allocated for the network for class A and the rest of them are allocated as host, ok? So, 7 bit means 2 to the power 7, so 128, such network can be allocated; these are very big organizations, where you can see under which the amount of host that can be allocated is 2 to the power 24 is a huge number. So, this many hosts, because all 24 bits are reserved.

So, basically, you take among these 128 network IDs, you deserve 1 network ID which means actually you are buying the right for 2 to the power 24 host. So, if you are that big an organization, of course, you will have to pay a lot for this network ID, a class A network ID. So, if you buy that, you must have a plan of having 2 to the power 24 hosts or close to that number of hosts. If you are that big of an organization, then you buy one of those network ID and under which this many hosts you can allocate.

So, what will happen? Whatever that unique network ID this 7-bit combination. So, it might be let us say all 0, the last one 1. So, it might be the first five 0, then one 0. So, whatever it is, this unique ID that you will be having is your unique network ID, worldwide this is recognized.

So, whenever suppose you have a network, ok. So, that is your maybe local network or it might be geographically it is first network; but always what will be happening, whenever this network ID is encountered, it will be always routed to your network.

And then inside how you are organizing the host that is your task or your job ok; we will see that also later on, this subnet concept is that only, so creating further hierarchy, ok. But anyway for the time being we can see that this is the kind of distinction ok. If you go to class B, then what happens; this 14-bit is reserved for network ID. So, this is a network.

So, this is for medium-sized organizations, where you have more networks that can be created, 2 to power 14. So, that is quite a big number compared to 2 to the power 7. So, many such networks can be constructed and they are medium size. So, they can at most get 2 to the power 16 host ok, this many hosts are taken. The last one where this entire thing will be network and only 8 bits are host, ok.

So, here these are really small organizations, but they can be very big in number; many such organizations might exist, so that is why your network there are 2 to the power 21 networks that can exist. And each of them might have only 2 to the power 8 or 256 hosts, not more than that. So, these are very small numbers. So, basically, if you just wish to buy a few IP addresses, which is close to around 200, 250 something like that.

So, you actually buy this kind of, you actually go and book one of this class C network ID ok; rest are used for different purposes. So, D is used for multicasting, E is reserved for future use and you can further classify them, classification is similar. So, you are at the initial, you are trying to create a unique case.

So, 0, first bit 0, immediately identify it is class A; first bit 1, it can be anything then you will look for a second bit; if second bit is 0, then it is immediately B you know that. And then the rest of the things will be network and host; you also know for class A how many networks, how many bits are allocated for the network, and how many bits are allocated for the host.

So, this particular sequence is known and you will be aware of what kind of IP address is there, and what class of IP address is this. So, by reading from the beginning first few bits, you will know already what kind of IP address it is, how far it should be network

ID, and what the span or what is the number of bits that represent host ID is, ok? So, now, knowing this different class of IP addresses, what might happen? Sometimes suppose you have taken class B address, ok.

So, class B address means, the first 2 bits will be 1 0; then there will be 14 bits, and you will have a unique ID for that. So, 2 to the power 14 possibilities are there, and one of these IDs will be given to you ok, up to this it is fine. Now, you have these 16 bits of host. So, 16-bit of host you can generate 2 to the power 16 nodes, that is quite big; what you might wish, suppose let us talk about university, ok.

So, it has different departments. So, it has reserved let us say a particular IP address or class of IP address which is a class B IP address, because it knows that it might have quite a few hosts, too many departments, and every department has multiple machines and they all have to be uniquely identified, they must be allocated with some unique IP address.

So, he has gone and reserved one of the class B addresses. So, this 2 to the power 4, 14 will be fixed. So, the first 16-bit him will be fixed IP addresses for each of the stations he has; but for the other 2 to the power 16, he knows that if he randomly gives this, it will be very hard for him to track who is where. If it gives arbitrarily, so everybody will be; means all these addresses will be jumbled up and then really routing the packet through them, you have to go through all the entries to try to see where exactly who are.

Whereas, we can be a little more organized over here. And what is that organization? We can probably create multiple small sectors ok, but that is called the subnet. So, let us say each of the departments of a university is the 1 1 subnet that I want to create; but I want to also uniquely identify them so that I can create a hierarchical routing. So, what does that mean? Let us try to understand this.

