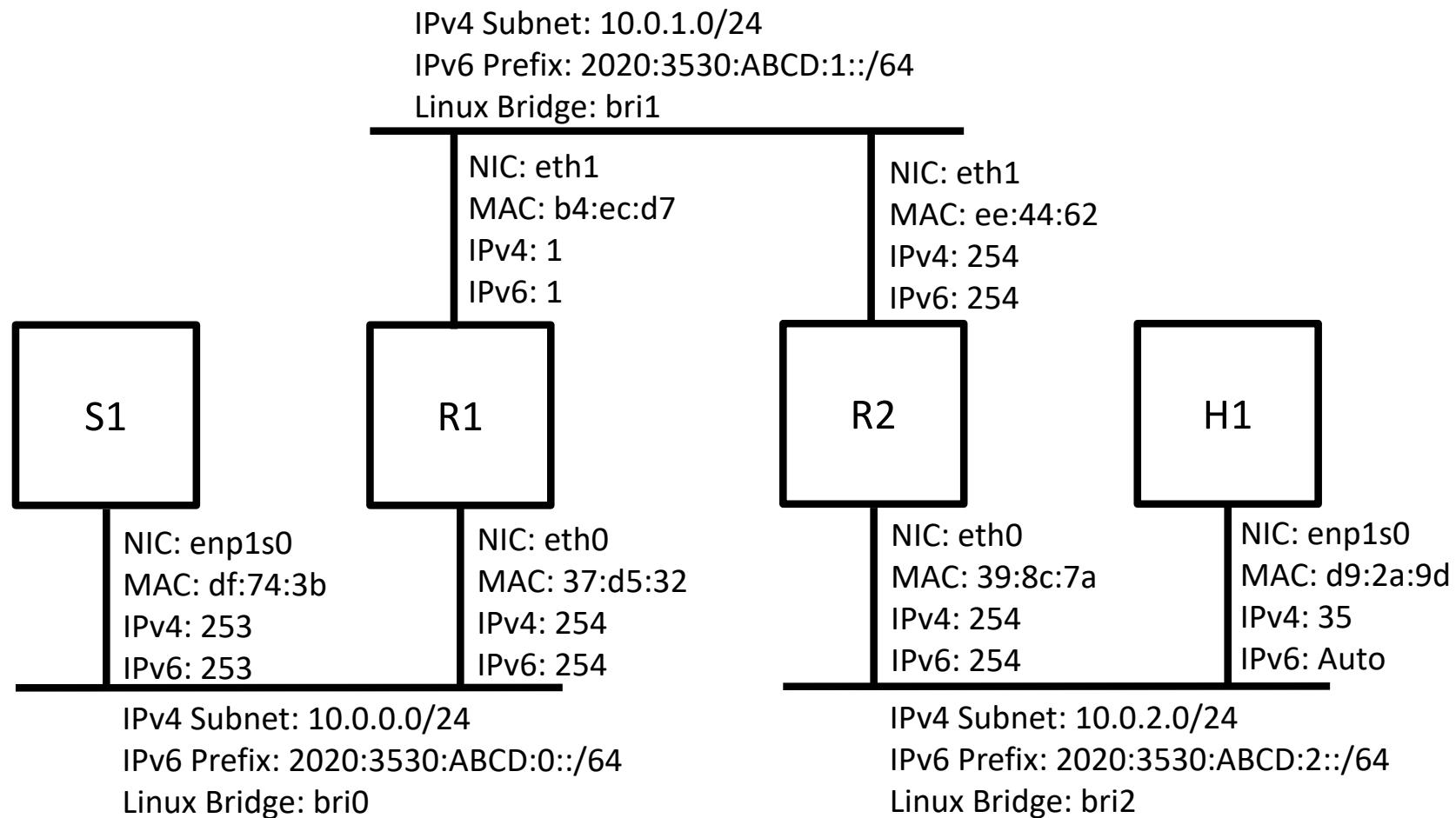


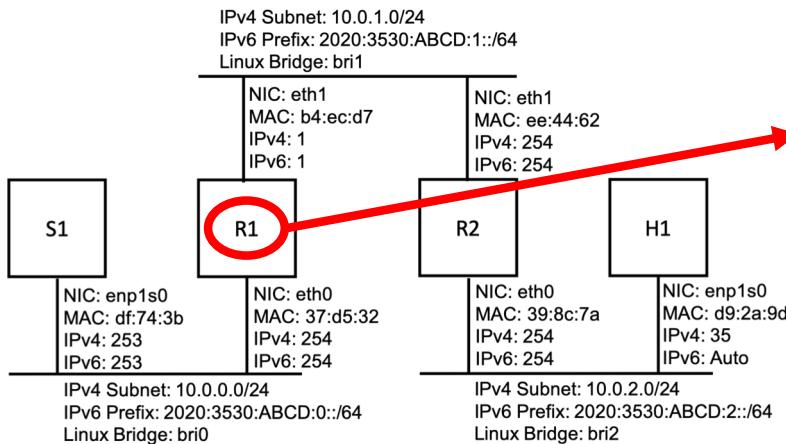
CS3543 Routing

Actual Demo Network



Routing Table of R1 (IPv4 and IPv6)

- What is the next hop gateway and the outgoing I/F to reach everywhere in the network from R1?



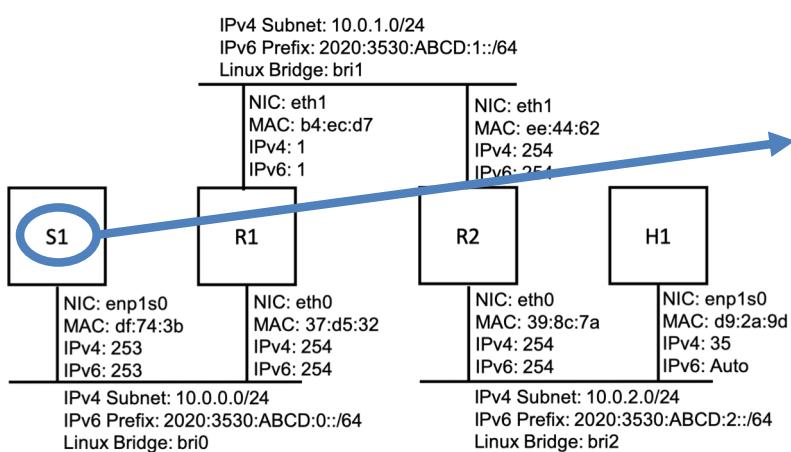
```
vyos@vyos:~$ show ip route
Codes: K - kernel route, C - connected, S - static, R - RIP, O - OSPF,
       I - ISIS, B - BGP, > - selected route, * - FIB route

C>* 10.0.0.0/24 is directly connected, eth0
C>* 10.0.1.0/24 is directly connected, eth1
S>* 10.0.2.0/24 [1/0] via 10.0.1.254, eth1
C>* 127.0.0.0/8 is directly connected, lo
vyos@vyos:~$ show ipv6 route
Codes: K - kernel route, C - connected, S - static, R - RIPng, O - OSPFv3,
       I - ISIS, B - BGP, * - FIB route.

S>* ::/0 [1/0] via 2020:3530:abcd:1::254, eth1
C>* ::1/128 is directly connected, lo
C>* 2020:3530:abcd::/64 is directly connected, eth0
C>* 2020:3530:abcd:1::/64 is directly connected, eth1
C * fe80::/64 is directly connected, eth1
C * fe80::/64 is directly connected, eth0
vyos@vyos:~$ _
```

