

# Routing the Internet

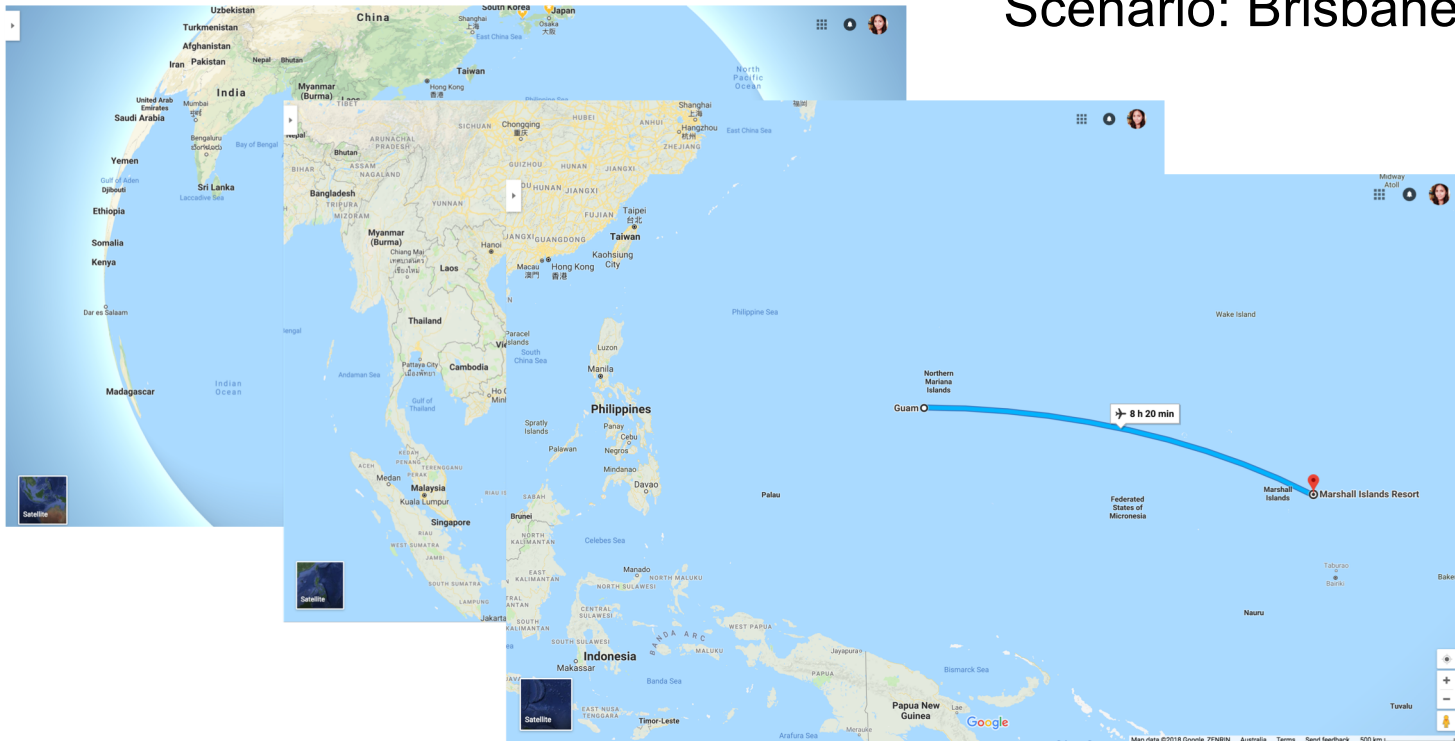
*aka Routing 101*

# What is Routing?

- Finding the best path in the best possible time

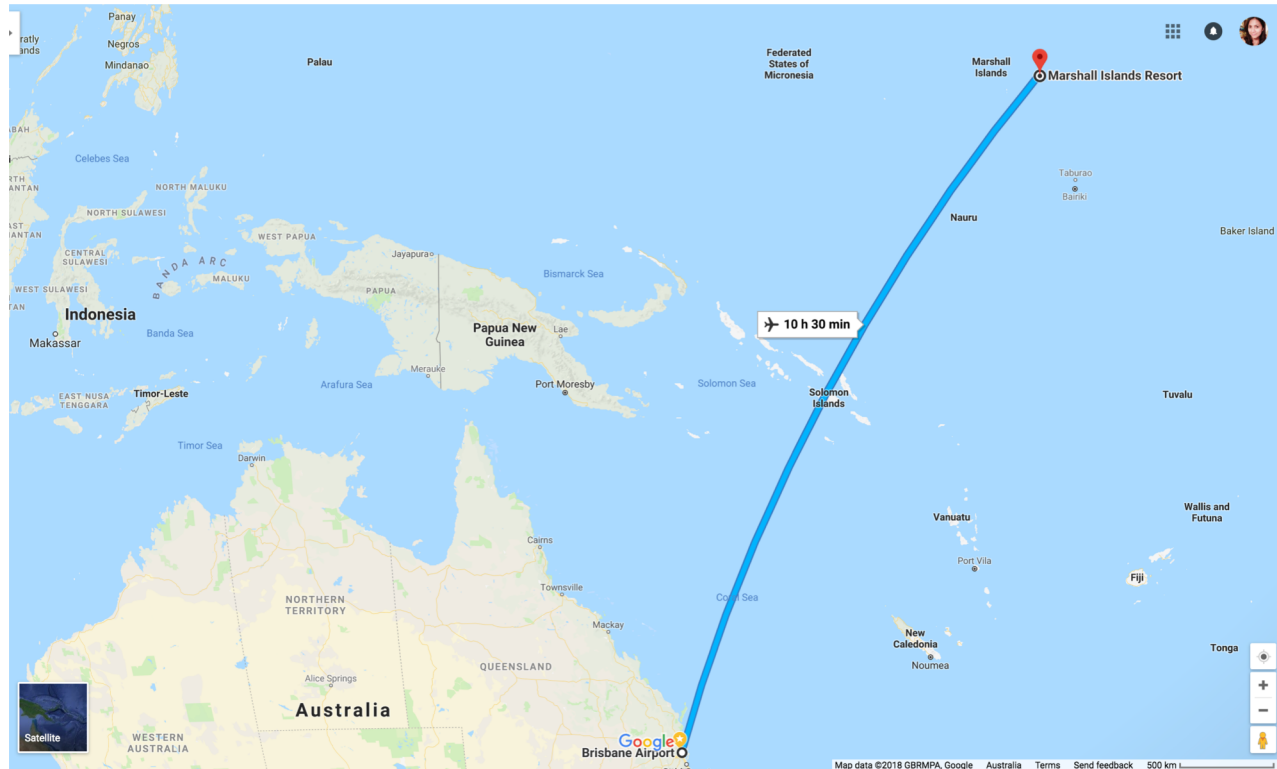
# Route to Majuro

Scenario: Brisbane to Majuro



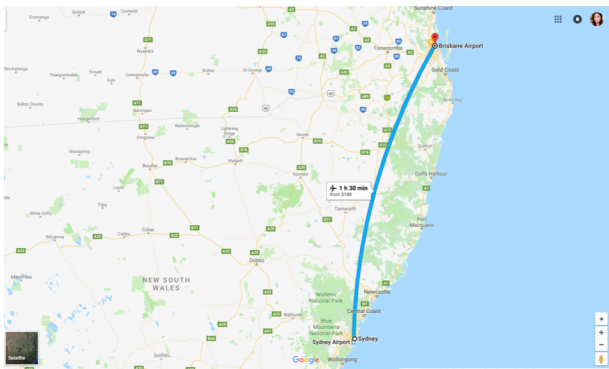
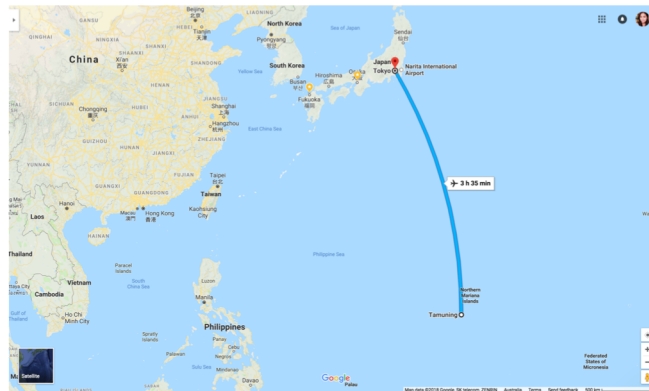
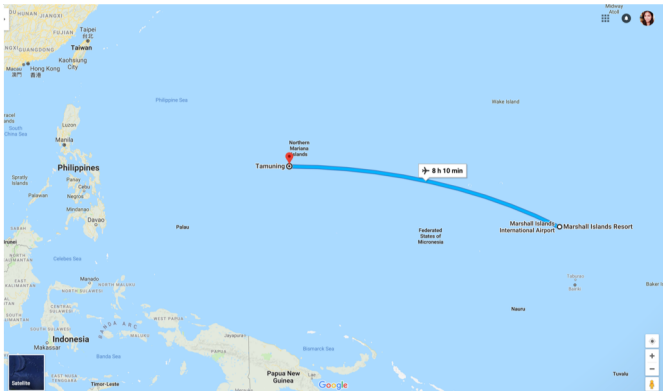
# Route to Majuro

