Homework I

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Question 1. IP Addressing and Subnetting

a) To configure B and C as a subnet, it takes at least two available IP address, plus the reserve address for broadcast and the subnet itself. So it would be a subnet with subnet mask of `30`, or in dot-decimal notation of `255.255.255.252`. In conclusion, the number of addresses available for the Ethernet would be reduced by four.

b) As ARP proxy, B would pretend to be C in front of A.

i. Packets send sequence would be like table 1.

Table 1: All Packets Sent

Message Type	Sender	Sender's MAC Addr	Sender's IP Addr	Target MAC Addr	Target IP Addr
ARP Req	A	A's MAC addr	A's IP	00-00-00-00-00-00	C's IP
ARP reply	B	B's MAC addr	C's IP	A's MAC addr	A's IP
IP msg	A	A's MAC addr	A's IP	B's MAC addr	C's IP

ii. To implement the proxy ARP, B's routing table need to add rules that for for all received or generated packets destination at C's IP address, the packets would go through the WIFI interface. And for packets received from C with destination address not B, B would forward the message to the Ethernet interface.

Question 2. CIDR

If the router actually containing that subset failed, the connected router would detect that the link become unavailable and delete the "correct" routing policy. In the meantime, all the packets with the destination of that subset addresses would be forwarded to the router advertising the "big" address blocks, since it's the only matching one, which lead to the wrong domain.

Question 3. Internet Basics

a) The core router need to know the actual network number since the router still based on the routing table to forward a packet. Because the packet only contains a destination IP address, it does not contain the AS number it wants to go to. In other word, BGP only helps the router to build the routing table, it do not generate its own forwarding table.

b) In theory, network administrator could redistribute all of the EBGP routes into the IGP. However, this is not recommended because of the large number of EBGP routes in the real Internet might cause the IGP crashes. By setting up iBGP among routers within an AS, and inject a default route (or boarder router pretend to have direct link with destination), the internal router could learn the best border router to use when sending a packet to any address.

c) Firstly, advertising the entire AS-path would make routing loop easily detected. Secondly, sometimes network administrator might want the network traffic go through specific path due to some policy decisions. Only by know the entire AS-path can such requirement be fulfilled.

d) Internet supports broadcast. Routers in Internet are able to forward broadcast messages to each LAN. It's LAN's duty to continue the broadcast in its network segments. Thus it is necessary for the LAN to be able to do a broadcast.

Question 4. Routing Policies

a) E would be willing to accept advertisement from D to maximize its monetary. Since if E accept from B, it would increase expenses. And if E accept from C, there will be no profit, since C is a peer.

b) To enforce E accept advertisement from C, network administrator could set up a higher local preference.

c) E would prefer A to use AS level path $A \to D \to E$. Because receiving traffic from D would increase profit via providing service to D.

d) To cause the traffic to propagate on path $A \to D \to E$, E can prepend its AS path towards B and C to make the path longer. That is, instead of advertising AS path [E], E can advertising a longer AS path [E,E] to both B and C, and advertising the original AS path to D. By doing this, A would receive AS paths as:

- [B,E,E] from B,
- [C,E,E] from C,
- [D,E] from D.

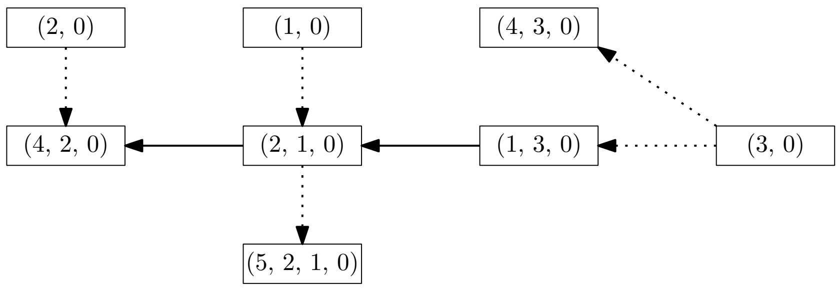
A would choose the shorter one, $A \to D \to E$.

e) B, C and D should have at least the same local preference at AS A.
If, otherwise, local preference of D is lower, path $A \to D \to E$ would be discarded in the first place.

