In all the examples we have used for how routers work, they have all been linear, it went from R1 to R2 etc in a line. But typically, routers are connected in a hierarchy like this:

A diagram of a network

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Routers in a hierarchy are easier to scale and enable more consistent connectivity. This can be explained with the example of imagine the Tokyo network had 2 more networks, accounting and helpdesk:

A diagram of a network

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In this case a router is added to each of the networks to control traffic for each network, and each router is connected to one router (the one that connects all 5) and now those 2 networks have access to the rest of the networks in the diagram.

To understand why a hierarchical router structure enables more consistent connectivity lets show an example where the routers are structured lineally:

A diagram of a network

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If someone from the sales team wants to send data to someone on the marketing team they only have to cross 3 routers, but now if someone from the sales team wants to speak to someone on the helpdesk team, they need to cross 5 routers. The same happens if any of the networks need to send data to the internet, the engineering team only needs to cross 3 routers to send data to the internet, whereas the helpdesk team needs to cross 6 routers to send data to the internet.

Also, if some sort of failure happens at the marketing router, it cuts of access for the networks under it to send data. However, these problems are solved when your routers are deployed in a hierarchy.

Pic from before:

A diagram of a network

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If something happens to the marketing router, the other routers can still send data to the one router which connects all the routers for Tokyo and send data to the other networks. And if the sales team wants to speak to the engineering team it only has to cross 3 routers, the same goes for the other teams on the Tokyo network, the teams only need to cross 3 routers to speak to each other. And for any team to send data to the internet, they only need cross 2 routers.

A diagram of a network

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Let’s focus on router R5, lets look at R5’s routing table. In this network structure we have 6 networks and R5 is going to need a route for every network. There will be 3 networks to account for the 3 teams in Tokyo pointing to R6, R7, R8. Then 3 more networks for the teams in new York each pointing to router 4:

A table with numbers and arrows

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Let’s talk about the /24 and explore its meaning. /24 means that we want to match the first 3 octets on an IP address: ###.###.###.#### so /24 refers to the bits in the IP address. IP addresses are 32 bits broken into 4 different octets and each octet is represented as a decimal number: (next page)

A computer code and a computer tower

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So /24 would be referring to any IP address matching 136.22.17.x

This is useful because lets say a packet showed up to router 5 with the DST IP address of 10.40.77.9, each of the routes would look at the first 3 octets to find a match:

A table with numbers and arrows

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As we can see the third one is a match so it would be forwarded to router 8. Now notice in R5’s routing table, the last 3 IP addresses all point to R4 (the 3 network teams in the New York office). Everything in the New York office starts with 10.20 so we can simplify these 3 routes into 1 route which tells router 5 to only look at the first 2 octets (10.20.x.x) to then forward the packet to router 4. We can do this by instead of the separate 3 routes, we can have one which says

10.20.0.0 /16 ---> R4:

A table with numbers and arrows

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The /16 means to find a match in the first 2 octets, and if it matches, forward the packet to R4, then R4 can forward it to the next appropriate router. So if R5 received a packet with the DST IP address of 10.20.77.9, since it has 10.20 as the first 2 octets, this packet would be sent to router 4 for delivery. This is known as route summarisation.

Going back to the image of the router structure:

A diagram of a network

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Let’s look at router 8 and its routing table. One of the networks is directly connected to R8 which is the 10.40.77.x network which is the marketing team on Tokyo. Then R8 will have 2 more routes for the 2 other teams in Tokyo which point to R5. Then it will also include the 3 teams on New York which all point to R5:

A table with numbers and arrows

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Just like before we can summarise the bottom 3 into one route which is 10.20.0.0 /16 --> R5. Lets look at the position of R8, whether a packets from R8’s DST is to New York or Tokyo, the next hop is to the R5 router. So we can merge all the routes pointing to R5 into one route which will be 10.0.0.0 /8 ---> R5. So if a packet from R8’s has a DST IP address to 10.x.x.x, it will forward it to the R5 router. And it could be a DST to Tokyo or New York.

A screenshot of a computer

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But what if a packet shows up on R8 with the DST IP address of 10.44.77.x. both routes match so where would the packet be forwarded to? It would be forwarded to the 10.40.77.0 /24 route to DC because its more similar, since its /24 it has a priority of similarity, so it gets forwarded to that route to direct connect.

However we must account for if R8 wants to send anything to the internet, it will also have to hop to R5 first. For this we can remove the 10.0.0.0 /8 ---> R5 entry and give it a default route of 0.0.0.0 /0 ---> R5. Meaning every packet with the DST IP address that isn’t from the 10.40.77.0 network will be forwarded to the default route which is R5, then R5 will handle the rest whether that means its going to a different team in the Tokyo network, or if its going to one of the teams in the New York network, or if its going to the internet.

A screenshot of a computer

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