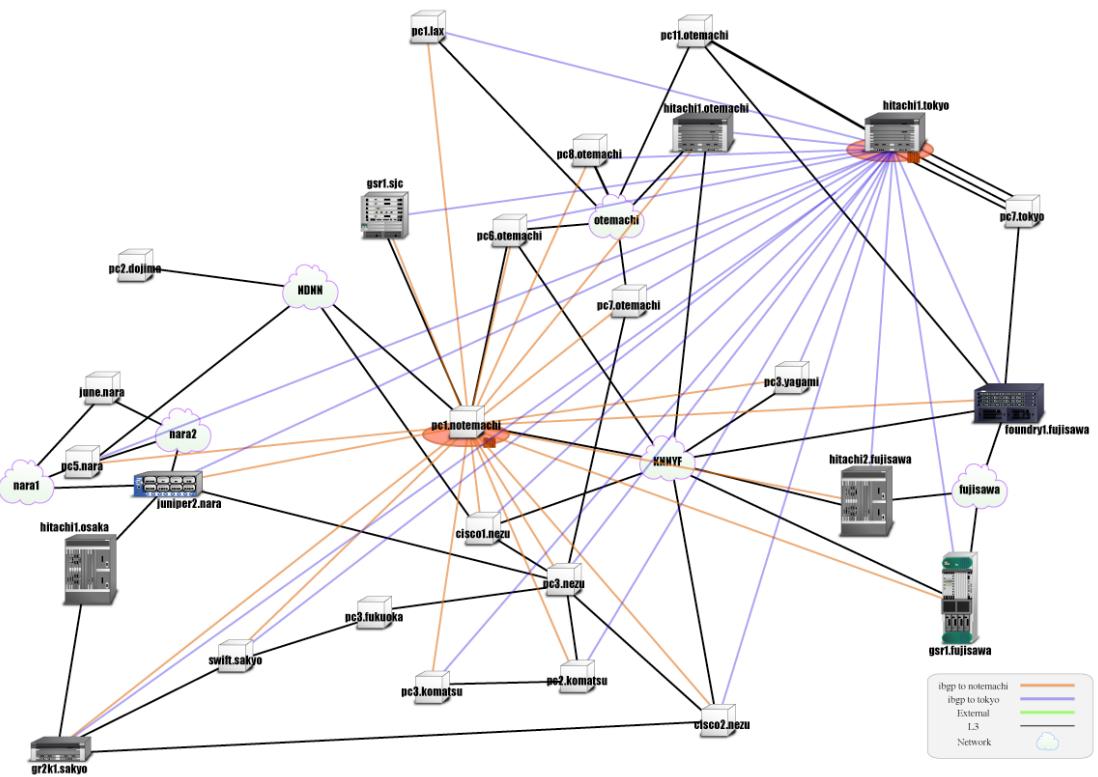
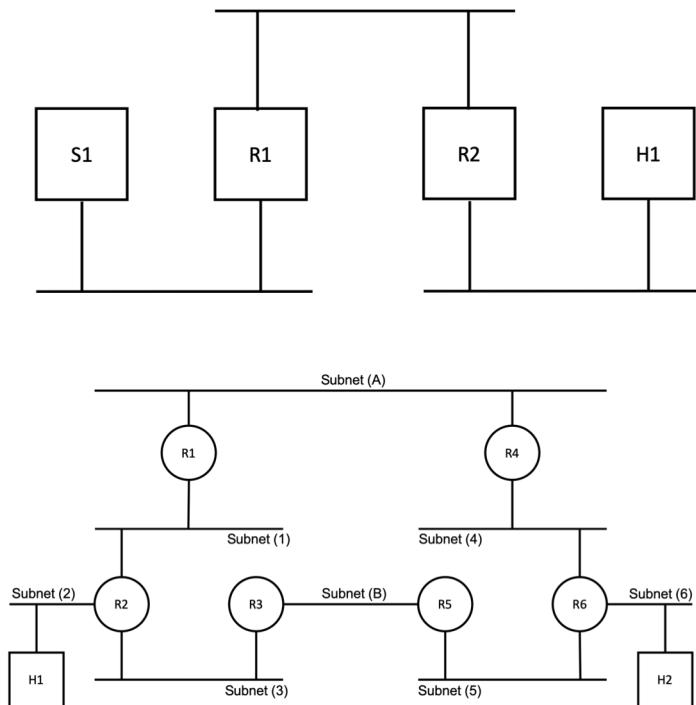
Routing Table of S1 (IPv4 and IPv6)

- What is the next hop gateway and the outgoing I/F to reach everywhere in the network from RS?



```
kotaro@server1:~$ ip route show
default via 10.0.0.254 dev enp1s0 proto static
10.0.0.0/24 dev enp1s0 proto kernel scope link src 10.0.0.253
kotaro@server1:~$ ip -6 route show
::1 dev lo proto kernel metric 256 pref medium
2020:3530:abcd::/64 dev enp1s0 proto kernel metric 256 pref medium
fe80::/64 dev enp1s0 proto kernel metric 256 pref medium
default via 2020:3530:abcd::254 dev enp1s0 proto static metric 1024 pref medium
kotaro@server1:~$ _
```

