

Lecture 8 (Routing 5)

Inter-Domain Routing Exercises ANS

Q1. BGP

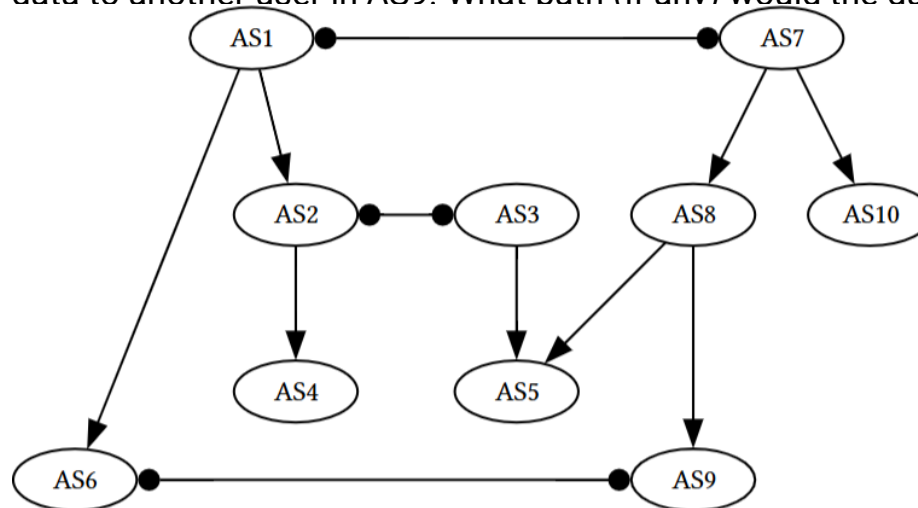
Consider the following configuration of autonomous systems and their relationships.

A square-triangle line indicates a provider-customer relationship, and a circle-circle line indicates a peer relationship. We have two tier 1 providers (AS1 and AS7). Assume we are using the following selection and export rules for all ASes:

Selection: Prefer to send data through customers > peers > providers in order to minimize costs.

Export: To customers, advertise all paths. To all other ASes, advertise only paths to customers (and paths to your own AS, of course).

- 1) A user in AS4 tries to send data to a friend in AS5. What path (if any) would the data take to get to the friend?
- 2) A user in AS6 tries to send data to a friend in AS5. What path (if any) would the data take to get to the friend?
- 3) A user in AS1 tries to send data to another user in AS9. What path (if any) would the data take?



Q. BGP ANS

1) A user in AS4 tries to send data to a friend in AS5. What path (if any) would the data take to get to the friend?

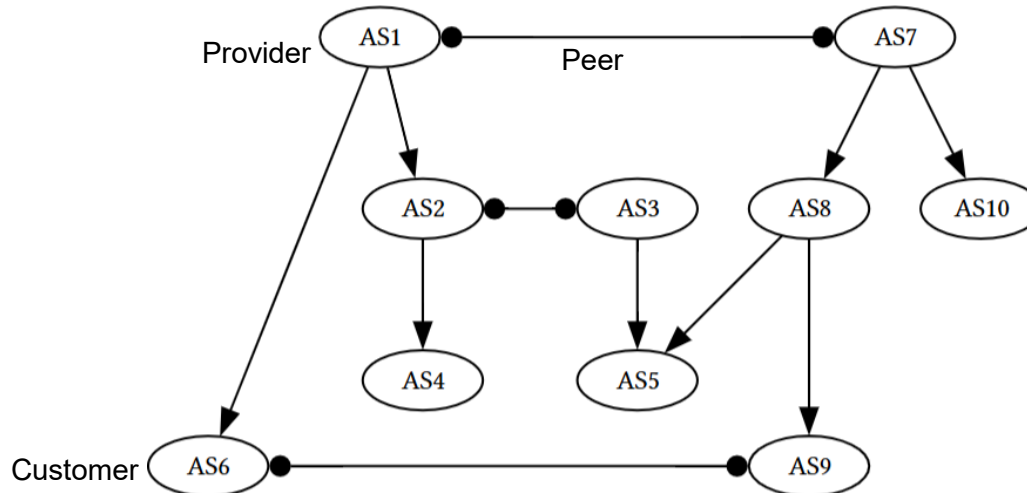
ANS: AS4 → AS2 → AS3 → AS5

2) A user in AS6 tries to send data to a friend in AS5. What path (if any) would the data take to get to the friend?

ANS: AS6 → AS1 → AS7 → AS8 → AS5. Since AS2 won't advertise its peer's (AS3's) path (about how to reach AS5) to its provider (AS1), so AS1 doesn't know it can reach AS5 through AS2.

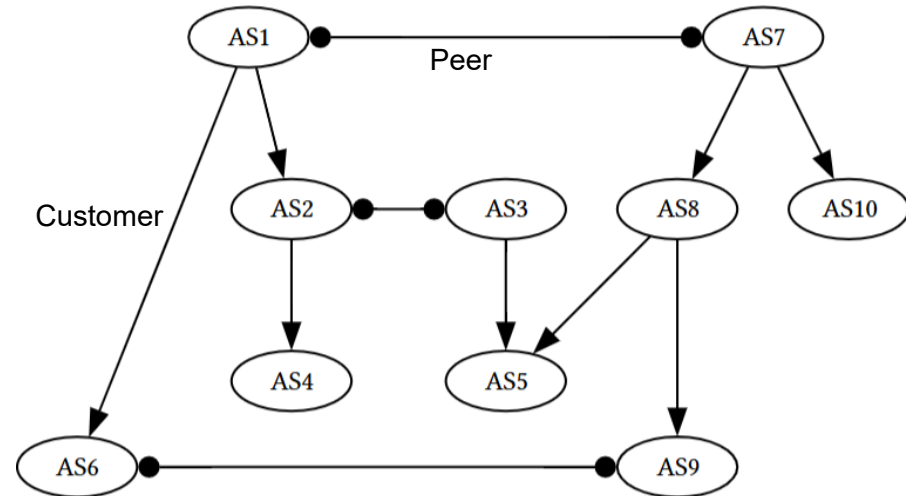
3) A user in AS1 tries to send data to another user in AS9. What path (if any) would the data take?