Scenario: Brisbane to Majuro  
Alternative Route





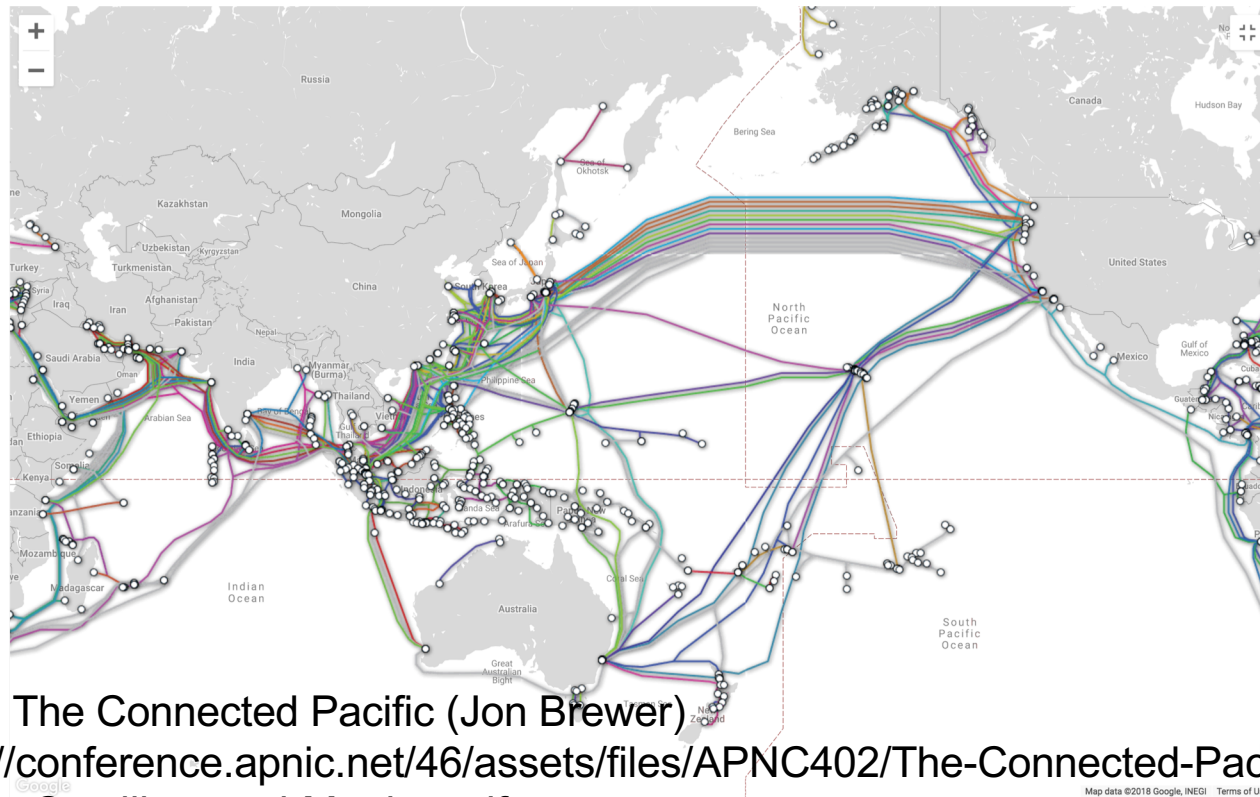
# Internet route to #pacnog23



traceroute to apnic.net (203.119.101.61), 64 hops max, 52 byte packets

- 1 10.105.105.254 (10.105.105.254) 2.058 ms 3.004 ms 2.107 ms
- 2 ip-64.86.76.151.dynamic.nta.mh (64.86.76.151) 2.398 ms 1.964 ms 2.340 ms
- 3 ix-ge-0-3-8-0.thar1.pv4-piti.as6453.net (180.87.9.25) 37.218 ms 41.676 ms 53.338 ms
- 4 if-ae-21-2.tcore2.tv2-tokyo.as6453.net (180.87.181.132) 72.466 ms 71.139 ms 69.890 ms
- 5 180.87.181.22 (180.87.181.22) 170.889 ms 171.985 ms 172.069 ms
- 6 syd-gls-har-wgw1-be-100.tpgi.com.au (203.221.3.7) 168.131 ms 170.932 ms 237.957 ms

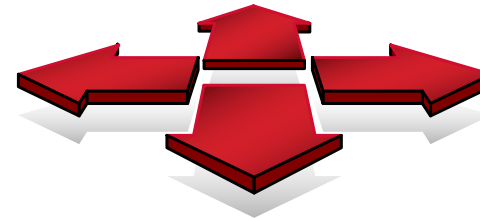
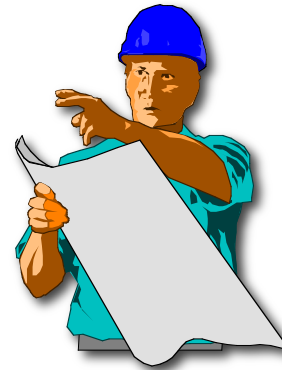
# How connected is Pacific to the world?



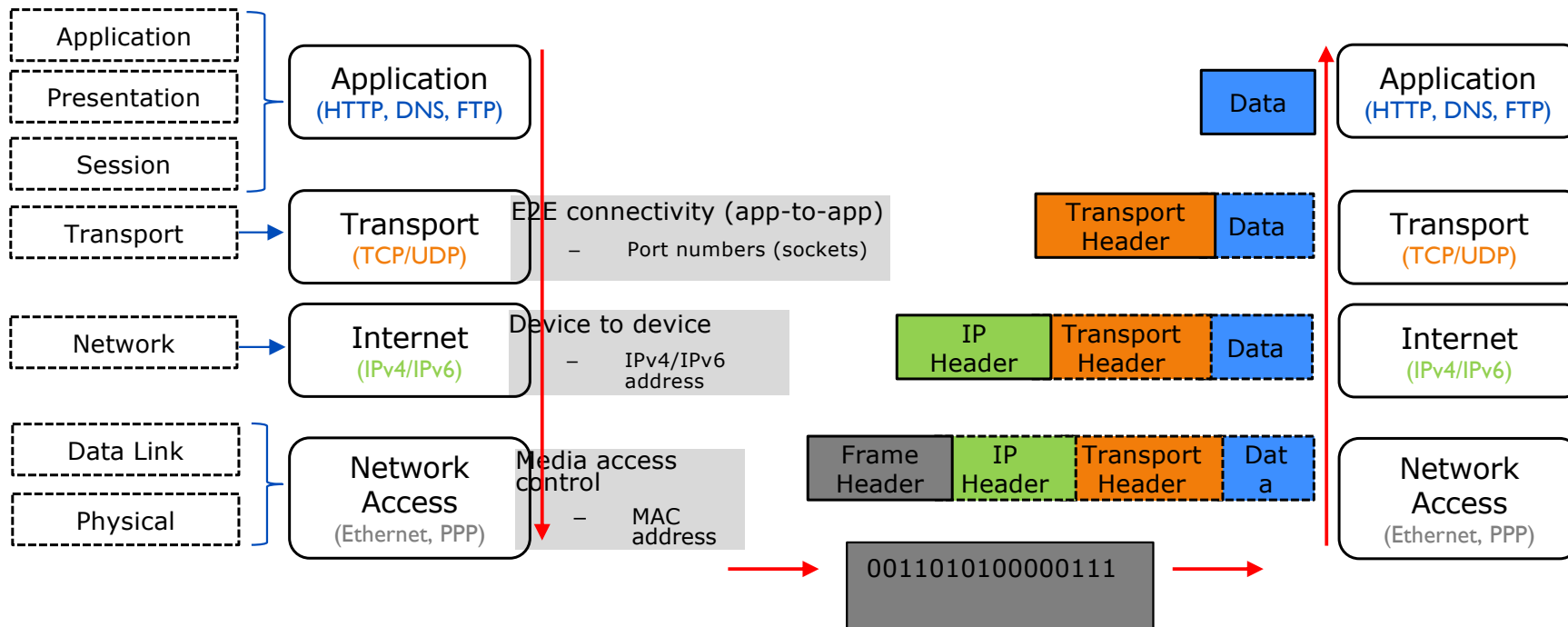
Read: The Connected Pacific (Jon Brewer)  
<https://conference.apnic.net/46/assets/files/APNC402/The-Connected-Pacific-Cables-Satellites-and-Metrics.pdf>

