

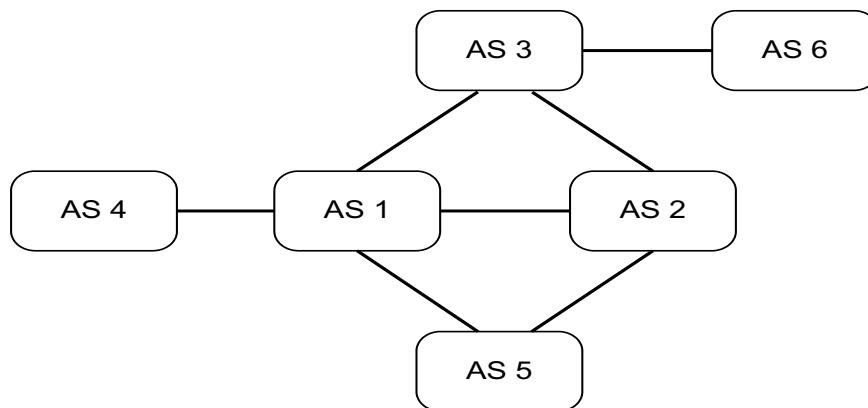
ECE 461 – Internetworking

Problem Set 5

Problem 1. Policy Based Routing in BGP

The figure shows a network with six autonomous systems. AS4 “owns” the prefix 10.0.1.0/24 and sends an advertisement to AS1 with the following prefix, and ORIGIN and AS-PATH attributes:

10.0.1.0/24, ORIGIN{AS4}, AS-PATH{AS4}.



- a. Assume that no routing policies are employed (i.e., no advertised routes are selectively ignored and all known routes are advertised). Explain how the other autonomous systems process and disseminate the advertisement for prefix 10.0.1.0/24. Indicate which autonomous systems advertise the prefix to their neighboring autonomous systems. Provide the ORIGIN and AS-PATH attributes used in the advertisements.
 - b. Now consider that autonomous systems AS1, AS2, and AS3 are transit networks, and AS4, AS5, and AS6 are stub networks. For each autonomous system, explain how the processing and advertisement for prefix 10.0.1.0/24 should be changed (compared with your answer to (a)).
- a.
- Without policies, an AS (say AS X) advertises the prefix to all its neighbors, unless AS X is contained in the AS-PATH
 - When a node advertises the prefix it pre-pends its own AS number to the AS-PATH.
 - When the advertisements are done, all nodes learn about all feasible paths to AS4.

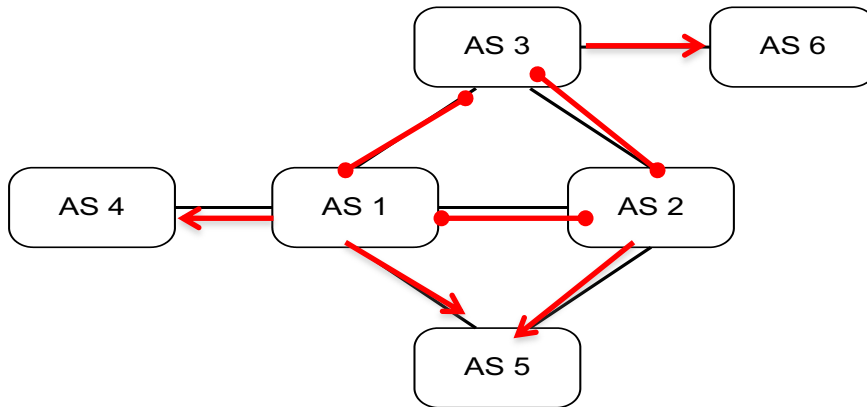
AS-4 to AS 1:	10.0.1.0/24, ORIGIN{AS4}, AS-PATH{AS4}
AS-1 to AS-3:	10.0.1.0/24, ORIGIN{AS4}, AS-PATH{AS1, AS4 }
AS-3 to AS-2, AS-3 to AS-6:	10.0.1.0/24, ORIGIN{AS4}, AS-PATH{AS3, AS1, AS4}
AS-2 to AS-5: AS-2 to AS-1:	10.0.1.0/24, ORIGIN{AS4}, AS-PATH{AS2, AS3, AS1, AS4}
AS-5 to AS-1:	10.0.1.0/24, ORIGIN{AS4}, AS-PATH{AS5, AS2, AS3, AS1, AS4}
AS-1 to AS-2:	10.0.1.0/24, ORIGIN{AS4}, AS-PATH{AS1, AS4 }
AS-2 to AS-5: AS-2 to AS-3:	10.0.1.0/24, ORIGIN{AS4}, AS-PATH{AS2, AS1, AS4}
AS-3 to AS-2, AS-3 to AS-6:	10.0.1.0/24, ORIGIN{AS4}, AS-PATH{AS3, AS2, AS1, AS4}
AS-1 to AS-5:	10.0.1.0/24, ORIGIN{AS4}, AS-PATH{AS1, AS4 }
AS-5 to AS-2:	10.0.1.0/24, ORIGIN{AS4}, AS-PATH{AS5, AS1, AS4}
AS-2 to AS-1: AS-2 to AS-3:	10.0.1.0/24, ORIGIN{AS4}, AS-PATH{AS2, AS5, AS1, AS4}
AS-3 to AS-1, AS-3 to AS-6:	10.0.1.0/24, ORIGIN{AS4}, AS-PATH{AS3, AS2, AS5, AS1, AS4}

b. Policies are added:

AS4, AS 5, AS6 : a stub network does not advertise any network other than those originating in the stub network

AS 1, AS2, AS3, → transit networks with peering relationships do not advertise path that they have received from a peer to another peer.