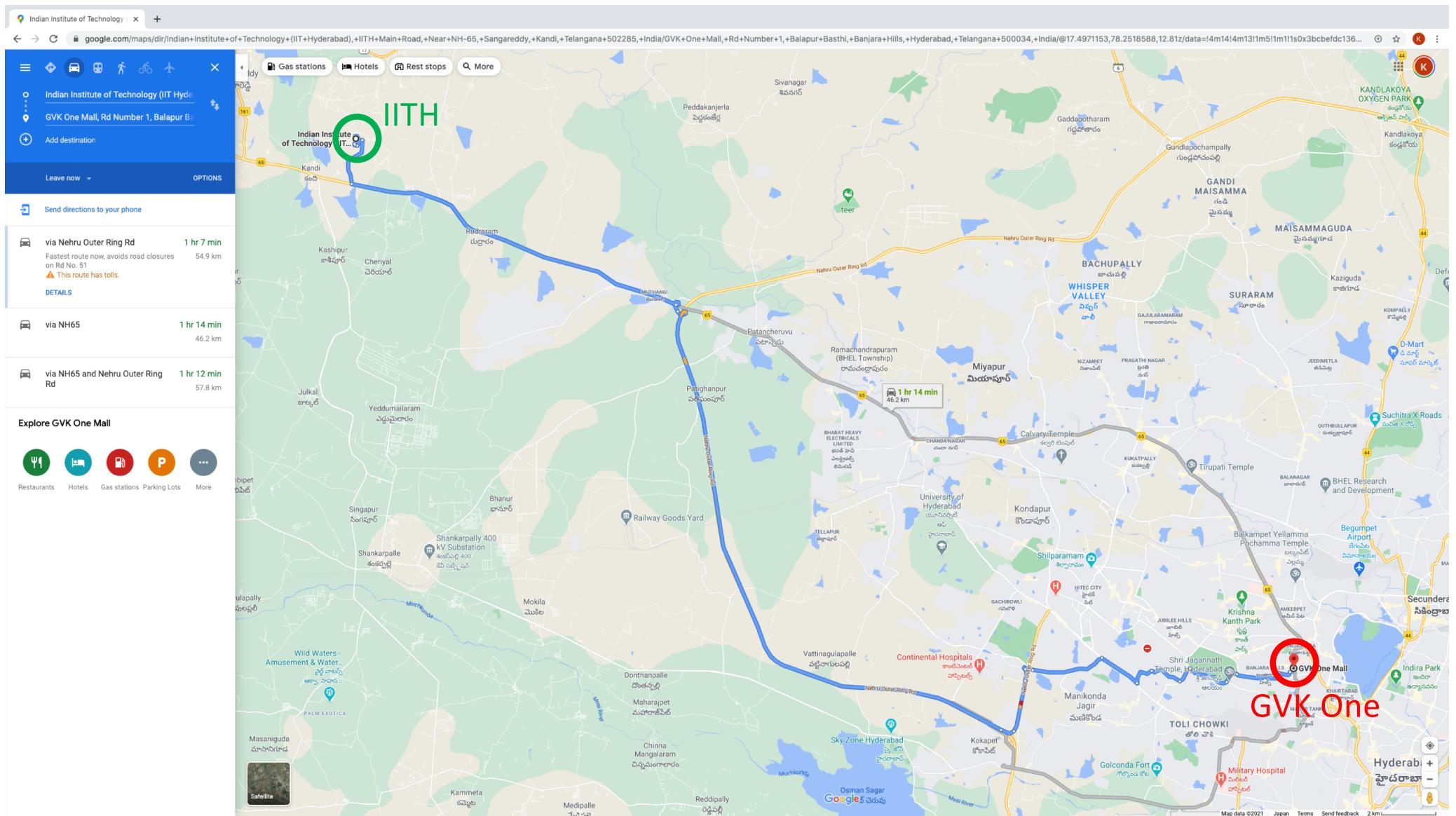
Motivation Towards Dynamic Routing



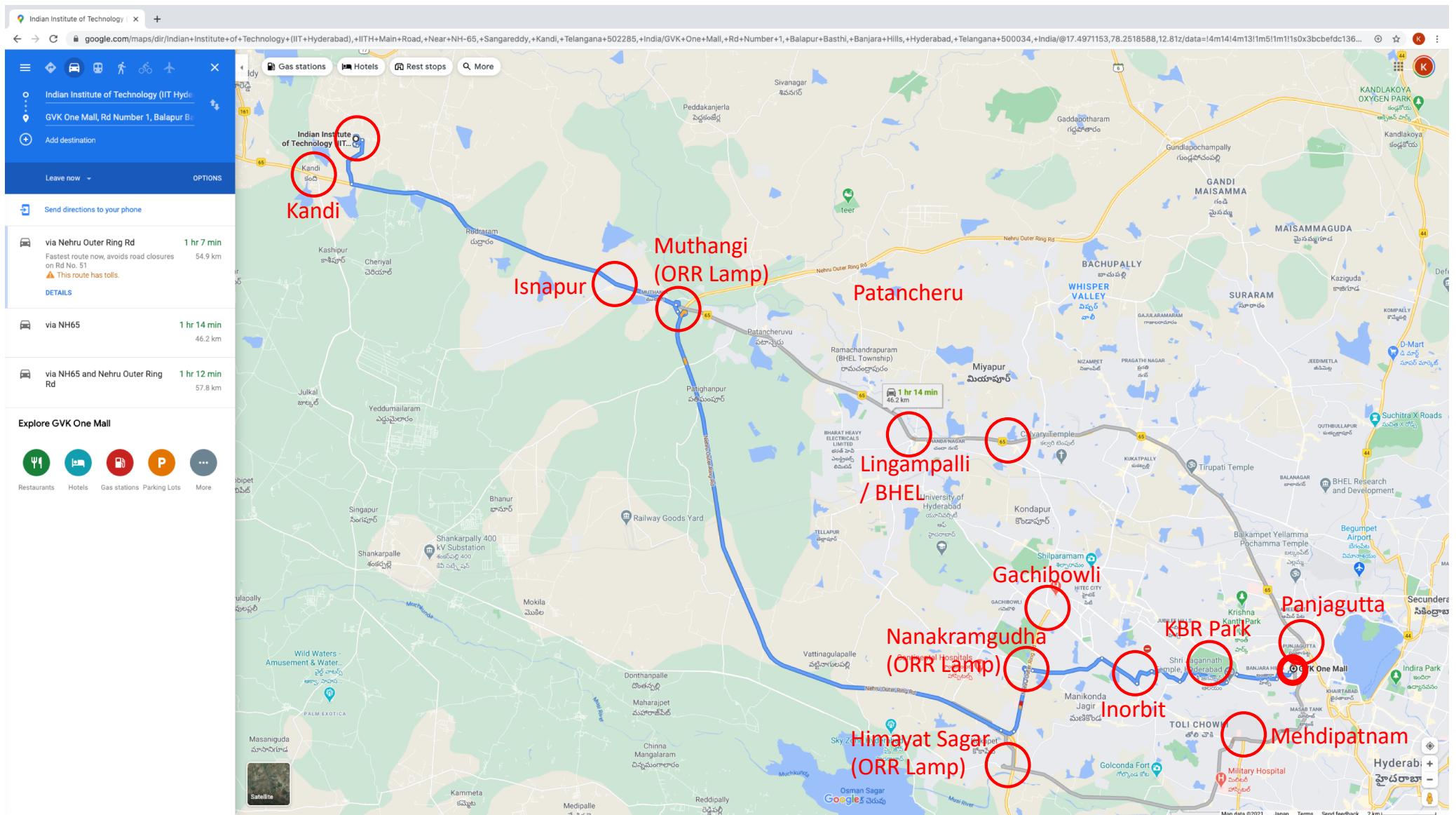
Static Routing v.s Dynamic Routing

- Static
 - Manual configuration to all routers
 - Work nicely for simple network
 - No route calculation means low CPU load
 - Trouble in trouble shooting
 - Policy-based routing
- Dynamic
 - Routers advertises routes to the others
 - Automatically calculate routing table
 - Less human work
 - Automatic calculation in the case of trouble
 - Another database in addition to routing table

How do you go from IITH to GVK One Mall?



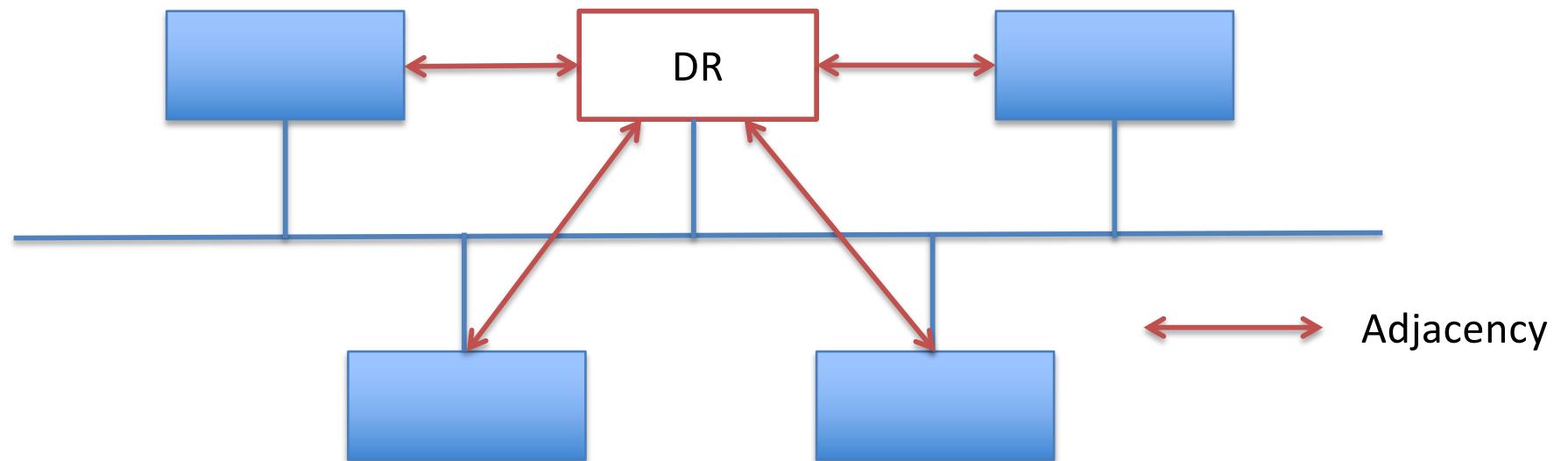
How do you go to GVK One Mall from IITH?



Supplemental Contents for OSPF

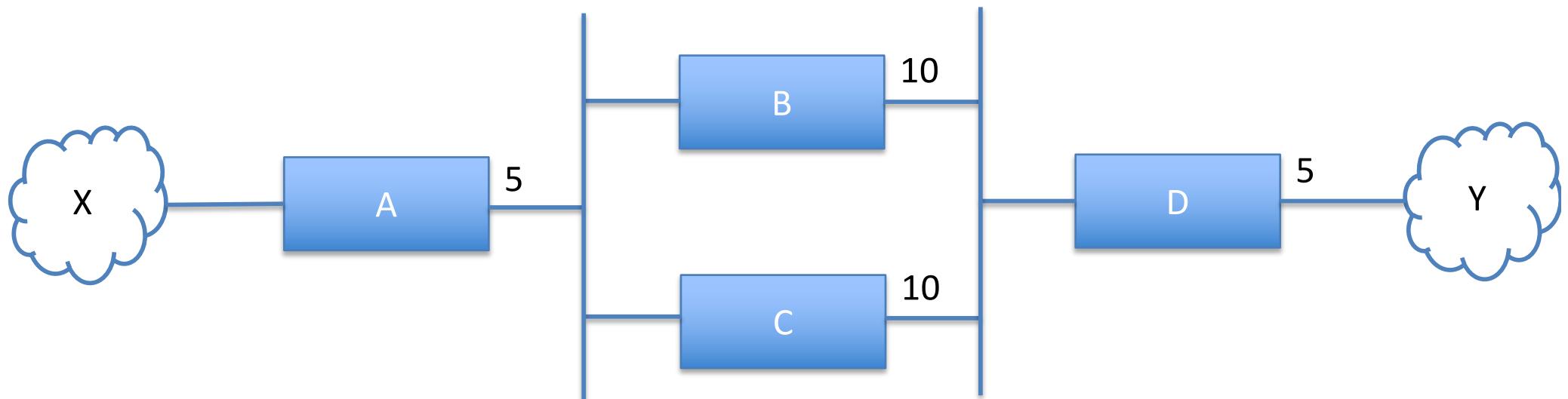
OSPF: Neighbor and Adjacency

- Neighbor: Relationship between OSPF routers in the same network
- Adjacency: Relationship between OSPF routers that exchange Link State
- Designated Router: Establish Adjacency to exchange Link State with other routers in the same network
 - Avoiding “FULL-Mesh” Link-state exchange
 - DR should have enough computation capacity



OSPF Equal Cost Multi Path

- Load balancing on the multiple paths that have same cost to reach destination



A's Routing Entries for Destination Y

Destination	Next Hop	Cost
Y	B	20
Y	C	20

Q1. “Per-packet” or “Per-address” load balancing?
Q2. Will the amount of traffic be 50% + 50%?

Supplemental Contents for BGP

(How does policy work?)