# Routing versus Forwarding

- Routing = building maps and giving directions
- Forwarding = moving packets between interfaces according to the “directions”



# Back to basics 😊



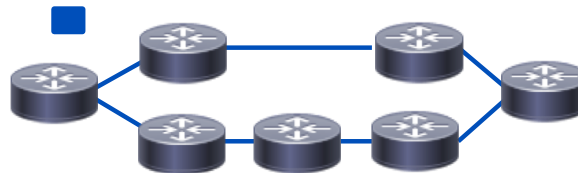
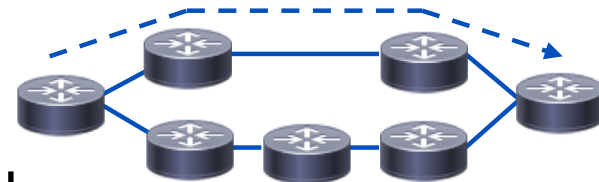
## Addressing is the key!

# Internet/Network Layer

- Host to host communication across networks
  - Addressing
    - unique and hierarchical network-wide address
  - Routing
    - the best path to the destination
- Current protocols
  - IPv4 and IPv6

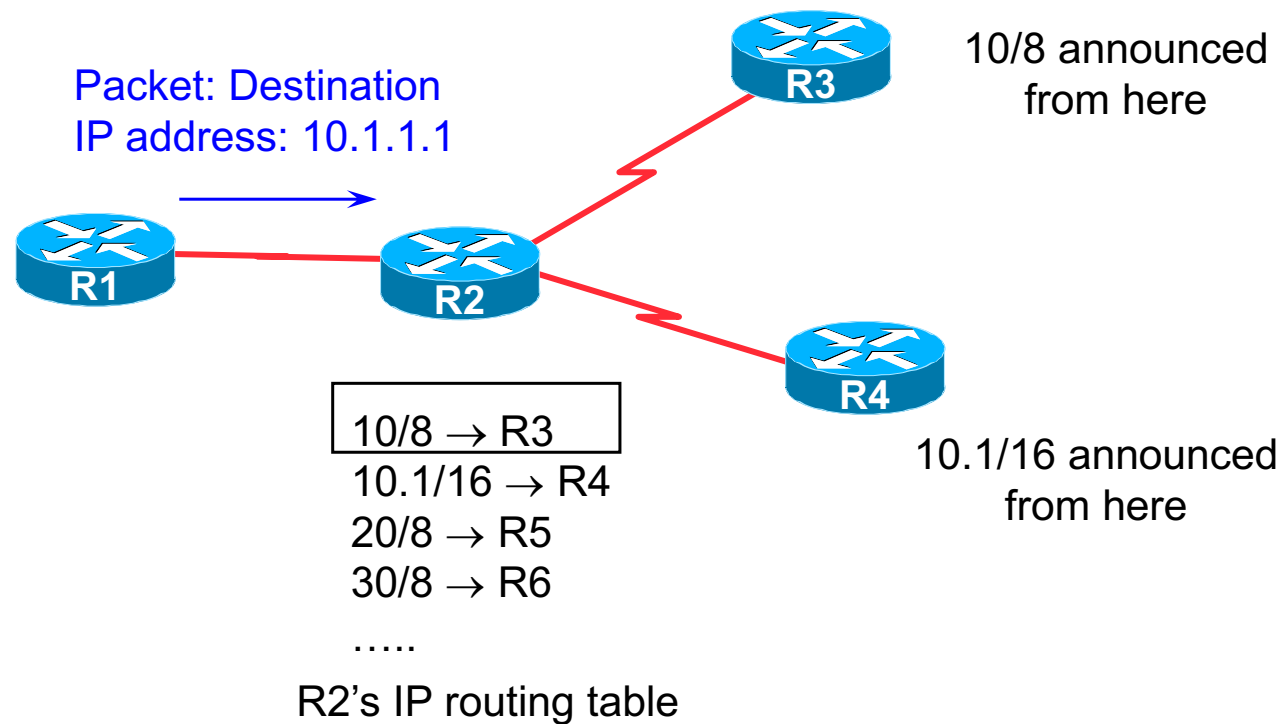
# L3 Device/Router

- L3 device gets the packet one step closer
  - The next hop to reach the destination!
- Router
  - Exchanges network information
  - Finds the best path to a destination, and
  - Forwards the packet to the next hop (a step closer) to reach the destination