Question 5. Dispute Graphs

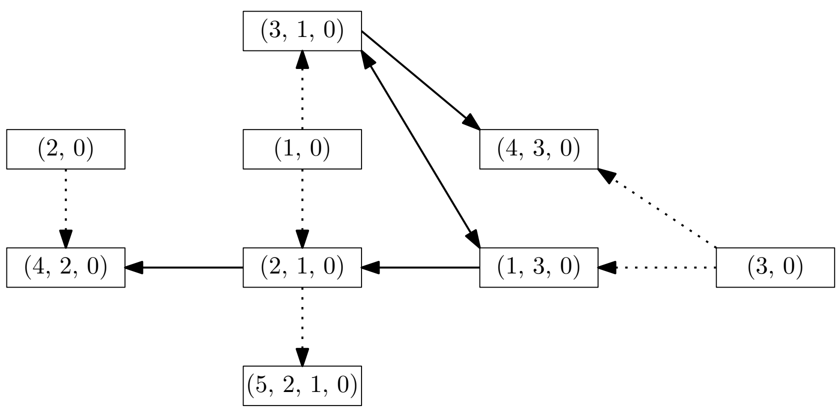
a) The dispute graph for the system is shown in fig. 1.

Figure 1: Dispute Graph for Original System



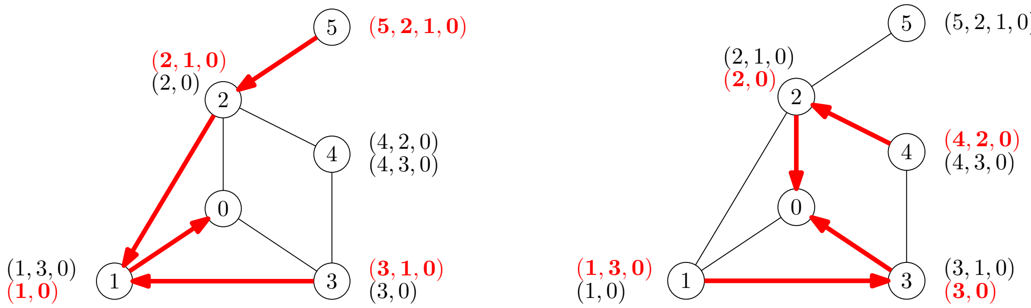
b) The dispute graph for the new system is shown in fig. 2.

Figure 2: Dispute Graph for New System



c) i. After adding path $[3, 1, 0]$ to the system, AS0, AS1 and AS3 became a DISAGREE. Since the rest of the system contains no dispute cycle, based on the DISAGREE we know that the system have two stable state as shown in fig. 3.

Figure 3: Two Stable State of the System

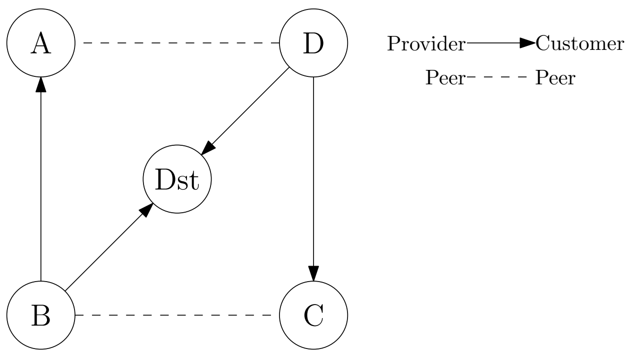


ii. The system would always converge.
We know that a DISAGREE would converge even though it contains a dispute cycle(wheel). And the system now has no dispute cycle(wheel) other than the DISAGREE. Thus, we can conclude that the system would always converge.

Question 6. Hierarchical BGP

Consider network shown in fig. 4, with destination *Dst*.

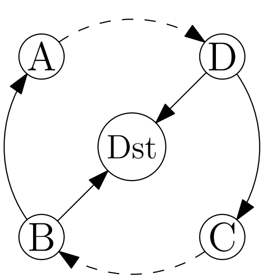
Figure 4: Example



B is provider to A and Dst, D is provider to C and Dst. By export policies, B would export its path to Dst to A, and export its path to A and Dst to C. The same situation falls on D. Thus, C would learn a path to Dst through B.

Based on local preference, D might prefer C than Dst since both of them are customers. And C might prefer B than. Since both of them are not customers of C, C can choose any of them. On the other hand, A might prefer D than B. In this way, it might result in not acyclic graph and dispute wheel, as shown in fig. 5.