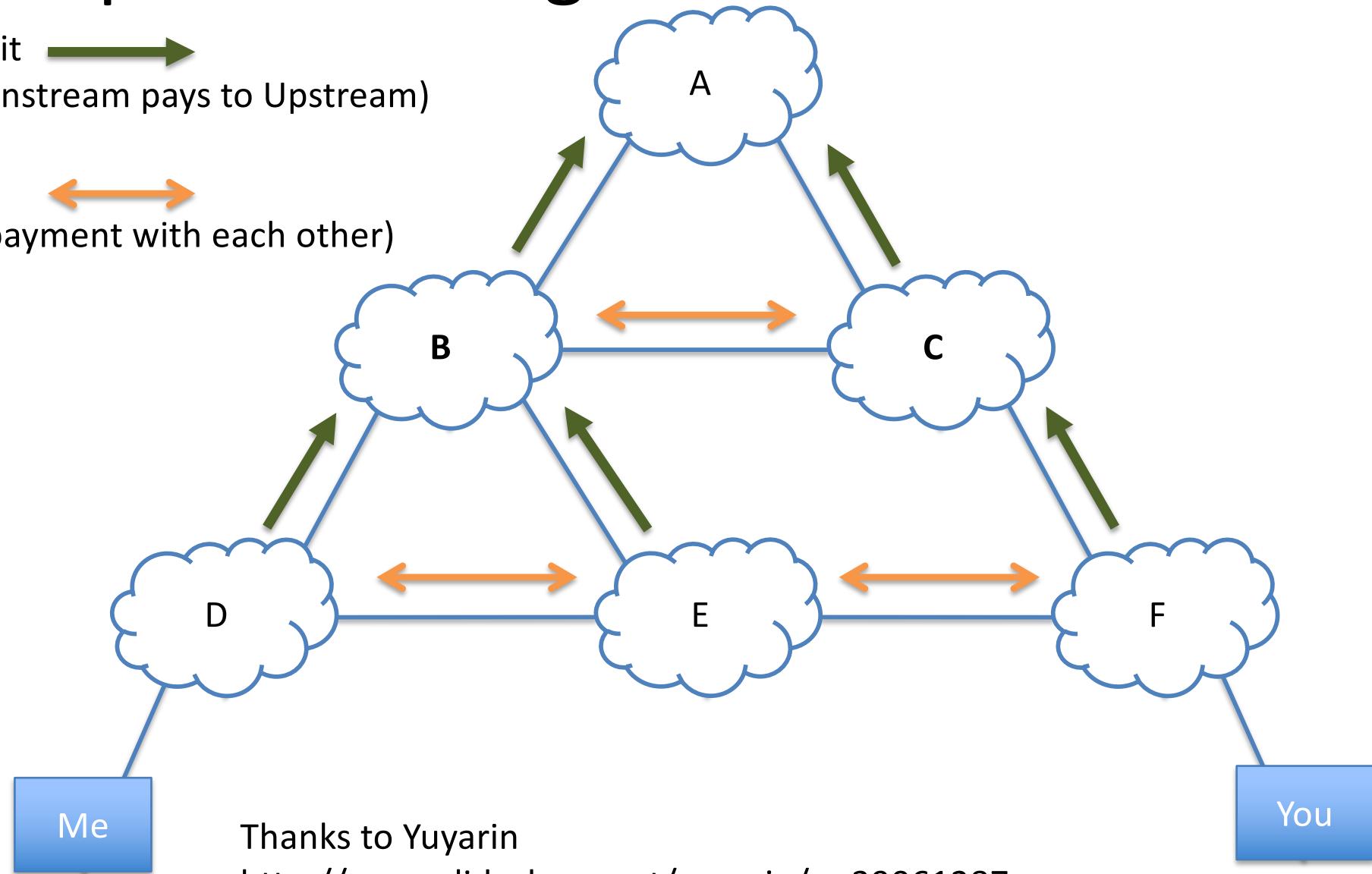
Quiz: What is the path to let the packet through from Me to You?

Transit 

(Downstream pays to Upstream)

Peer 

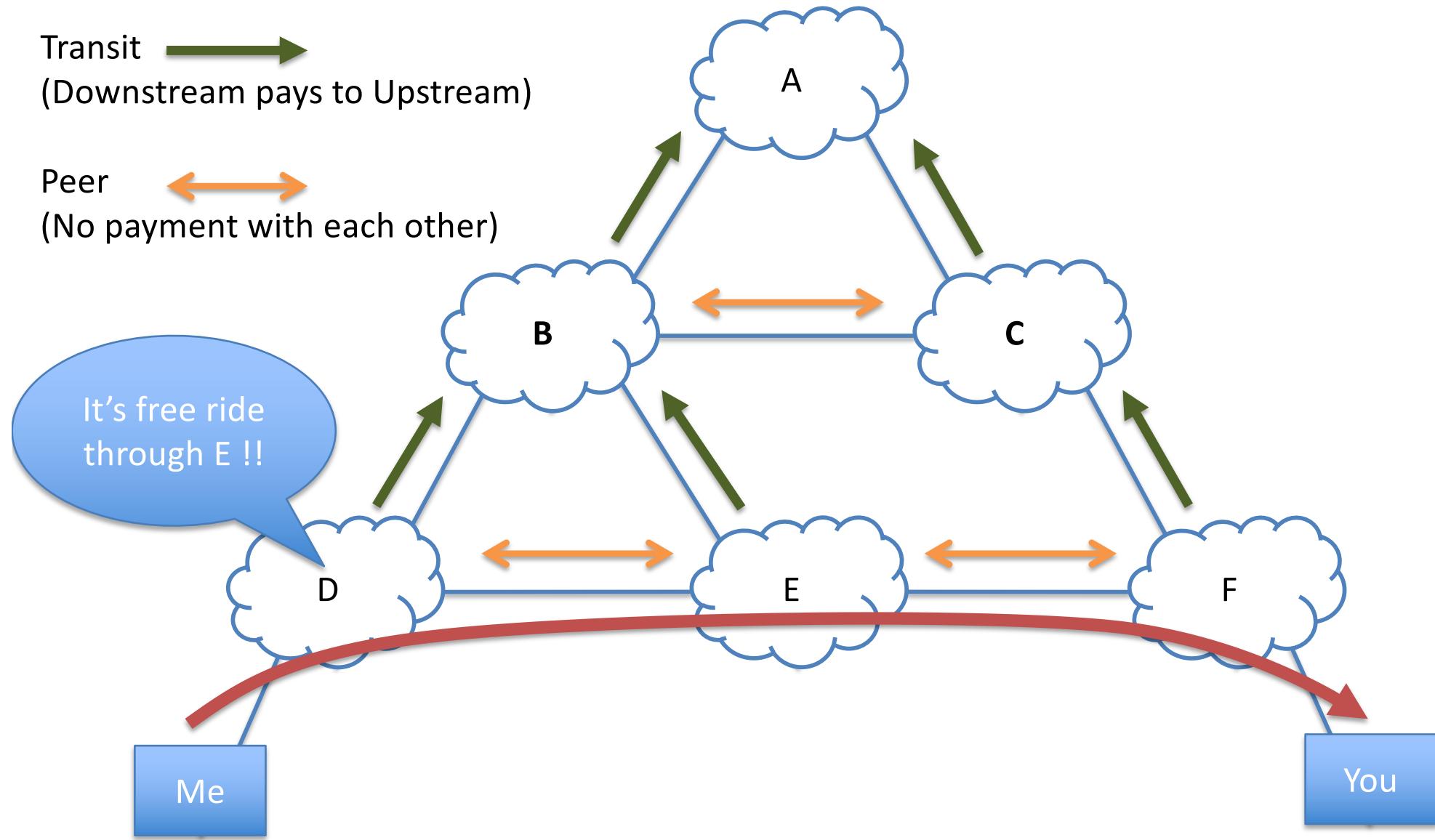
(No payment with each other)