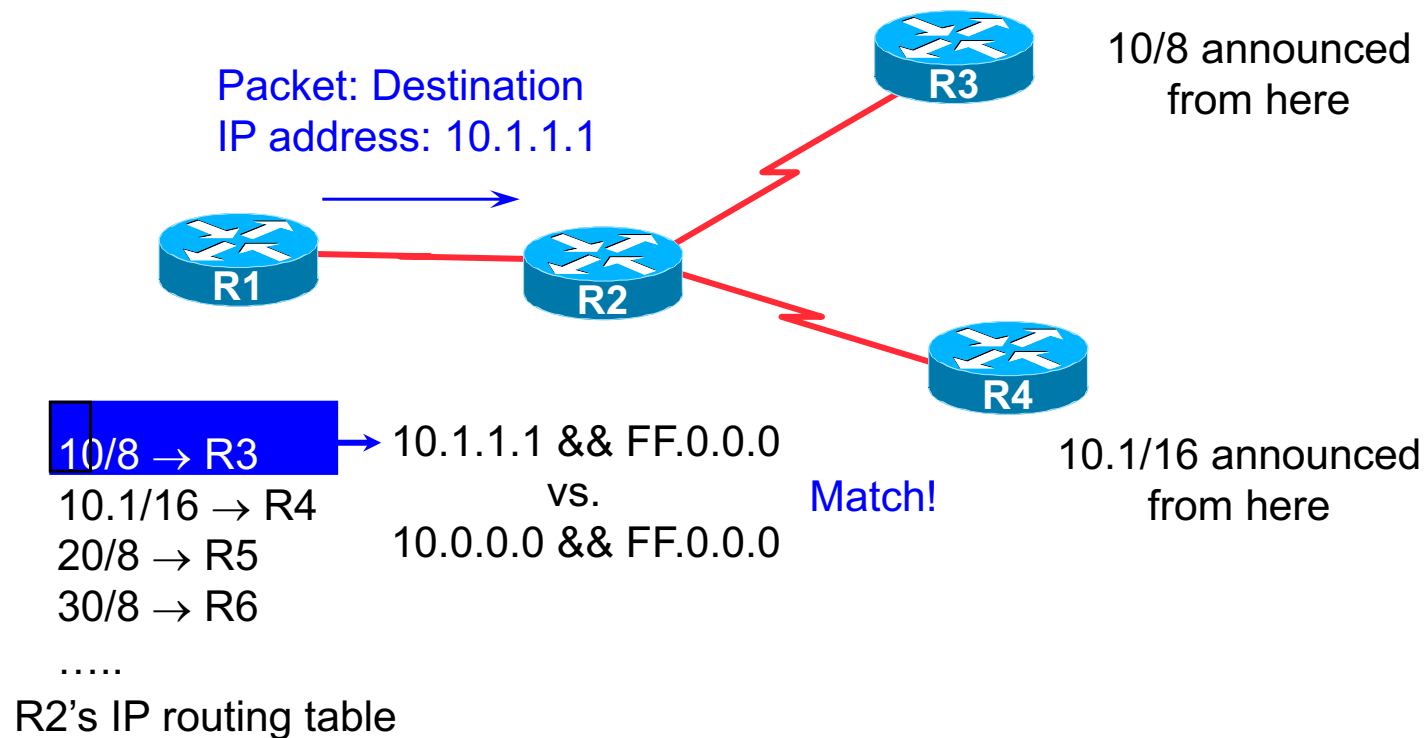
# IP route lookup

- Based on destination IP address



# IP route lookup: Longest match routing

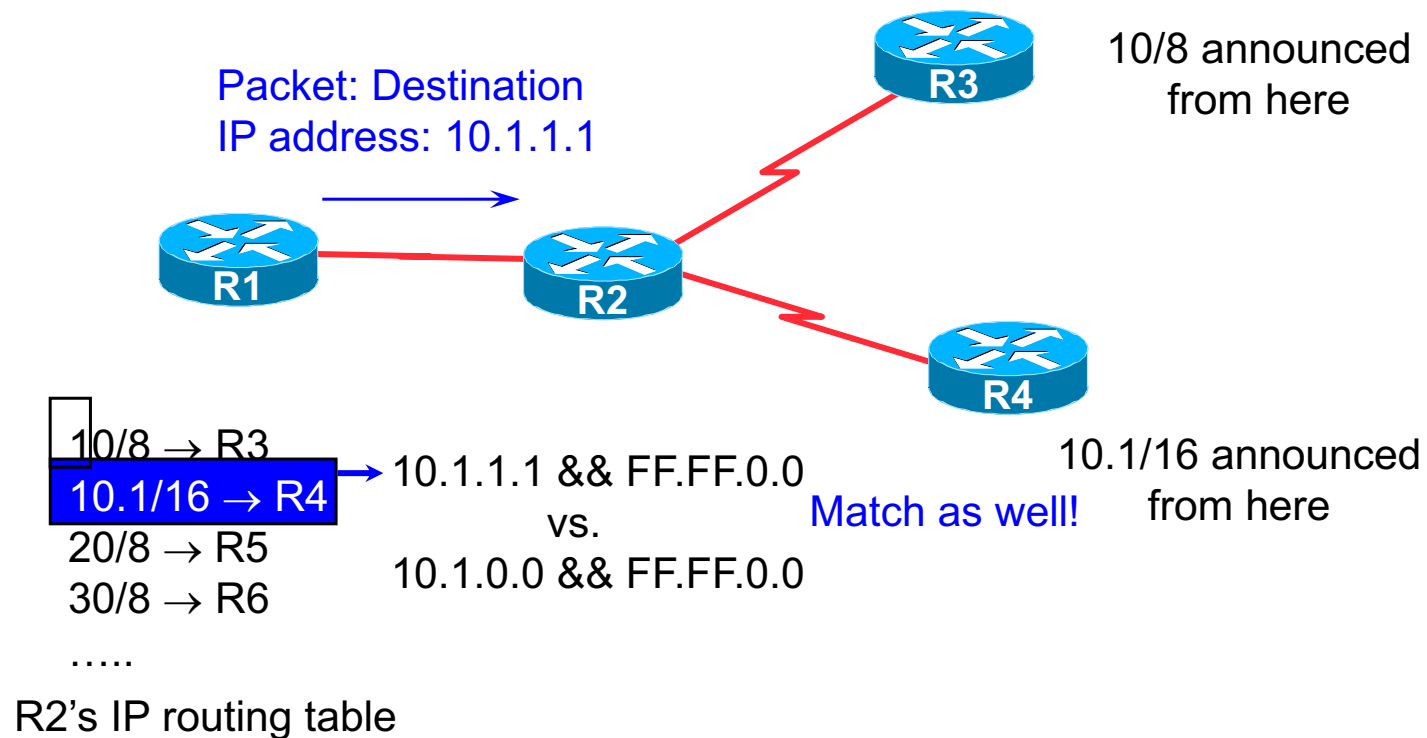
- Based on destination IP address





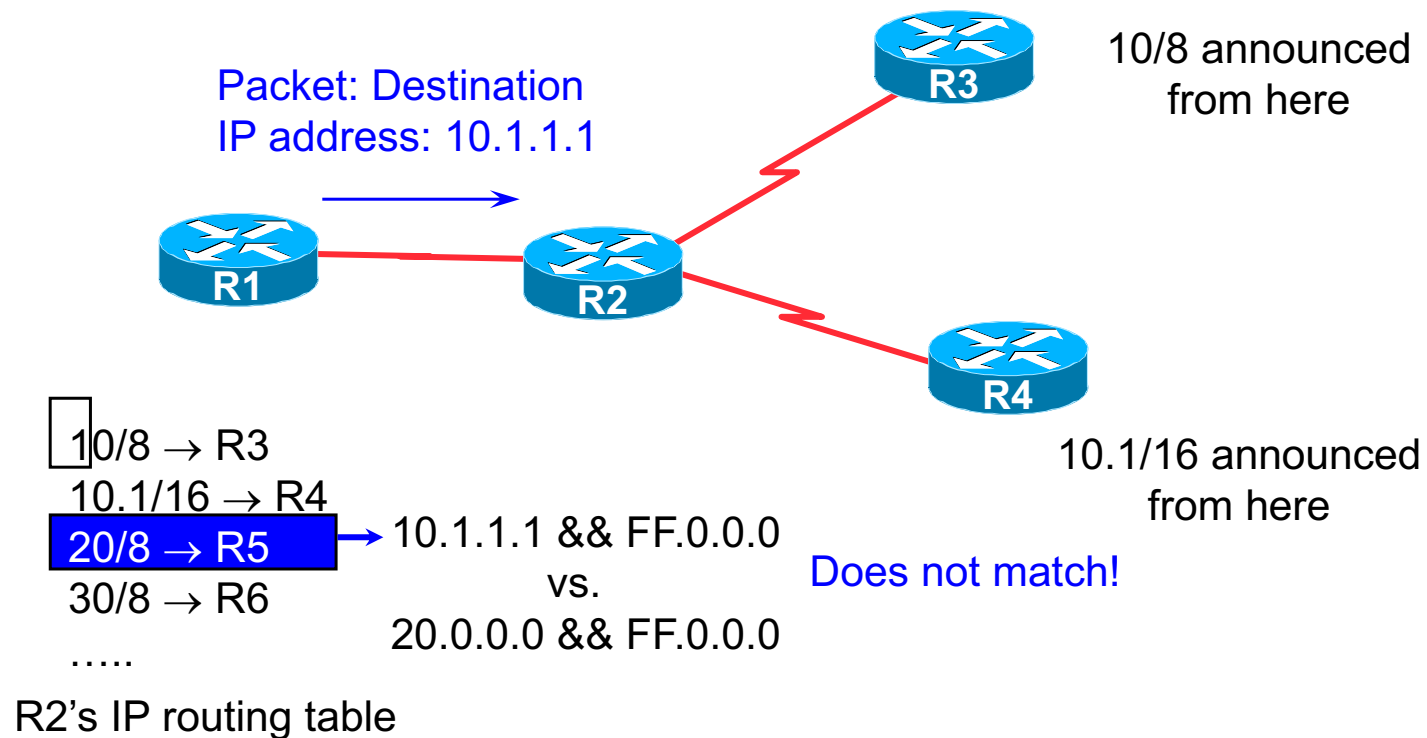
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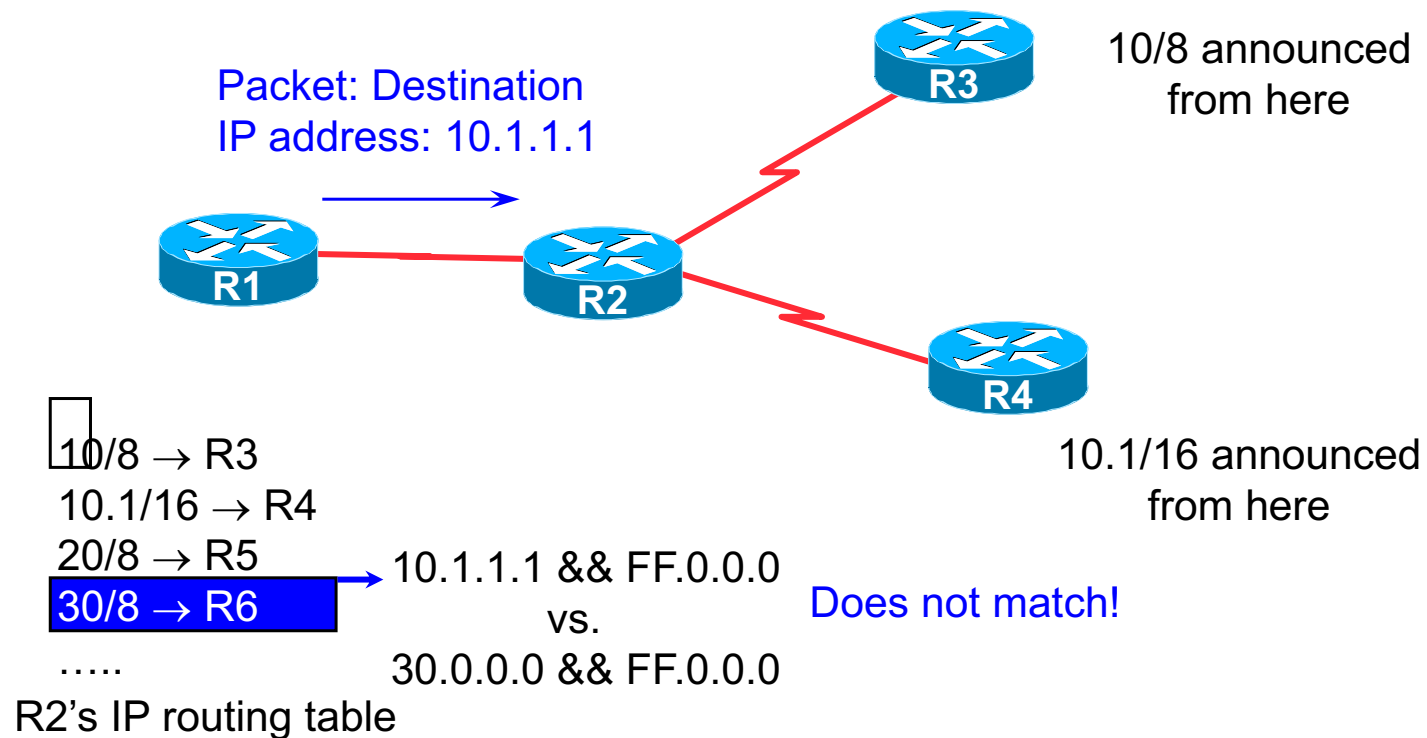