ANS: AS1 → AS7 → AS8 → AS9. Same reasoning as Part 2).



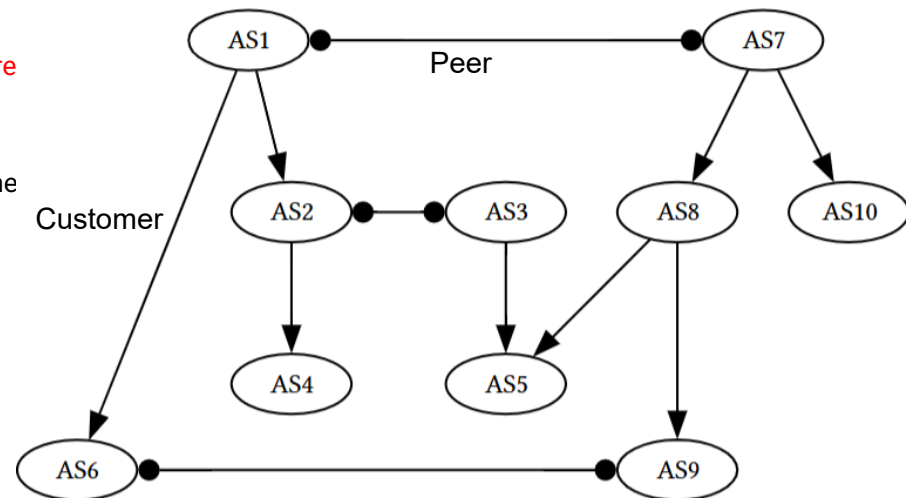
Explanations (based on Gao-Rexford Rules)

- 1) $AS4 \rightarrow AS2 \rightarrow AS3 \rightarrow AS5$. This path respects all Gao-Rexford rules:
 - AS2 has a peer neighbor (AS3) AND a customer neighbor (AS4)
 - AS3 has a customer neighbor (AS5 paying)
 - Path is valley-free (no going up after going down)
- 2) $AS6 \rightarrow AS1 \rightarrow AS7 \rightarrow AS8 \rightarrow AS5$. Since AS2 won't advertise its peer's (AS3's) path (about how to reach AS5) to its provider (AS1), so AS1 doesn't know it can reach AS5 through AS2.
 - Export policy: AS2 receives a route from peer AS3 (about reaching AS5)
 - Export rule: **Routes from peers are only advertised/exported to customers (not to providers)**
 - Therefore: AS1 (AS2's provider) does NOT learn about the $AS3 \rightarrow AS5$ path
 - So AS1 can only reach AS5 via AS7 (its peer) and then $AS8 \rightarrow AS5$. This forces the long path through Tier 1 providers



Explanations (based on Gao-Rexford Rules)

- How about $AS6 \rightarrow AS9 \rightarrow AS8 \rightarrow AS5$?
- $AS9$ is a **customer** of $AS8$, and $AS5$ is also a **customer** of $AS8$. So:
- **$AS5 \rightarrow AS8$** is customer to provider for route origination
- **$AS8 \rightarrow AS9$** is provider to customer advertisement
- **$AS9$ learns the $AS5$ route from its provider $AS8$**
- Now the key export rule applies: **Routes learned from a provider or peer are exported only to customers**
 - $AS9$ learned the route to $AS5$ from **provider $AS8$** , therefore $AS9$ **cannot advertise that route to peer $AS6$** . So $AS6$ does **not** learn the $AS6 \rightarrow AS9 \rightarrow AS8 \rightarrow AS5$ path.
- The valley-free view says the same thing:
- **$AS6 \rightarrow AS9 =$ peer. $AS9 \rightarrow AS8 =$ up. $AS8 \rightarrow AS5 =$ down**
- That is **peer, then up, then down**, which is not valley-free. In Gao-Rexford, the allowed pattern is:
 - zero or more **up** edges,
 - then at most one **peer** edge,
 - then zero or more **down** edges.
- So this path violates the rule.
- **$AS6 \rightarrow AS9 \rightarrow AS8 \rightarrow AS5$ is invalid because $AS9$ learns the route from a provider and cannot export it to its peer $AS6$.**



Explanations (based on Gao-Rexford Rules)

- 3) $AS1 \rightarrow AS7 \rightarrow AS8 \rightarrow AS9$. This path respects all Gao-Rexford rules:
 - AS1 is a Tier 1 AS (no providers)
 - AS7 is also a Tier 1 AS (peering with AS1)
 - To reach AS9, AS1 needs a path advertised by AS7
 - AS7 receives routes from customers (AS8) and peers (AS1)
 - Export rule: AS7 advertises customer routes (AS8's path) to all ASes
 - So AS1 can use: $AS1 \rightarrow AS7 \rightarrow AS8 \rightarrow AS9$
- The principle is the same (export policies hide certain paths), but the mechanics are slightly different. Comparison:
 - Part 2: AS1 tries to reach AS5 through AS2 (but AS2 hides the peer path)
 - Part 3: AS1 tries to reach AS9 through AS7 (which advertises its customer's route)