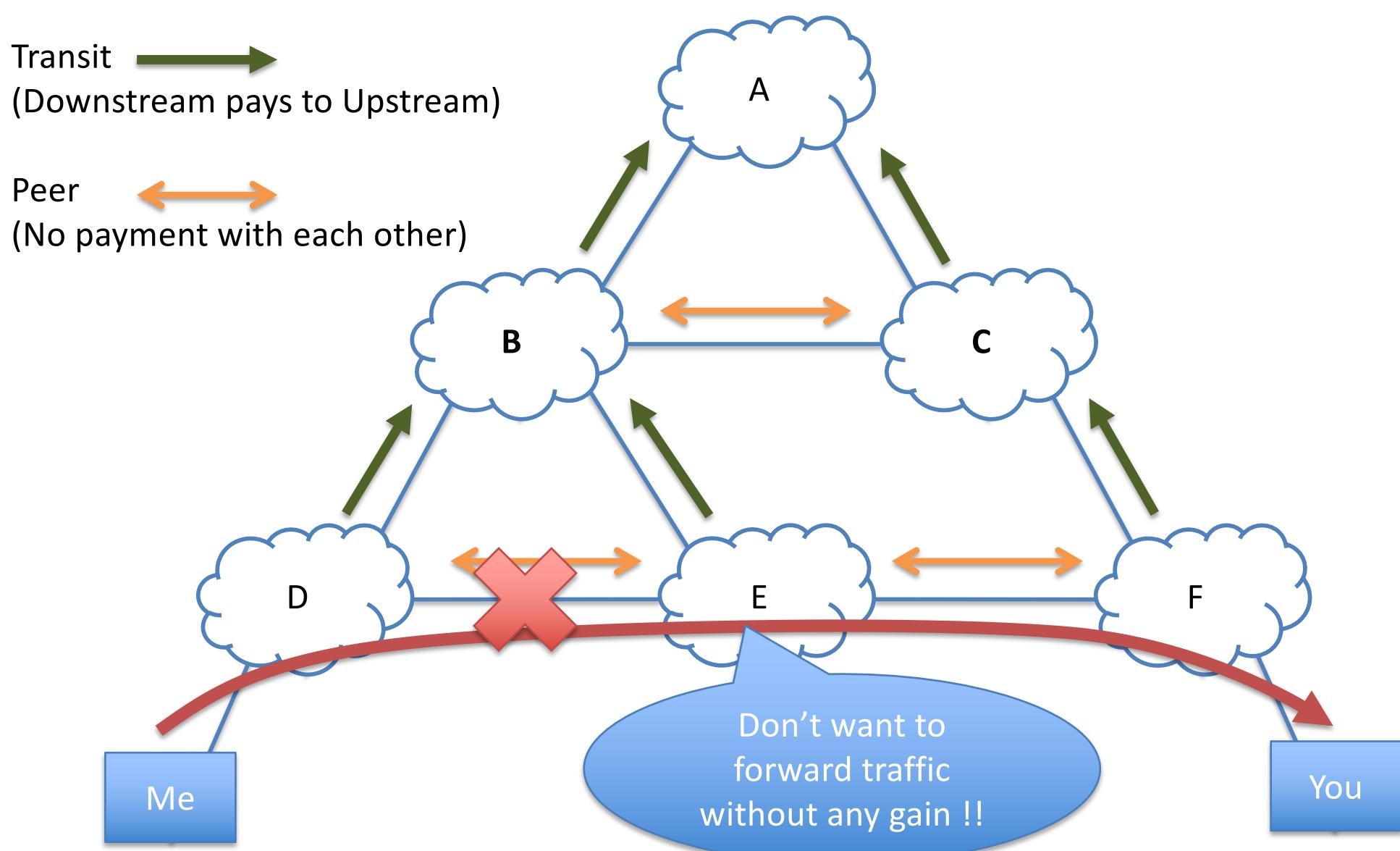
Thanks to Yuyarin

<http://www.slideshare.net/yuyarin/ss-39061287>

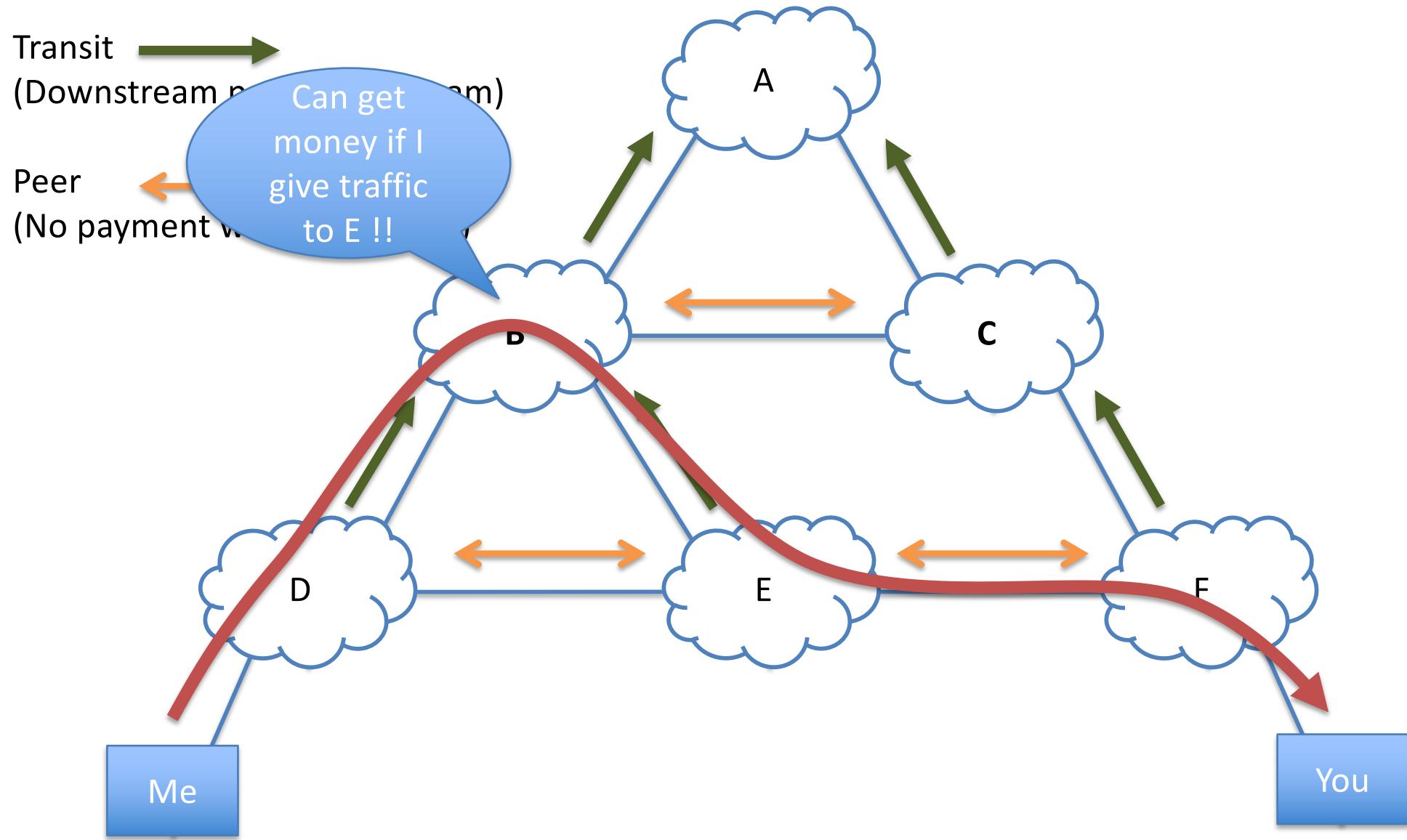
Answer 1 (1/2)



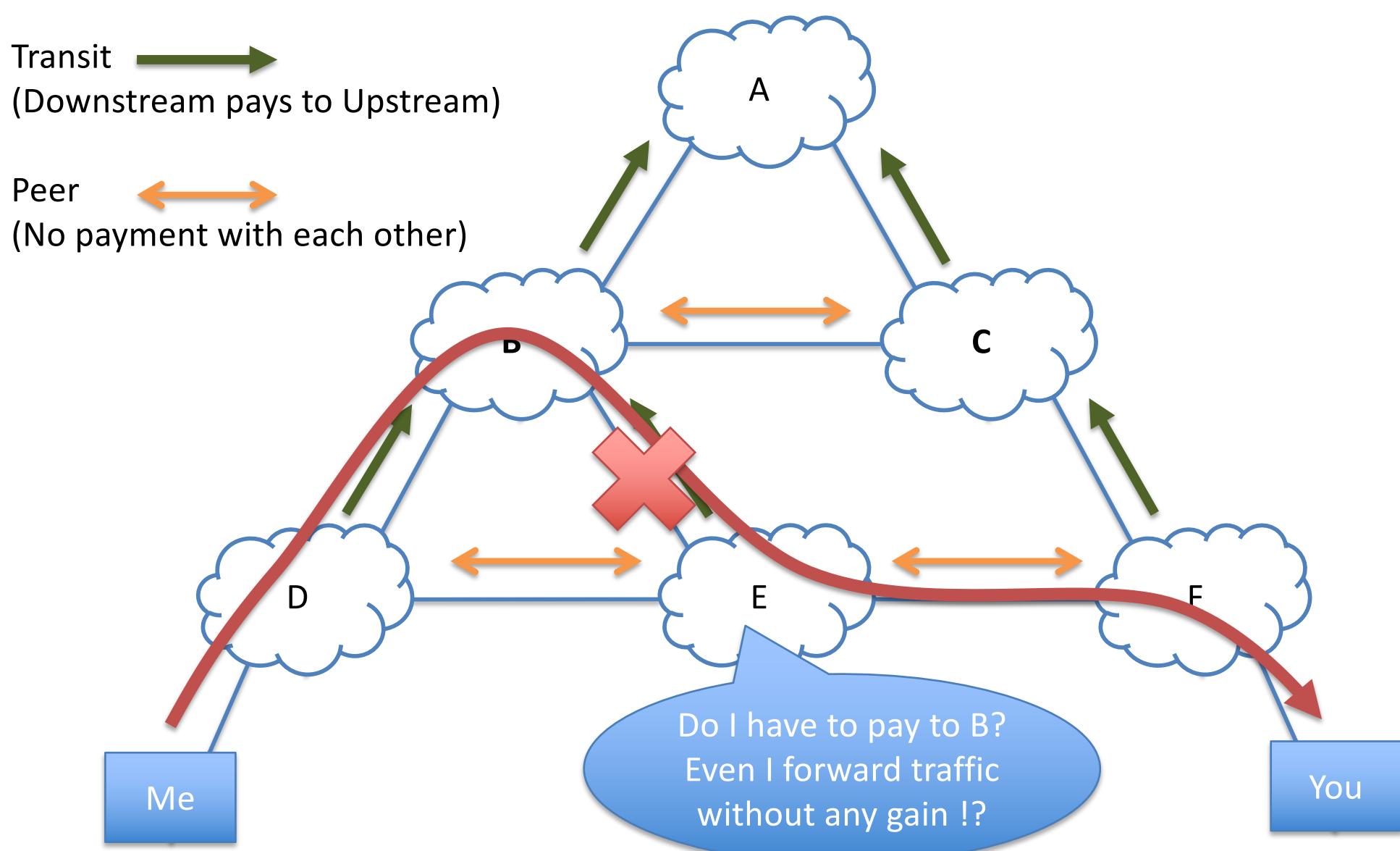
Answer 1 (2/2)