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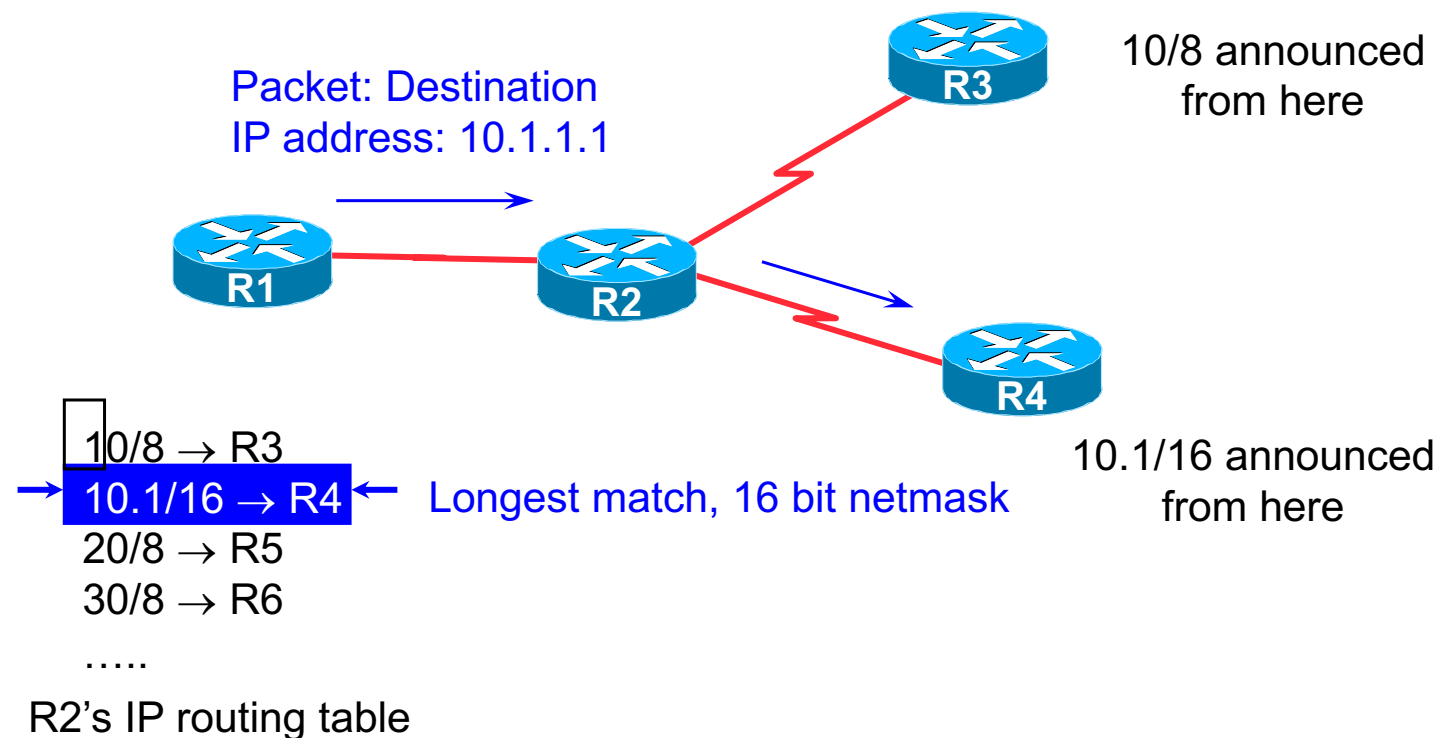
# IP route lookup: Longest match routing

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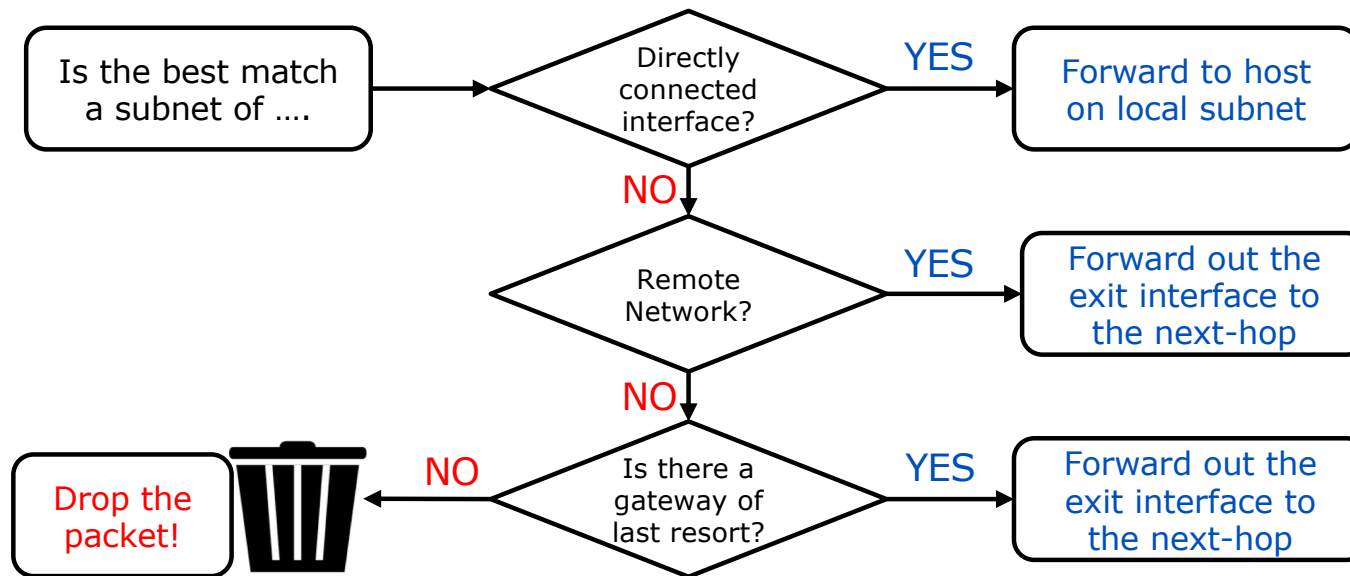
# IP route lookup: Longest match routing