The figure below indicates the customer-provider and peer relationships.



AS-4 to AS 1: 10.0.1.0/24, ORIGIN{AS4}, AS-PATH{AS4}

AS-1 to AS-3,
AS-1 to AS-2,
AS-1 to AS-5:

10.0.1.0/24, ORIGIN{AS4}, AS-PATH{AS1, AS4}

AS 5 will not advertise the path since it is a path network

AS-3 to AS-6: 10.0.1.0/24, ORIGIN{AS4}, AS-PATH{AS3, AS1, AS4}
AS3 does not advertise to AS2 since AS2 is a peer.

AS-2 to AS-5: 10.0.1.0/24, ORIGIN{AS4}, AS-PATH{AS2, AS1, AS4}
AS2 does not advertise to AS3 since AS3 is a peer.

Problem 2.

Suppose a BGP router sees the following two advertisements for destination network 10.0.1.0/8:

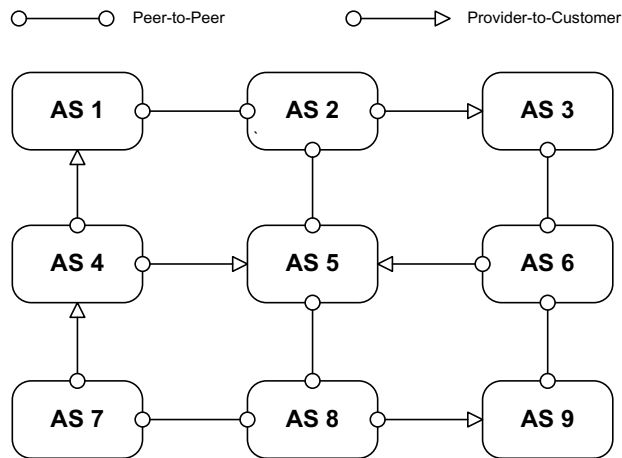
- 10.0.1.0/8, AS-PATH { 202, 101, 89, 59}
- 10.0.1.0/8, AS-PATH { 876, 32}

Explain how the second advertised AS-PATH could result in a longer route.

Solution: The first route traverses 4 ASes, the second route only one AS. However, the length of the route is determined by the number of routers traversed. This information is not contained in BGP Update messages.

Problem 3. (15 Marks) BGP

Consider the network of autonomous systems shown in the figure. The edges indicate the peer relationships and the customer/provider relationships between the autonomous system (For a customer-provider relationship, the circle indicates the provider and the triangle indicates the customer).



- a. (10 Marks) Determine if the following pairs of autonomous systems can exchange traffic with each other via a BGP route. For each case, briefly explain your answer. If a route exists, provide the likely routing path between the autonomous systems. If a route does not exist, provide the reason.
- a1) AS 1 and AS 9.
 - a2) AS 2 and AS 8.
 - a3) AS 7 and AS 3.
 - a4) AS 4 and AS 6.
 - a5) AS 1 and AS 6.
- b. (5 Marks) Suppose that the relationship between AS 2 and AS 5 is changed to a provider-to-customer relationship, with AS 5 as provider and AS2 as customers. Which of your answers to part (a.) change and which remain the same? If an answer changes, provide an explanation (give a reason if a route does not exist and provide the route when a route exists).

The answers should be based on the following principles:

- Peers perform transit for traffic between their mutual customers
- Peers do not perform transit between their peers.
- Customers do not perform transit for their providers.

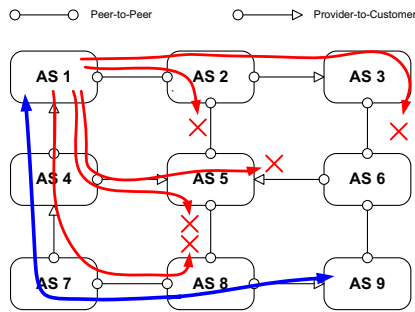
Part a)

- There are 5 subproblems, each subproblem is worth 2 points (one point for correct route, one point for a correct explanation)
- The solutions show all possible paths. A **blue** line indicates a successful path. A **red** line indicates that a path does not work and shows where it fails.