Answer 2 (1/2)



Answer 2 (2/2)



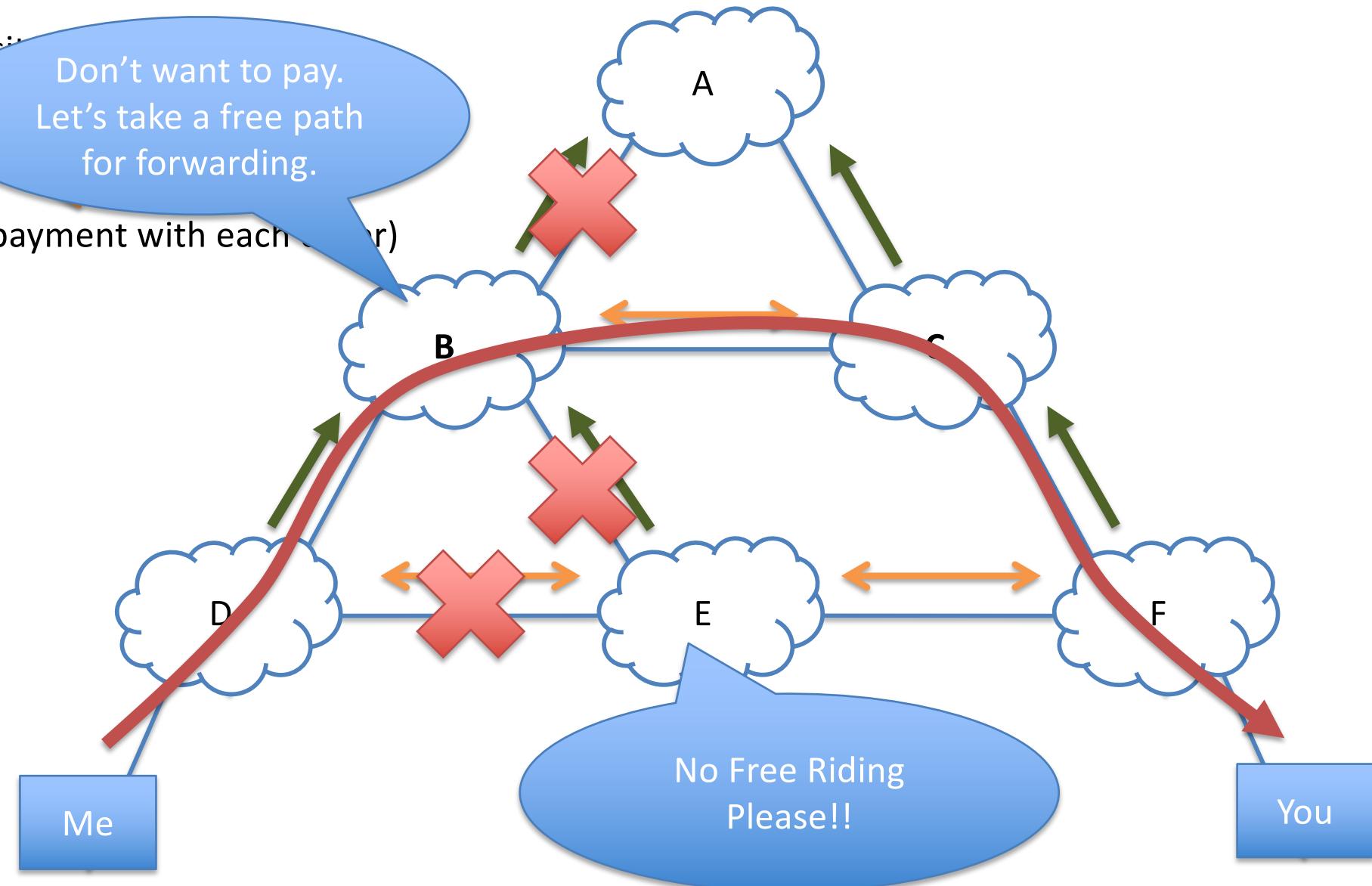
Practical Answer

Transit
(5)

Don't want to pay.
Let's take a free path
for forwarding.

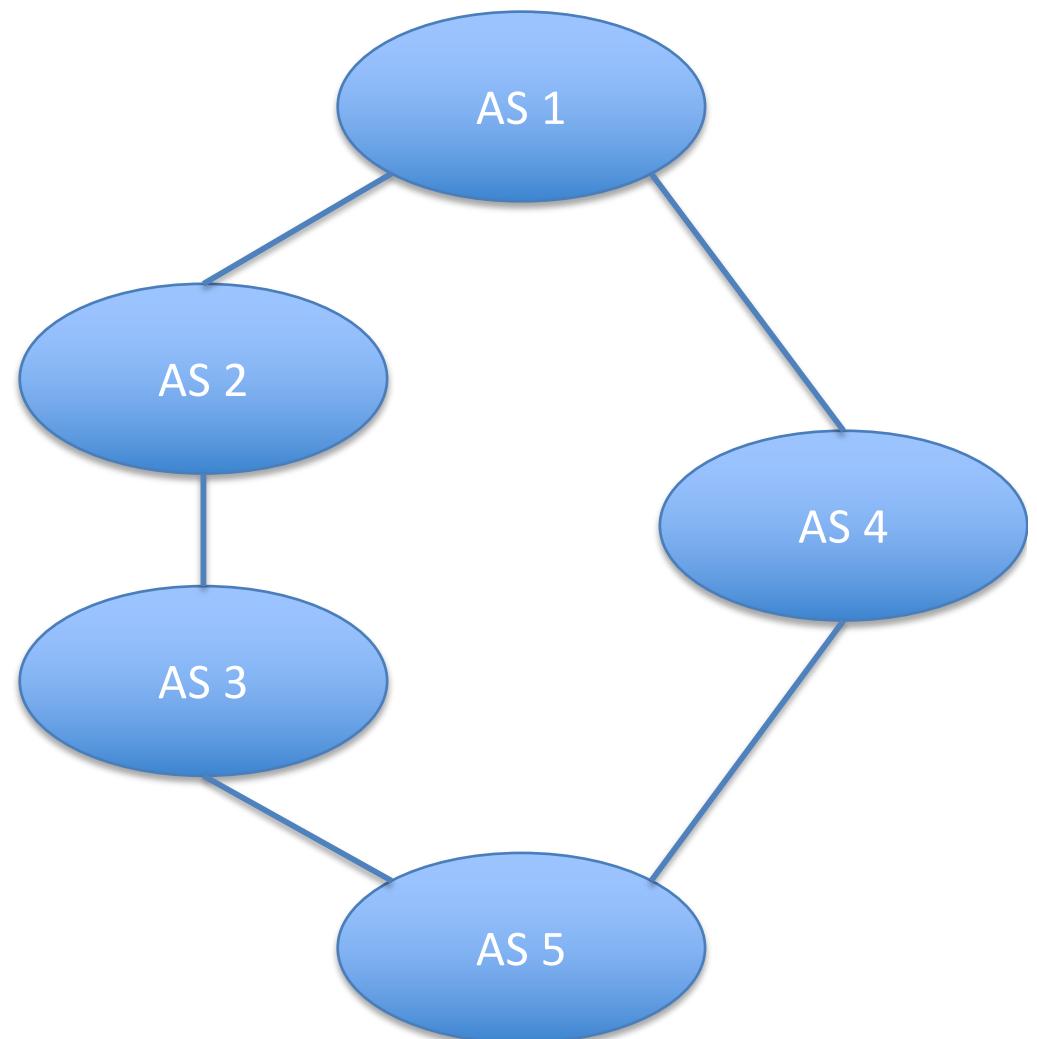
Peer

(No payment with each other)