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# Packet Forwarding

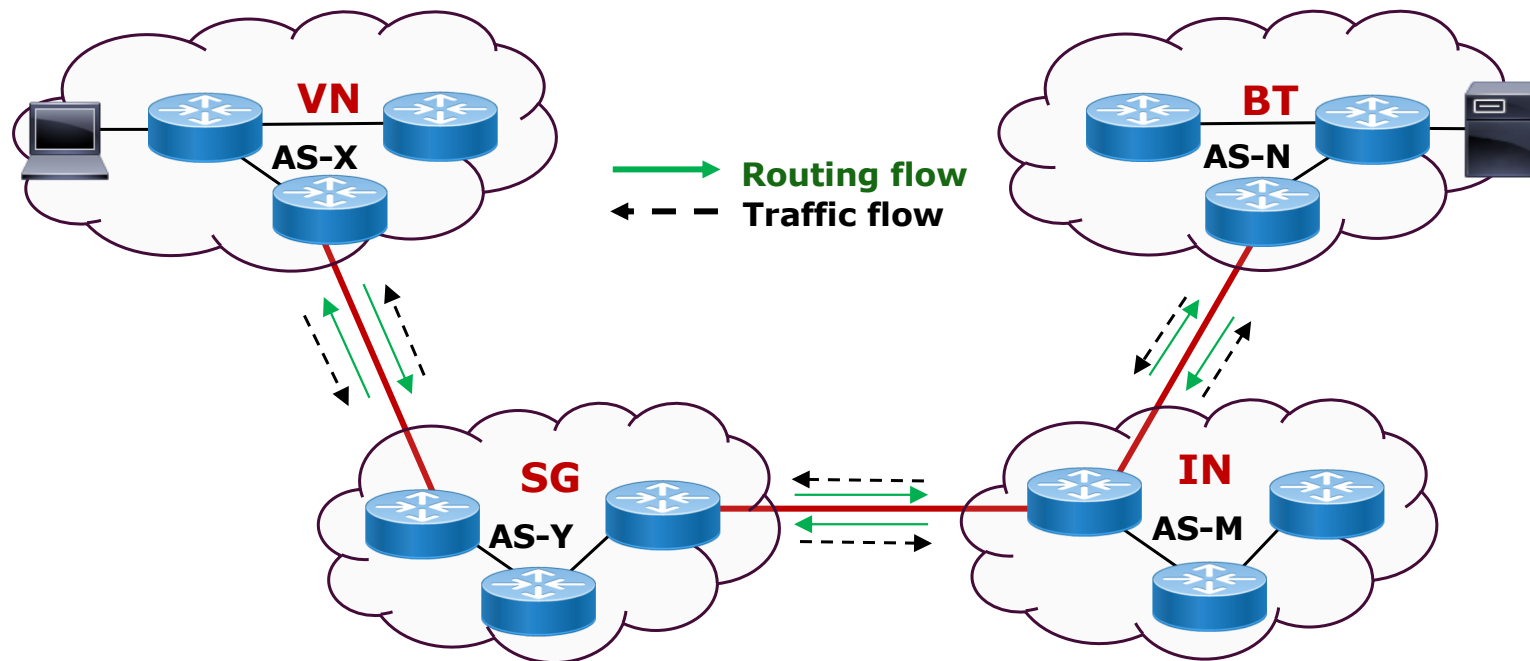
- If a best match is found, the router determines
  - the correct exit interface to reach the next-hop/destination



# Internet Routing

- How does a user in Marshall Islands access a service hosted in the Hong Kong?
  - The ISP in MH could directly connect to the ISP in HK
    - Neither scalable nor economical
  - Instead, the MH ISP shares its network information with its neighbor ISPs
  - The ISP in HK does the same with its own neighbors
  - Neighbor ISPs propagate the information to their neighbors, and so on...
    - Eventually, they both learn about each other's network!

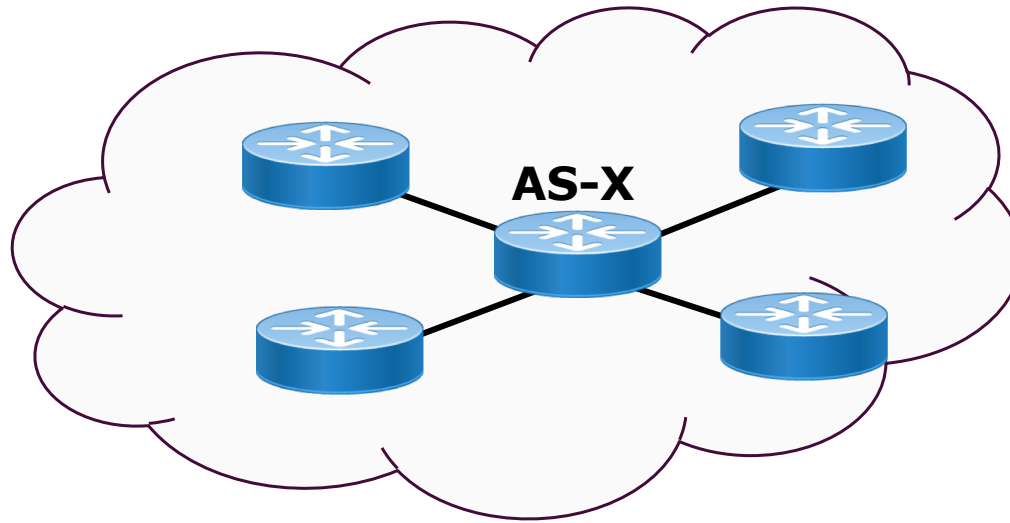
# Internet Routing



Exchange of network information – **Routing**  
Networks (ASes) connected together – **Internet**

# Autonomous System (AS)

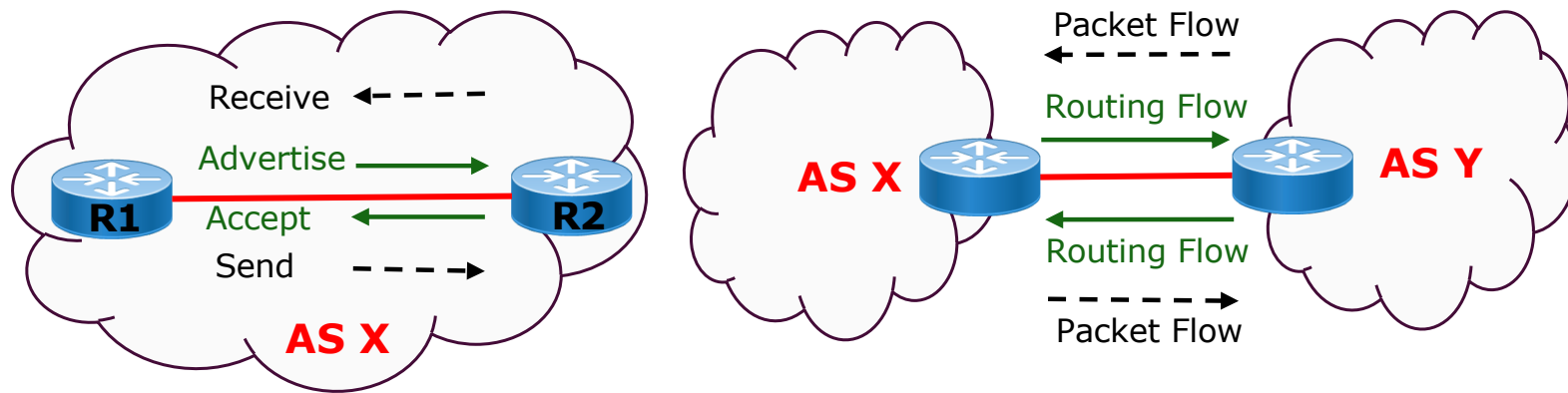
- A group of networks with the same routing policy (external)
  - Usually under single administrative control





