Router
with NAT
1Gbps

Internet

10GbE

ISP
250Mbps

L3 Switch
VLAN
2.5Gbps

L2 Switch
10Gbps

10GbE

PC 1
10Gbps

PC 2
10Gbps

PC 3
10Gbps

PC 4
10Gbps

VLAN 1

VLAN 2

Figure 1

You have been given the network of Figure 1. The description of the network is the following:

- Each of the 4 PCs is equipped with a 10Gbps network adapter.
- The 4 PCs are connected via CAT6 ethernet to an L2 switch, which supports 10Gbps per port.
- PC 1 and PC 2 are in VLAN 1, while PC 3 and PC 4 are in VLAN 2.
- The L2 switch is connected to an L3 switch that supports VLANs, via a CAT6 ethernet cable. The L3 switch supports 2.5Gbps per port.
- The L3 switch is connected to a router with NAT, via a CAT6 cable and it supports 1Gbps.
- You are paying your ISP to provide you with an internet connection of 250Mbps.

Answer the following questions:
1) What is the bandwidth between PC 1 and PC 2? Why?
2) What is the bandwidth between PC 3 and PC 4? Why?
3) What is the bandwidth between PC 1 and PC 4? Why?
4) If there was no L3 switch, and the L2 switch was directly connected to the router with a CAT6 cable, what would be the bandwidth between PC 1 and PC 4? Would your answers to questions 1 and 2 change?
5) What is the bandwidth between any of the four PCs and the rest of the internet?
6) Suppose you changed ISPs, and the new company provides you with 2.5Gbps internet connection. Which part(s) of your equipment do you need to change in order to get a 2.5Gbps link from your PCs to the rest of the internet?
7) Which part(s) of your equipment do you need to change in order to get a 10Gbps link between PC 1 and PC 4?

Answers

This is relevant to all the answers below: a CAT6 ethernet cable can support 10Gbps. It will not be the bottleneck of any of our connections.

1) The bandwidth between PC 1 and PC 2 is 10Gbps. These two computers belong to the same VLAN, so the packets don't need to get outside of the L2 switch, which can support the 10Gbps bandwidth. In other words, the packets will be sent to the L2 switch, and they will be routed to the correct destination by MAC address. IP addresses (which belong to layer 3) will not be needed, because PC 1 and PC 2 are part of the same VLAN.
2) The bandwidth between PC 3 and PC 4 is 10Gbps. These two computers belong to the same VLAN, so the packets don't need to get outside of the L2 switch, which can support the 10Gbps bandwidth. In other words, the packets will be sent to the L2 switch, and they will be routed to the correct destination by MAC address. IP addresses (which belong to layer 3) will not be needed, because PC 3 and PC 4 are part of the same VLAN.

3) The bandwidth between PC 1 and PC 4 is 2.5Gbps. Since these two computers do not belong to the same VLAN, the IP addresses of the packets will need to be read. An L2 switch does not forward packets based on IP addresses, so the packets will be sent to the L3 switch. The L3 switch has a maximum bandwidth of 2.5Gbps, which will be the final bandwidth of this connection. The packets do not need to be forwarded to the router, since the L3 switch supports VLANs.

4) If there was no L3 switch, and the L2 switch was directly connected to the router with a CAT6 cable, the bandwidth between PC 1 and PC 4 would be 1Gbps. The router is the only device that is capable of routing packets between different VLANs (can recognize IP addresses), so the maximum bandwidth will be that of the router. The packets do not need to be sent to the internet, so our internet bandwidth is irrelevant. If I wanted to maintain the 2.5Gbps bandwidth between PC 1 and PC 4, in the absence of the L3 switch, I would need to replace the router with a router that supports 2.5Gbps.
My answers to questions 1 and 2 would not change. In both cases, we have intra-VLAN communication, so the packets will be routed based on MAC addresses and will never leave the L2 switch, which supports 10Gbps.

5) The bandwidth between any PC and the internet is 250Mbps. Although we have a bandwidth of 10Gbps to the L2 switch, a bandwidth of 2.5Gbps to the L3 switch, and a bandwidth of 1Gbps to the router, the limiting factor (bottleneck) of the connection will be the bandwidth the ISP gives us. We are paying our ISP for a 250Mbps internet speed, so this is the bandwidth we will get.

6) If we changed our ISP and got an internet connection with 2.5Gbps bandwidth, the bottleneck of the connection between the PCs and the rest of the internet is our router. The only change we would need to make is to buy a router that supports 2.5Gbps.
Note: you cannot completely remove the router and directly connect the ISP to your L3 switch. Although the L3 switch supports VLANs, it does not have a NAT, so only one of the PCs will be able to connect to the internet.

7) As explained in question 3, the limiting factor in inter-VLAN communication will be the L3 switch, because all packets between PC 1 and PC 4 will need to be routed through it. Therefore, we would need to purchase an L3 switch that supports 10Gbps per port and VLANs. In that case, we could completely eliminate the L2 switch.