Part b)

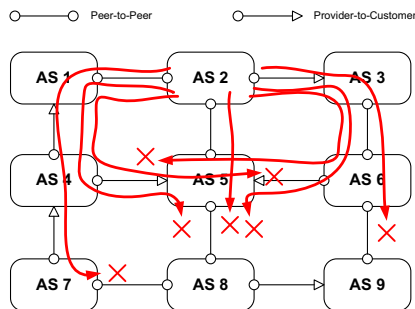
- It is important that students realize that b2 and b3 work (whereas a2 and a3 did not work).
- Less important: There are some changes of the paths in b4 and b5, but they both still fail.

a1) AS1 → AS9: The blue path works



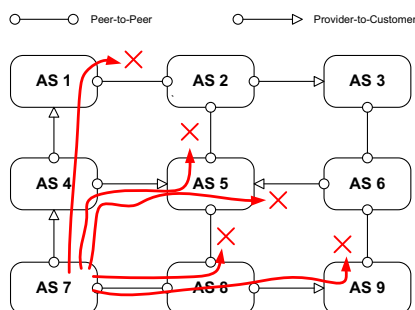
a2) AS2 → AS8: No paths works:

- peers do not provide transit to peers
- Customers do not provide transit to providers



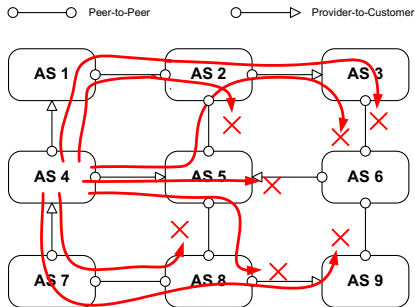
a3) AS7 → AS3: No paths works:

- peers do not provide transit to peers
- Customers do not provide transit to providers



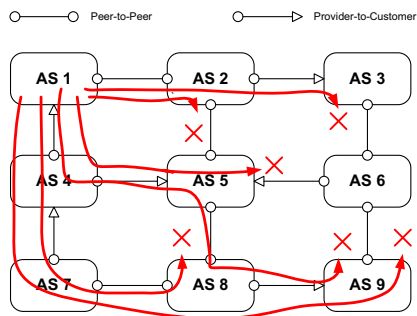
a4) AS4 → AS6: No paths works:

- peers do not provide transit to peers
- Customers do not provide transit to providers

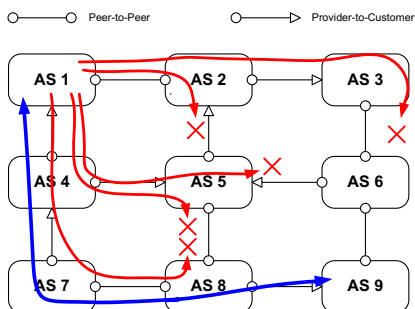


a5) AS1 → AS6: No paths works:

- peers do not provide transit to peers
- Customers do not provide transit to providers

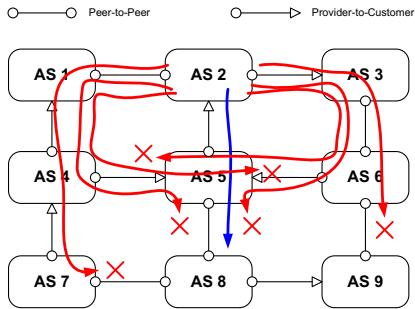


b1) AS1 → AS9: Still works. (No change)



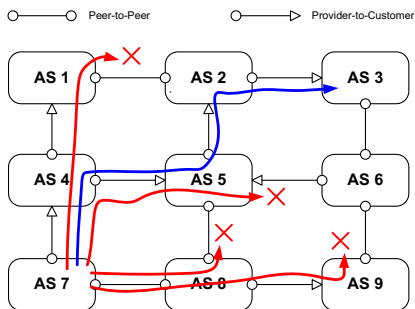
b2) AS2 → AS8: AS2 - AS5 - AS8 works **(Change)**

- AS5 performs transit between its peers and its customers.



b3) AS 7 → AS3: AS7-AS4-AS5-AS2-AS3 works **(Change)**

- The path consists of a sequence customer-provider relationships

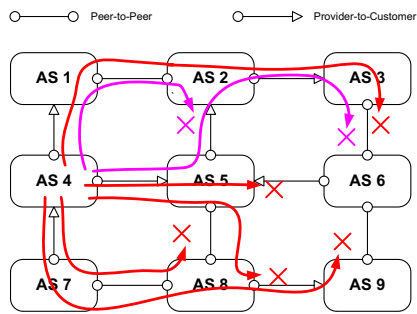


b4) **(Change, but still does not work)**

There are 2 paths between AS4 and AS6 that change. They are indicated in purple.

AS4-AS1-AS2-AS5-AS6: fails because AS2 does not provide transit for its provider AS5

AS4-AS5-AS2-AS3-AS6: fails because AS3 does not provide transit for its provider AS2



b5) (Change, but still does not work)

There are 2 paths between AS1 and AS6 that change. They are indicated in purple.

AS1-AS2-AS5-AS6: fails because AS2 does not provide transit for its provider AS5

AS1-AS4-AS5-AS2-AS3-AS6: fails because AS3 does not provide transit for its provider AS2