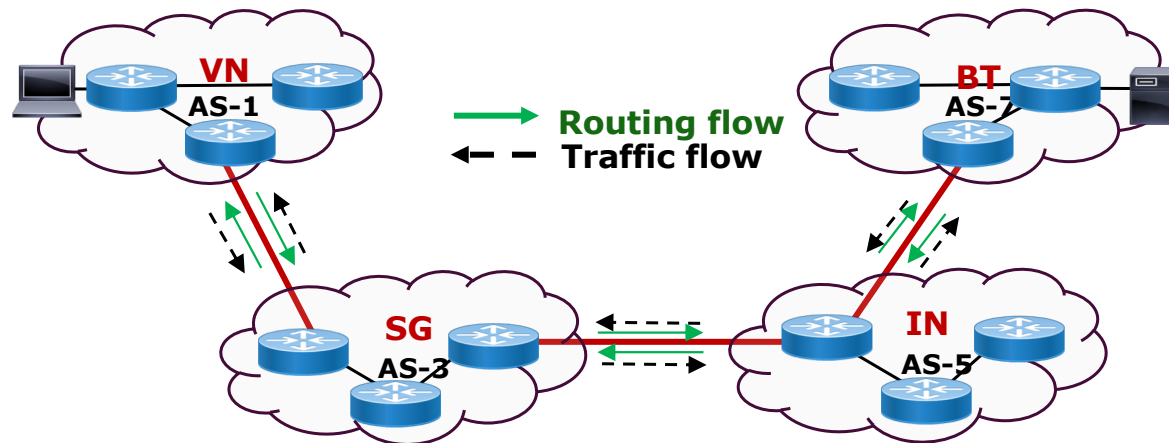
# Routing Flow & Traffic Flow

- Traffic and network info always flow in opposite direction!
  - network info exchanged in both directions for bi-directional traffic flow



# Routing & Traffic Flow: Internet

- For user (N1) in AS1 to send traffic to user (N7) in AS7:
  - AS7 must originate and announce N7 to AS5.
  - AS5 must accept N7 from AS7, and advertise to AS3.
  - AS3 must accept and forward N7 to AS1
  - AS1 must accept N7 from AS3



# Routing Policy

- To manipulate/control traffic flow in/out of a network
  - manipulate inbound routing info to influence outgoing traffic
  - manipulate outbound routing info to influence incoming traffic

# What is Routing Protocol?

- A set of rules defined to facilitate the exchange of routing information between routers (Layer 3 device) inside networks
- Builds routing tables dynamically based on updates from its neighbours
  - Allows the router to find the best path in a network that has more than one path to a remote network.
- Maintains connectivity between devices within the network.

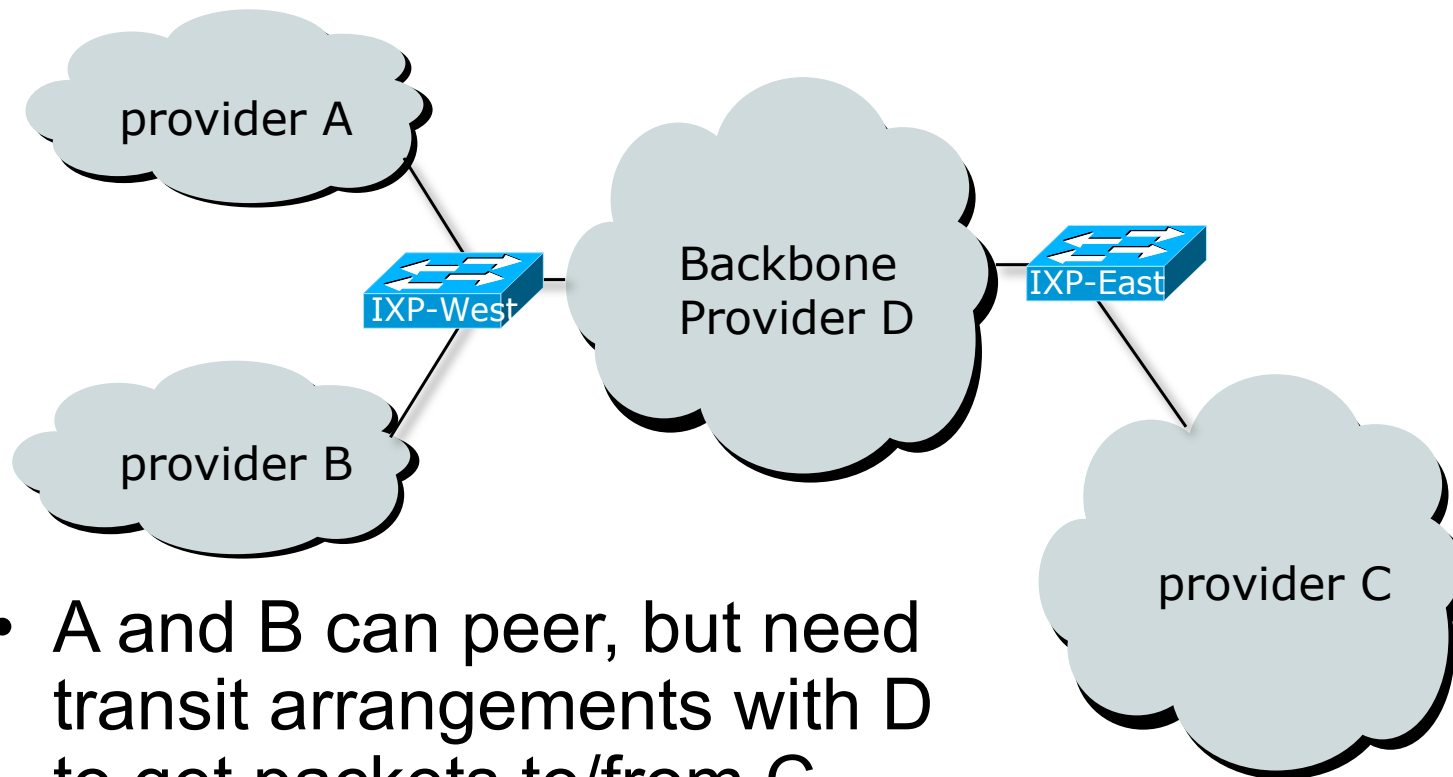
# Routing Protocols

- How do routers exchange network information with each other?
  - Routing Protocols!
  - IGP & EGP