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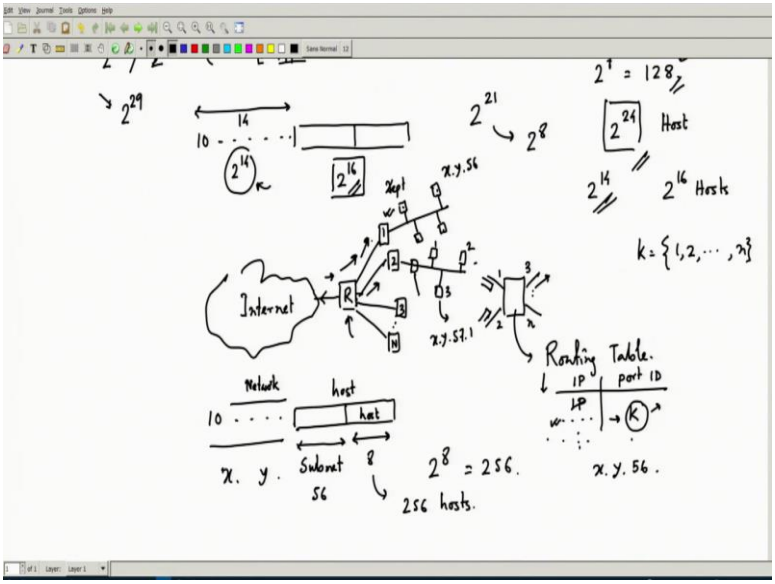

So, I have a router, let us call that an organizational gateway. So, this is where the organization that entire university actually goes out and connects to the outside internet, ok. This router is capable of basically switching things, ok. Now, when he will be switching, let us talk about this routing switching capability; how he does this switching, what it means, and what is the process through which he does switching.

So, what he will be seeing from any side; suppose the router has few ports, let us say it has 4 ports, it can have any n number of ports port 1, port 2, port 3 dot dot dot dot up to n ports, let us say it has n ports, ok. Now, inside the router will be keeping a table, that is called a routing table; it is a software entry, it is a tabular entry and he keeps generally most importantly two columns, ok.

What are those two columns we will come back to that. So, basically what he does is, he tries to see that if I have a particular IP address, ok. So, what is that IP address? That will be the IP address that he is storing in the routing table ok; how he populates that we will discuss later.

So, he stored that IP address; this is a value IP address from means which are allocated to some machine in this entire world, ok. So, he might have to keep a copy of each IP address that has been ever allocated in this world, it might happen that way, but it might not also; he might sometimes just put whatever he has seen so far. So, IP address entries are generally given whatever he has seen so far, and over the other side, he will be

putting a port ID. So, what he does? He puts an IP address ok; that four number 3 dot kind of thing. So, that way we represent the IP address.

And for that correspondingly he will be putting a port ID among these local ports, ok? So, whichever some K, where K is taken from this set of ports. So, K is some 1 to 2 up to n; whatever local number of ports he has, he will be giving a number arbitrary number, some counting number 1, 2, 3, 4, something like that. Then for each of these things, he will be putting a particular port and how he will be putting that something will be explored later on.

But he will also know that port is whenever a packet comes, he will try to open the packet, see the IP header, and try to see the destination header or destination ID. The destination ID will match this IP address. If it matches, then he knows that this packet has to be forwarded to if he has an entry of K, then K-th port.

And this K-th port he puts, because he knows that locally if he routes it to the K-th port; that is the shortest route from him to whatever destination you are specifying over this IP address. So, for reaching that IP address or for reaching the host or destination having that IP address; the shortest path from this local router is assumed to be routing it through the K-th port. We have already discussed that the router only decides locally.

So, over here in this node, what he has to do is what he is keeping and like this, he will have multiple entries, for every possible IP address he must have an entry. So, what will be happening? Router whenever he gets every port, he will be getting sub packets, ok. So, those packets whenever he has to route, he will actually open those packets, see the destination ID, and search through the routing table.