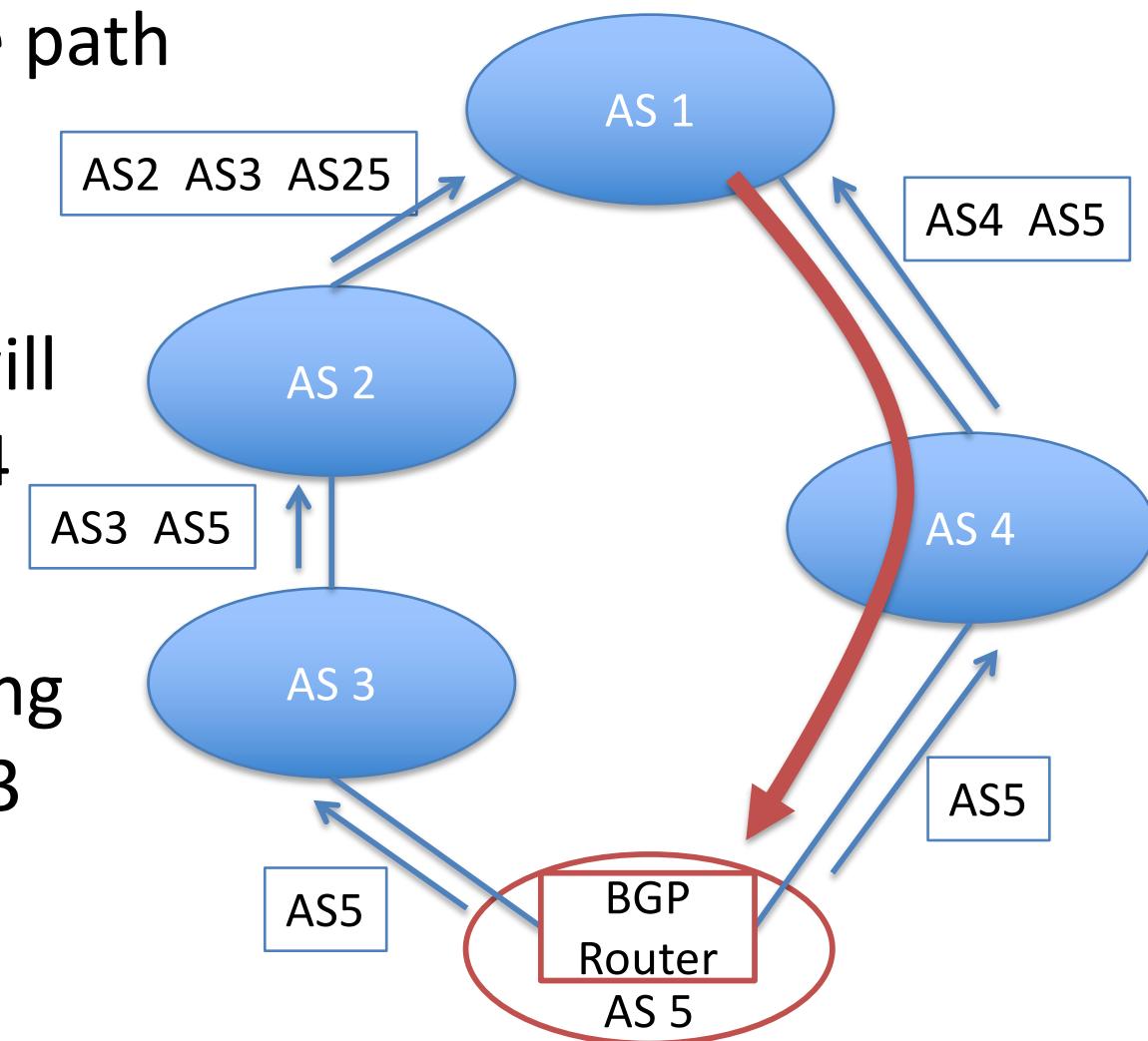
BGP Traffic Engineering

- How to control the path to be used in BGP?
- Incoming Traffic
 - AS_PATH Attribute
 - MED Attribute
 - Community
- Outgoing Traffic
 - LOCAL_PREF Attribute



AS_PATH Attribute

- Path Vector Algorithm on AS 1 selects the path to AS 5 via AS 4

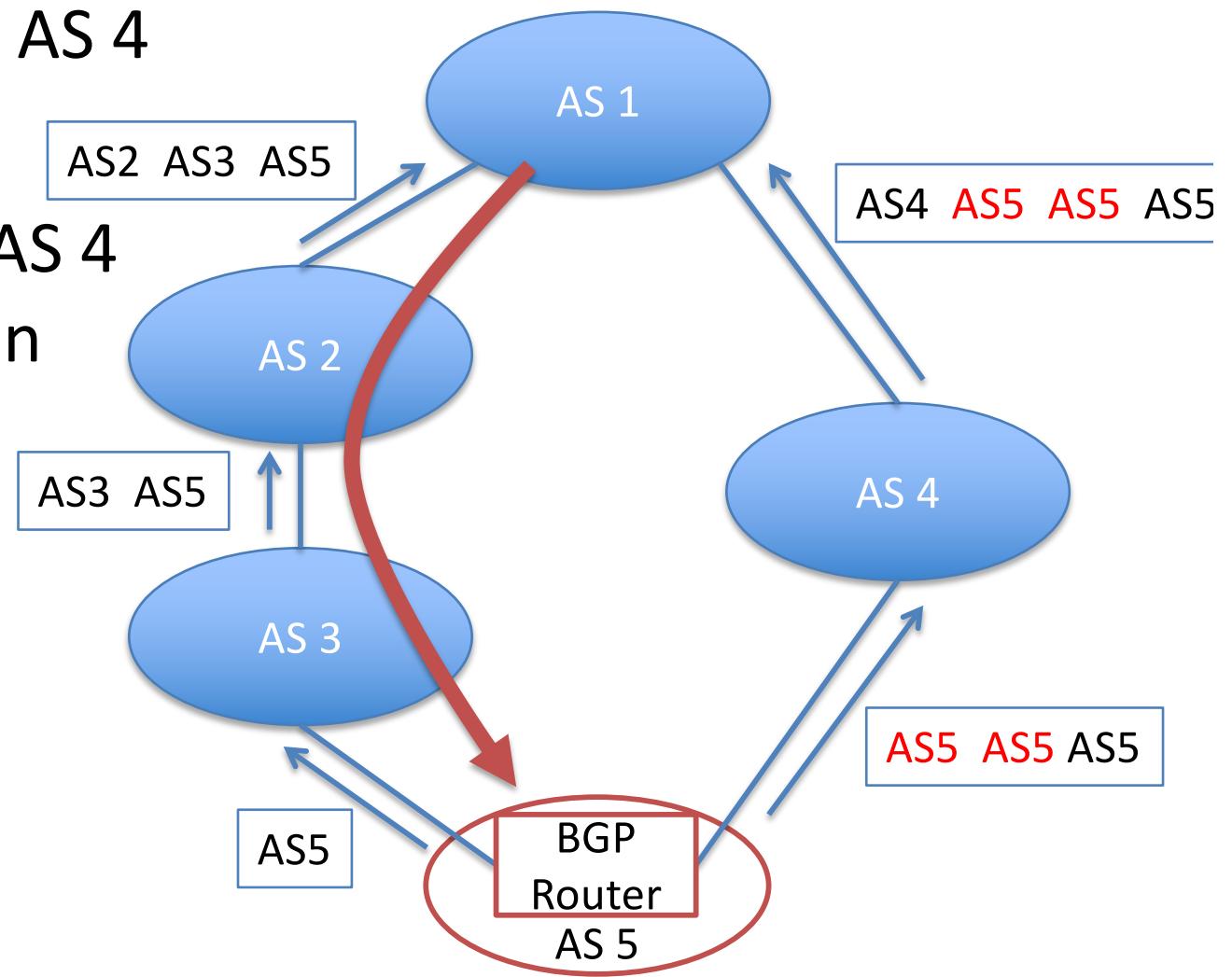


- Traffic from AS 5 will come through AS 4
- AS 5 wants incoming traffic through AS 3

AS_PATH Prepend

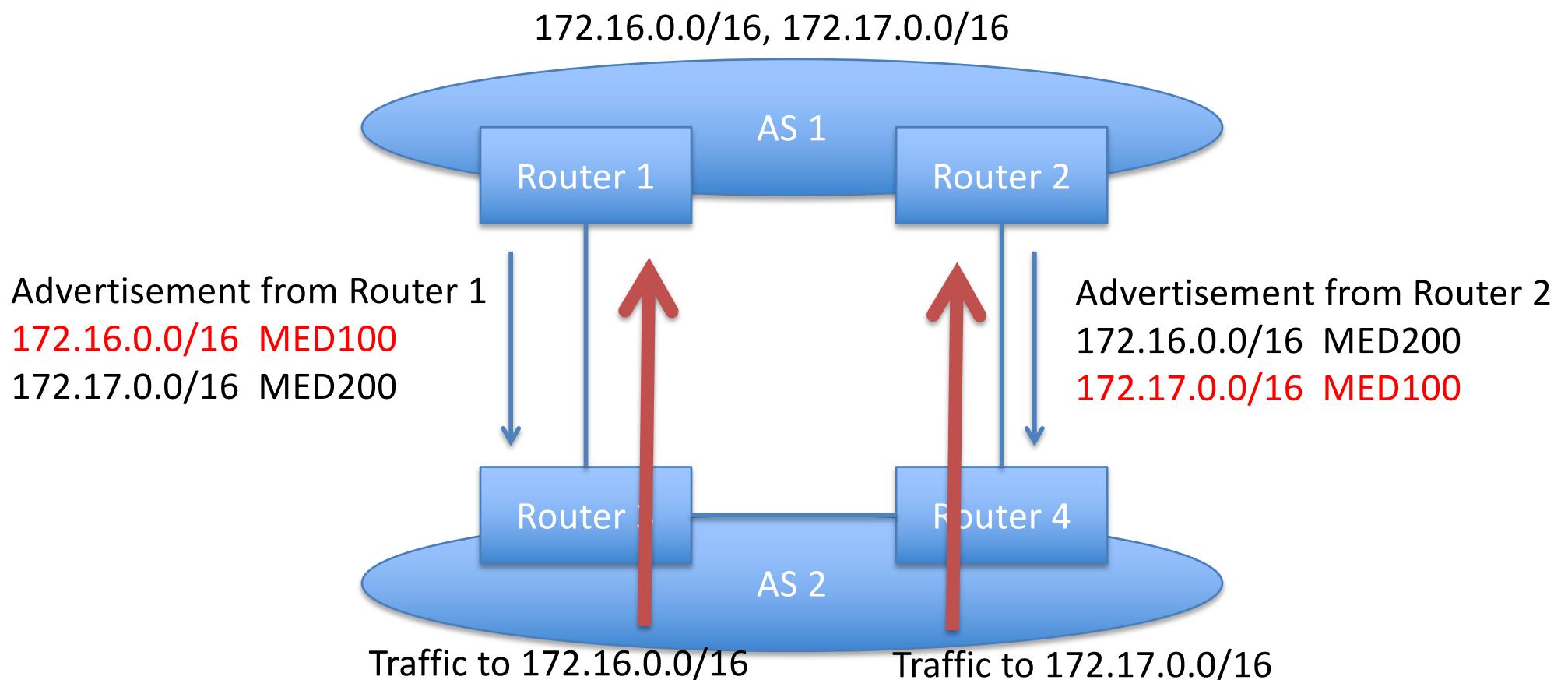
- BGP Router advertise a longer AS Path to AS 4