# Peering vs Transit

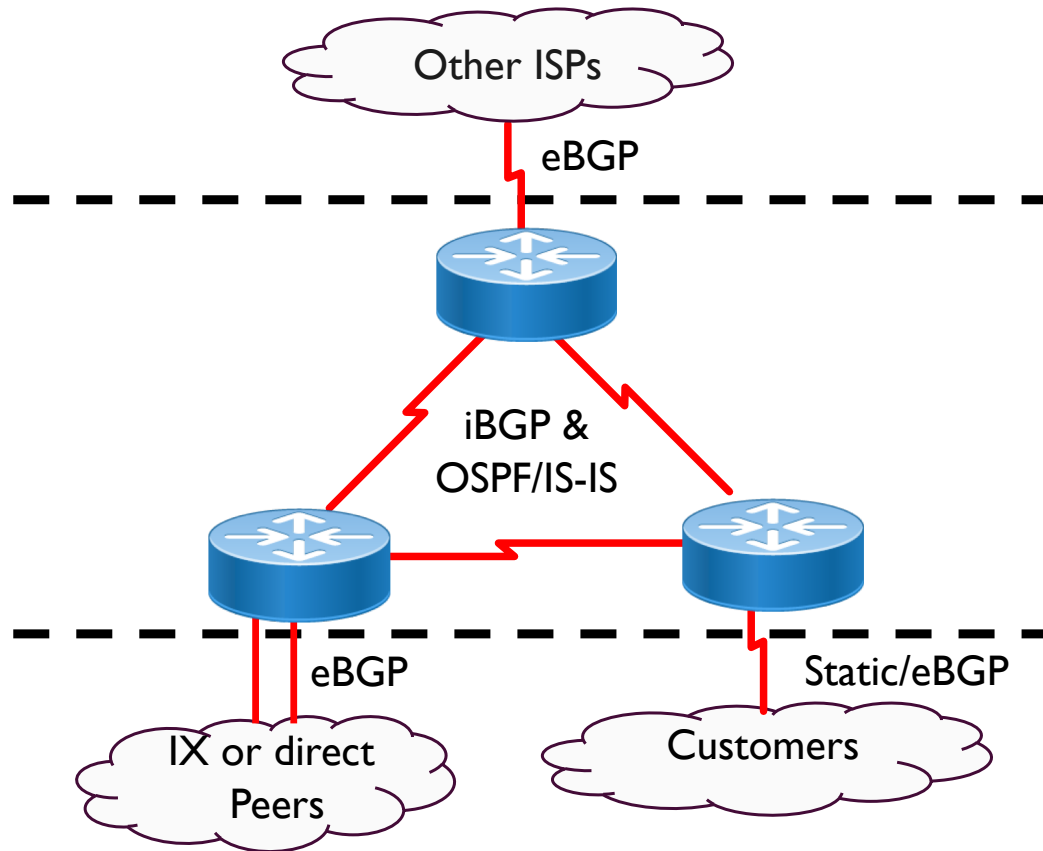
- Transit – carrying traffic across a network, usually for a fee
- Peering – exchanging routing information and traffic
- Default – where to send traffic when there is no explicit match in the routing table

# Peering and Transit example



- A and B can peer, but need transit arrangements with D to get packets to/from C

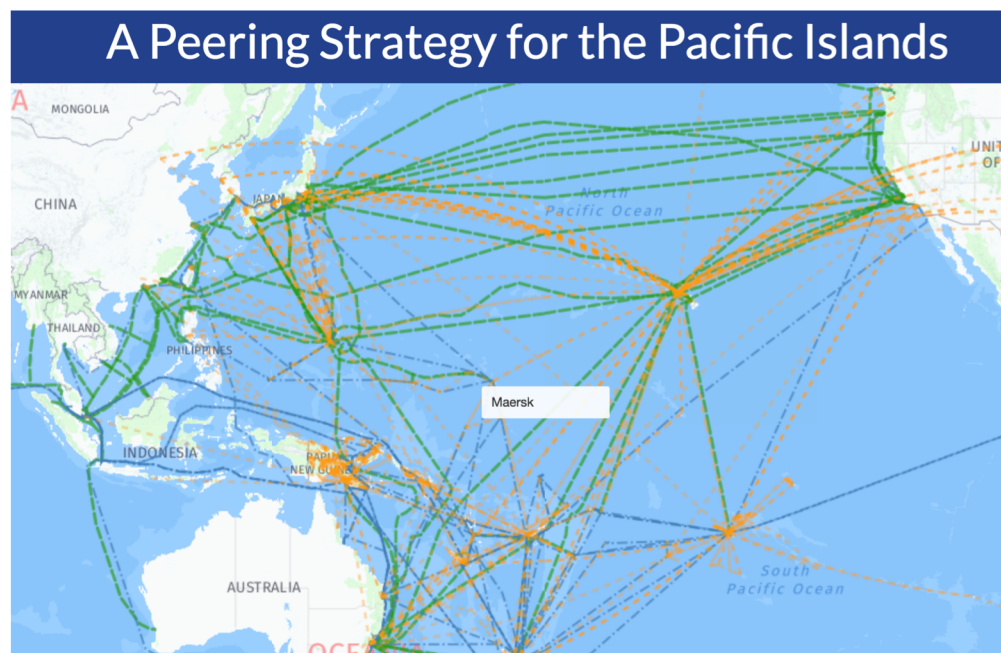
# Routing Protocols Hierarchy





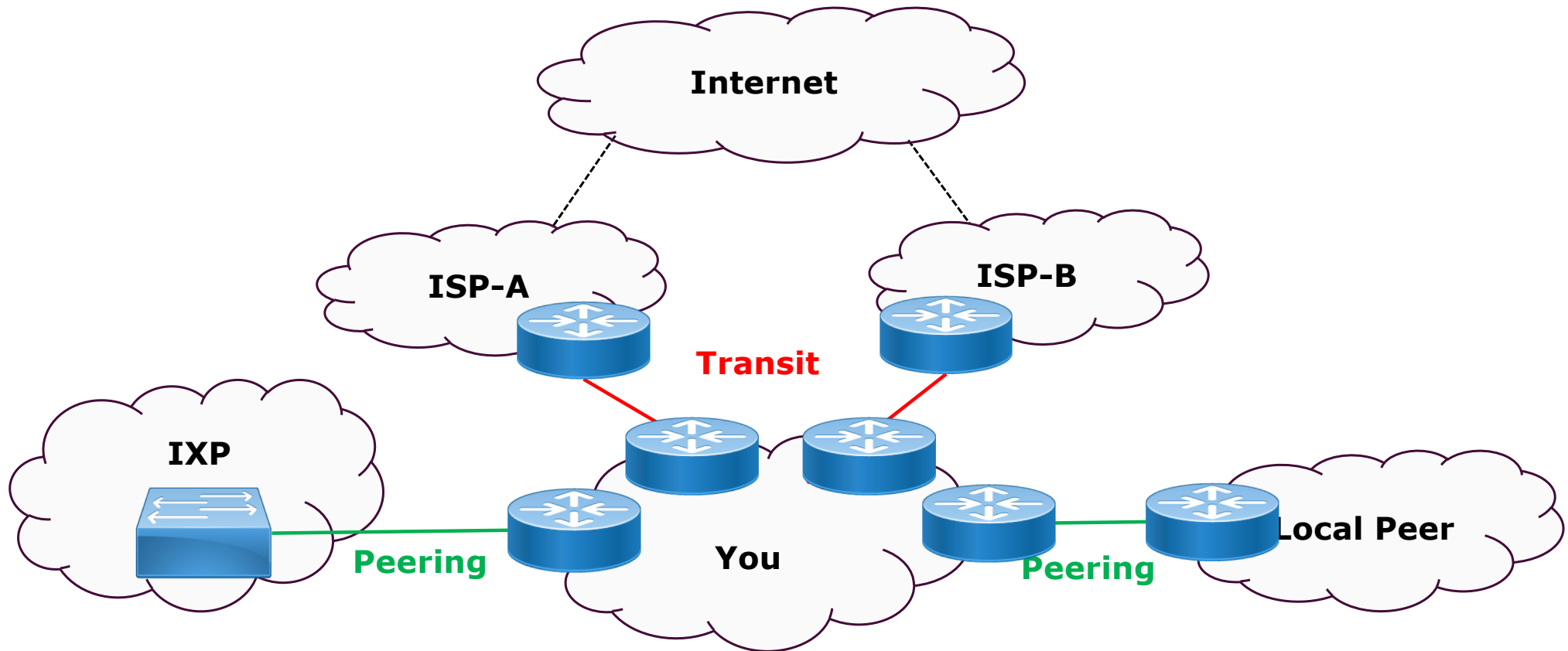
# Peering in the Pacific

- <https://pacpeer.org/>



This site reviews the telecommunications environment of the Pacific Islands. It looks at each community's connectivity to the world: telecommunications, sea freight, air routes, and trade. It provides real-time statistics on provider market share. It considers the complexity of island telecommunications through the mythical nation of Avaiki. Over time it will be expanded to include data on carrier interconnections and performance to each market's major trading partners.

# Multihoming





# Questions