Wherever he gets a match of IP address, he tries to see the port and in that port, he forwards that packet. And the packet goes out through that packet because it is supposed to be the shortest path; we will see how short it means, the IP layer or all these routers calculate what is the shortest path.

There are algorithms to do that the extra Bellman-Ford and many other algorithms. So, we will talk about one or two just to understand these things. So, we will also see how they construct this routing table. So, this will be the routing table population; but while

doing the routing, he will only see these things and route things. Now, over here he might also have multiple ports ok, this is routers.

So, this is the gateway router for that organization, let us say that institute; but now what you want to do is, you want to actually from this router, you want to put it to multiple routers. 1, 2, 3 dot dot dot dot up to capital N, all these routers are for a particular department and this department must have some ID, which is uniquely identified from the IP address.

This is something we want to see how we can do that that is where the trick of subnetting comes into the picture, ok? So, that is something we will try to do, how do we classify this one unique network ID that has been taken by this organization or the institute or university and from there this 2 to the power 16 host; now how they can be classified into smaller classes like departments or something else whatever you want to call them, ok.

So, we will try to see how that can be done by allocating the addresses properly and then configuring the routing routers. So, that they can identify which class of address belongs to over here, very quickly they can route; they do not have to really go through all the things. So, let us try to see what they do.

This class B address we have talked about; so it is 1 0 and then 14 bits are ok. So, that is fine. So, after that, you have this 8 and 8, 16 bits are there, ok. So, let us say this host I further subdivide; like the network and host has been divided, the host also I will further subdivide. So, let us call that first 8 bits are termed now as initially, this was network; this is subnet or sub-network, ok.

So, it is under this network you are classifying it. So, now, subnet how many; if 8 bit we put, so 2 to the power 8, that means 256 such subnet you can create. And for each of these subnets how many hosts now he can get? So, these are the actual hosts now, ok? How many hosts he can get? He can get 8-bit, so basically 2 to the power 56 host. So, each of the subnets are unique ID given to each department.

So, these routers will be responsible for each of those subnets, let us call that, ok? And over here probably there might be a LAN, Ethernet LAN or some other things, some other access technology which can be over here, each machine will have its own ID, but

that will be; with that suppose this department has a subnet ID of let us say 56, then these all these machines will have, the first two things are fixed. Let us call that suppose 1 0 and then something whatever that happens, let us call that x dot y, ok.

So, and that is x, this x dot y has been bought by this organization. So, every IP address will be starting with that x dot y; it is a class B address, and then the next thing will be 56 for this department. But if you go to this department, he might also have a LAN, and each of these machines actually will have their own IP address in the third one.

So, x dot y dot he might have 57. So, this might be 57 dot whatever host ID; this might be 1, this might be 2, this might be 3. So, dot 1, then dot 2, dot 3, and so on, 256 maximum host you can put. Of course, you can understand also, over here if the span is too big; even inside the department if the span is too big, then we can put bridges, over here we can put bridges and we can actually connect multiple this kind of means LAN.

So, multiple LANs are connected through a bridge; then they can get connected to a router, which is the departmental router and that is the subnet, ok. So, basically, what will happen? Now any IP address that is coming over here; as you can see, will be always, if it has to be forwarded over here, this must-have IP address x dot y dot.

Now, if I have 56, I must forward it over here; if I have 57, I must forward it over here. So, that is the advantage I get. I do not really have to keep track of every host, I do not need that, the last one whatever it is this router does not have to know that. So, he has to just forward; if he sees 56, he has to forward to router 1. Then router 1 might go and decide where exactly he has to forward, and which particular one he has to forward these things to. How that is being done that also we will be discussed later on.

This is the subnetting that they do, but how from the IP address this particular router will know how far I have to look? So, because I already know what is how much, and how many bits I have allocated for subnetting; they can construct a subnet mask, they call it a subnet mask.