- AS Path through AS 4 will be longer than the other path



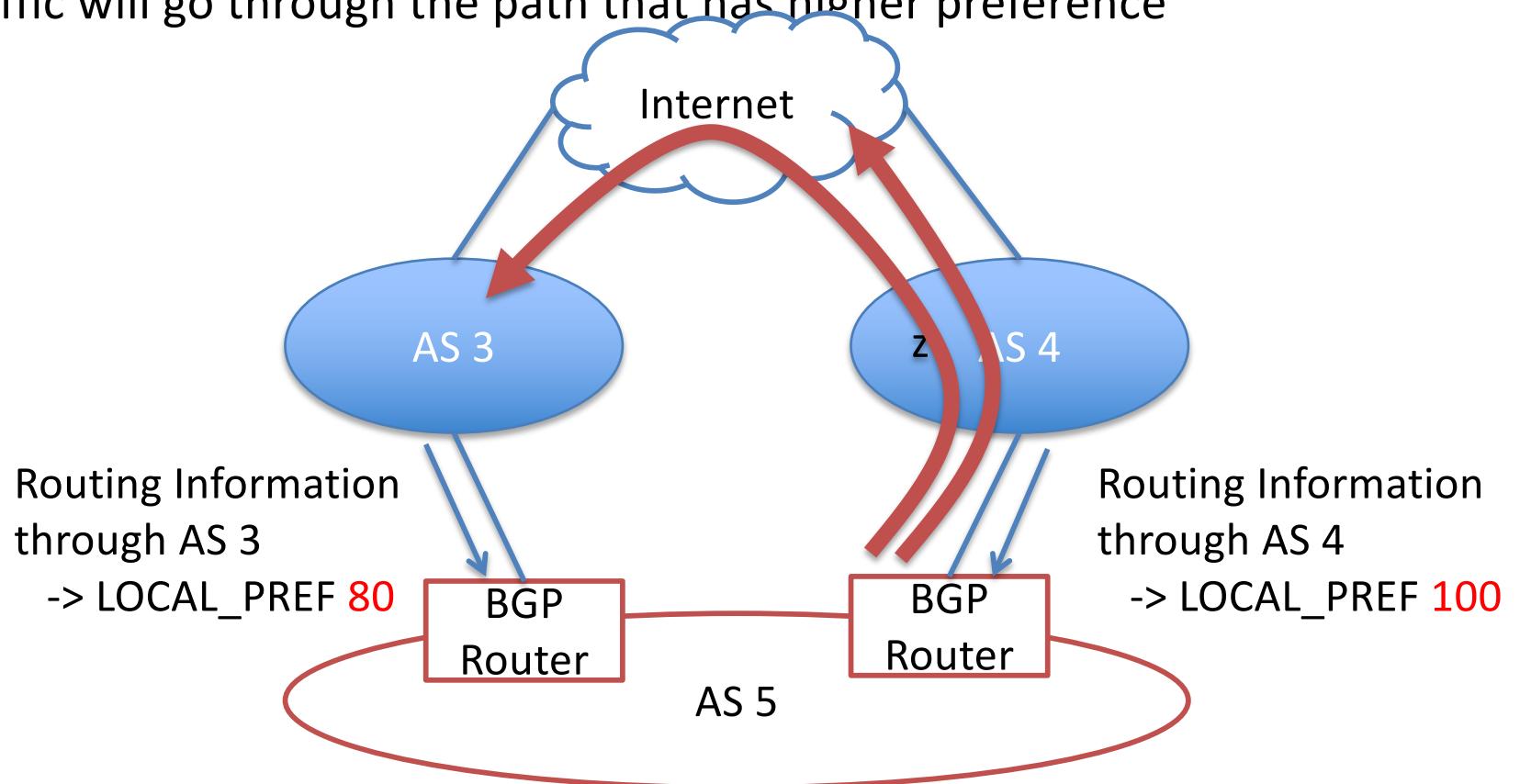
MED Attribute

- Controlling Paths used between Two Ases
 - AS_PATH determines only Shortest Path
 - What about multiple paths available between ASes?



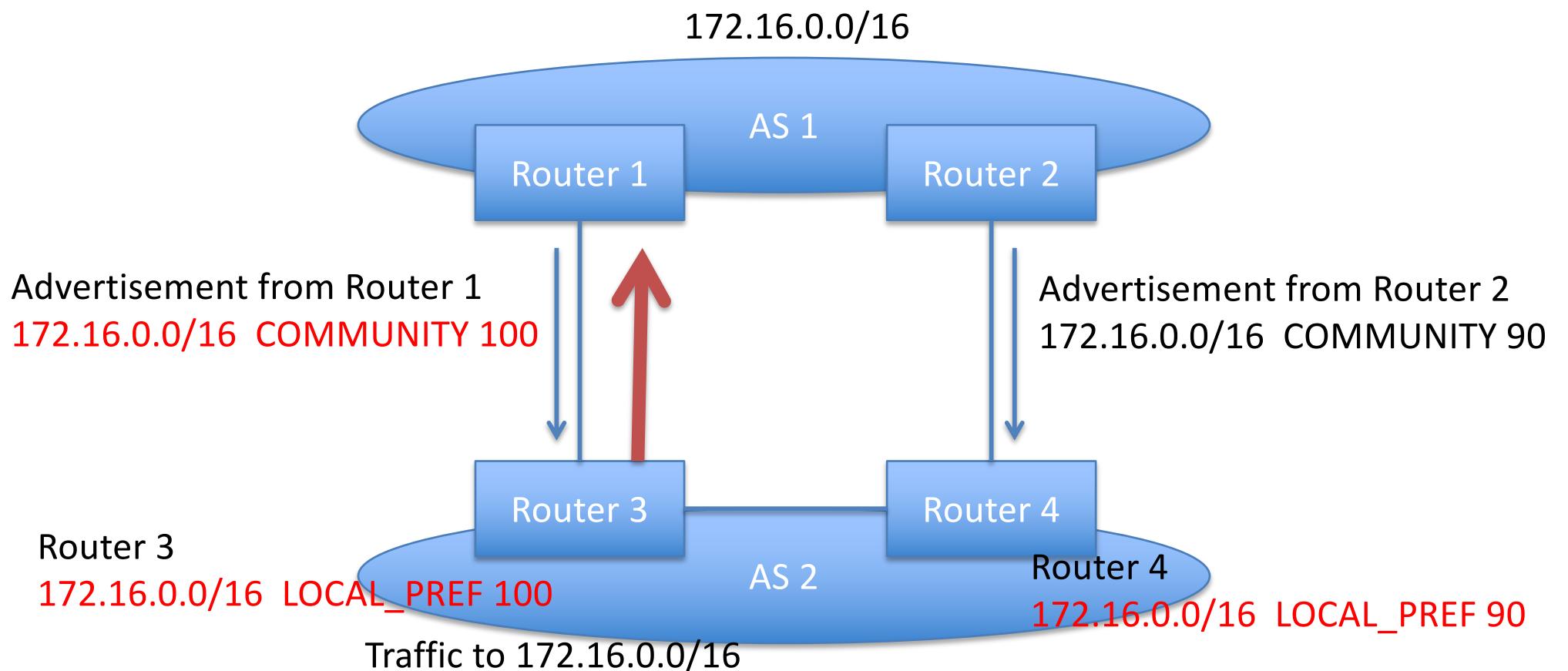
LOCAL_PREF

- How to control outgoing traffic if AS have multiple transits to the Internet?
 - Set LOCAL_PREF attribute to the incoming routing information
 - Traffic will go through the path that has higher preference



COMMUNITY

- Controlling Paths used between Two Ases
 - Injecting LOCAL_PREF to the routers in the neighboring AS



COMMUNITY

- Controlling incoming traffic between 2 ASes
- BGP router (A) advertises COMMUNITY along with the routing information
 - Ex: AS3000, 100
- BGP router (B), receiving the routing information converts COMMUNITY to LOCAL_PREF

Route Filtering

- Each router can determine
 - Which route to accept?
 - Which route to advertise?