Figure 5: Dispute Wheel Example



Question 7. Ethernet Multicast

a) If the membership reports only flooded some network segments, those bridges which does not receive the report will not know whether its connected LANs have multicast group members. In this case, if that bridge received a multicast message, by default it will not forward it to any connected LAN.

b) It is not possible for Ethernet multicast use flood-and-prune approach for several reasons:

- Ethernet network segments are connected by bridges, while Internet segments are connected by routers. Bridges record the outgoing interface for the hosts, while the routers keep a routing table including information about next hop and cost. A key method used in DVMRP is using the unicast routing table to figure out whether the LAN is a child on the tree. Bridges can't do that.
- Besides, bridge cannot determine whether a connected network segment is a 'child link' or a 'leaf link'. In DVMRP, this is achieved via *split horizon with poisoned reverse*. However, bridges in Ethernet do not exchange routing informations.

Question 8. Reverse Path Flooding

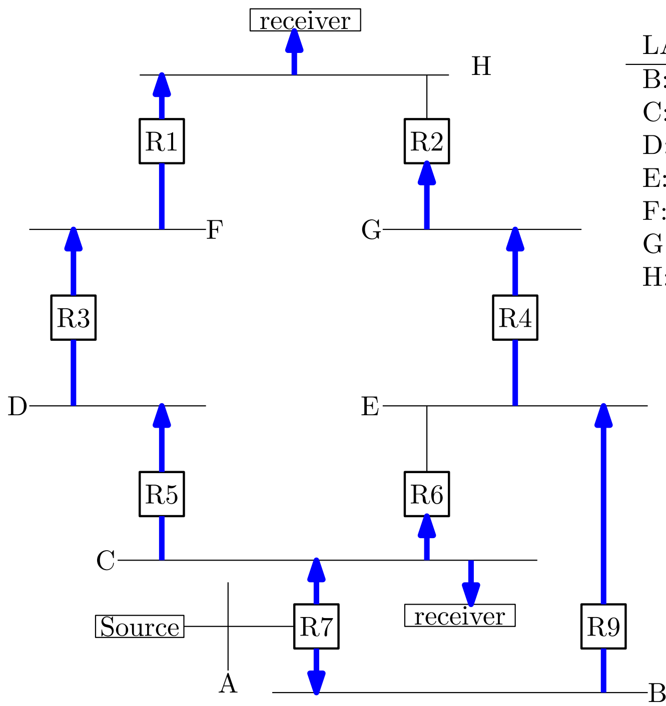
a) In distance vector routing, routers will exchange each other's distance vector. So a router would know its neighbor's distance to the source. If neighbor's distance to source is smaller than the router's distance plus the cost between them two, there is apparently no need to send the broadcast messages to that neighbor, because the neighbor must have a shorter path to get the that broadcast message.
In this way, each router would receive the broadcast message only once.

b) In link-state routing, each router could compute the shortest path to every LANs. Thus the router only need to send broadcast message to those paths and routers along that path would forward the message to the rest of the network through their computed shortest paths. Apparently, if the shortest path to some LANs is through the incoming interface, that LAN don't need current router to forward the broadcast message.
In this way, each router would receive the broadcast message only once.

Question 9. DVMRP

i. The path of broadcast is shown in fig. 6. Parent router for each LAN is marked in the figure.

Figure 6: Path of Broadcast Messages

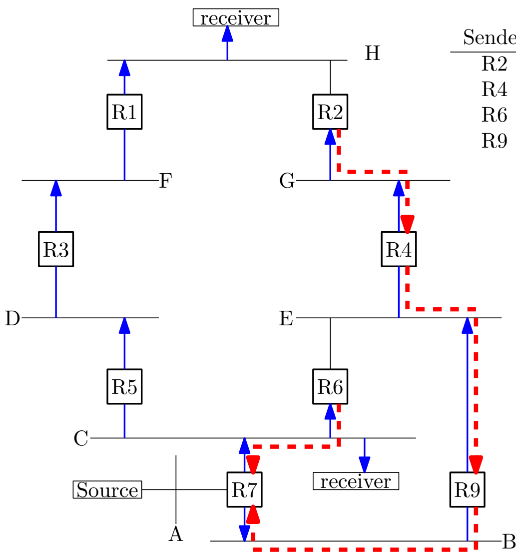


LAN:	Parent Router
B:	R7
C:	R7
D:	R5
E:	R9
F:	R3
G:	R4
H:	R1

ii. In Truncated Reverse Path Broadcast, only LAN G is a leaf LAN. Because R2 does not need to send broadcast message to LAN H, and LAN G itself does not have a group member host.

iii. Non-Membership Reports are shown in red dashed line in fig. 7.

Figure 7: Non-Membership Reports



Sender	Destination
R2	R4
R4	R9
R6	R7
R9	R7

iv. After pruning, LANs over which multicast messages from S are sent to are: `C D E H`, as shown in fig. 8.

Figure 8: After Pruning Message Flow