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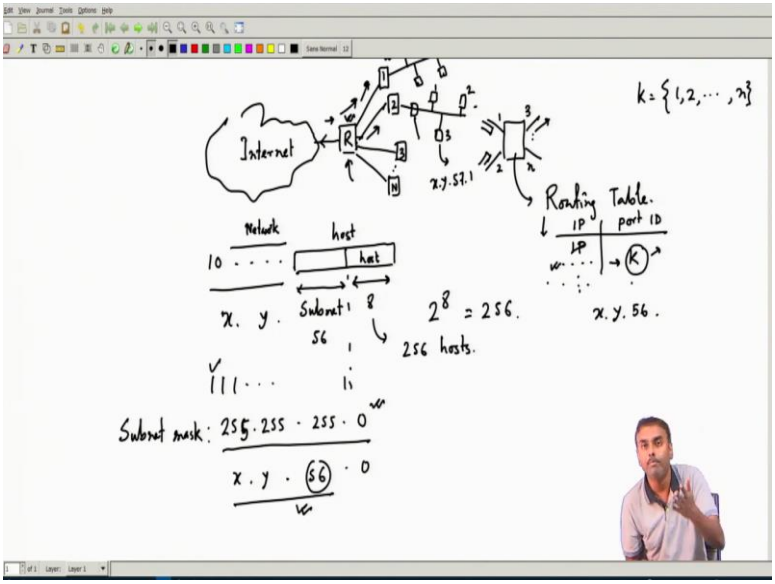

So, basically what they will do? They will put 1 for all of them and 0 for the host. So, basically, they will put 1 1 everywhere, up to this subnet; that means up to 24 bits. So, it will be always 256 or 255 dots 255, and for the rest of the things they will put 0, ok. So, this is called the subnet mask.

So, in the routing table, they will also have, these things these entries. So, basically what they will do? They will know that this is the subnet mask to operate inside the organization, the router knows that. So, he has that information, he will be having this subnet mask. So, what he will do? If he has to forward any packet to this side. So, he will first basically with the subnet mask, he will be actually ending the actual address.

If he does that what will happen? Whichever is 0 that will be masked, that will never come. So, this will be always 0 ok; only over here whatever address comes that will be coming. So, if suppose x y 57; because these are all 1, if I do ANDing, they will be whatever value it has that will come over here. So, each bit by bit ANDing AND operation if I do, so this is always 1. So, whatever is over here that will be coming over here. So, if it is one, it will be one; if it is 0 that will be 0.

So, if I have x, x ANDing with 255, that will be that 8-bit corresponding ANDing that will give me x. So, x dot y dot 56 if that comes over here, then immediately he knows; because the host IDs are not important now. So, he will take this subnet mask, and

operate it on the address; he will try to see what are these first three bytes actually of the IP address.

In his routing table, only this entry will be there, not for every host; because if for every host you put an entry, there will be 256 entries. Then your searching becomes mean takes longer; because every host will have an entry, you will have to search the entire address for every host which is too much searching. But if you have a subnet and corresponding subnet mass that you know; so basically you do that; you mask the host and then just try to see what is the subnet ID.

Looking at that then you know which router he has to forward to, and which particular subnet he has to choose. And all these associated IDs will be allocated addresses that are of that subnet. So, therefore, that must have this third byte specified as 56, if that is the subnet ID; the fourth one will. So, this one will be all with 57 and then they might have host IDs; does not matter, because this router will get.

Now, this router is because he knows the only thing that is getting forwarded to him; if it is from his subnet, otherwise it will not be forwarded. So, for him, it is very easy. So, he tries to see, if he can mask everything; he can see only the last 8 bits and then only those 8 bits how many hosts can be generated, that many hosts only he will be keeping in his routing table.

So, the routing table becomes much smaller and every router does not have to do all the job. So, it is a higher hierarchical routing that will be happening, and the addresses are very nicely geographically allocated; similar kinds of addresses are geographically allocated in a similar position with respect to the network construction.

So, this is what generally people do and that is the concept of subnetting, subnet mask, and associated that host ID and subnet ID that you have and this is how the routing is being done, ok. So, after discussing this, in the next class what we will try to do? We will try to discuss another very important concept and this is where you will see how layer 3 is talking to layer 2. So, we have talked about these above and below layers talking to each other.

So, in that particular portion, we will try to see, how these addresses are resolved whenever we are trying to communicate to somebody. So, this is something we will see

in how layer 2 and layer 3 operate together to resolve these things through address resolution protocol or ARP.

Thank you.