Lesson 12: Multicast and Mobile IP

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Outline

Content
- Recall the last lesson
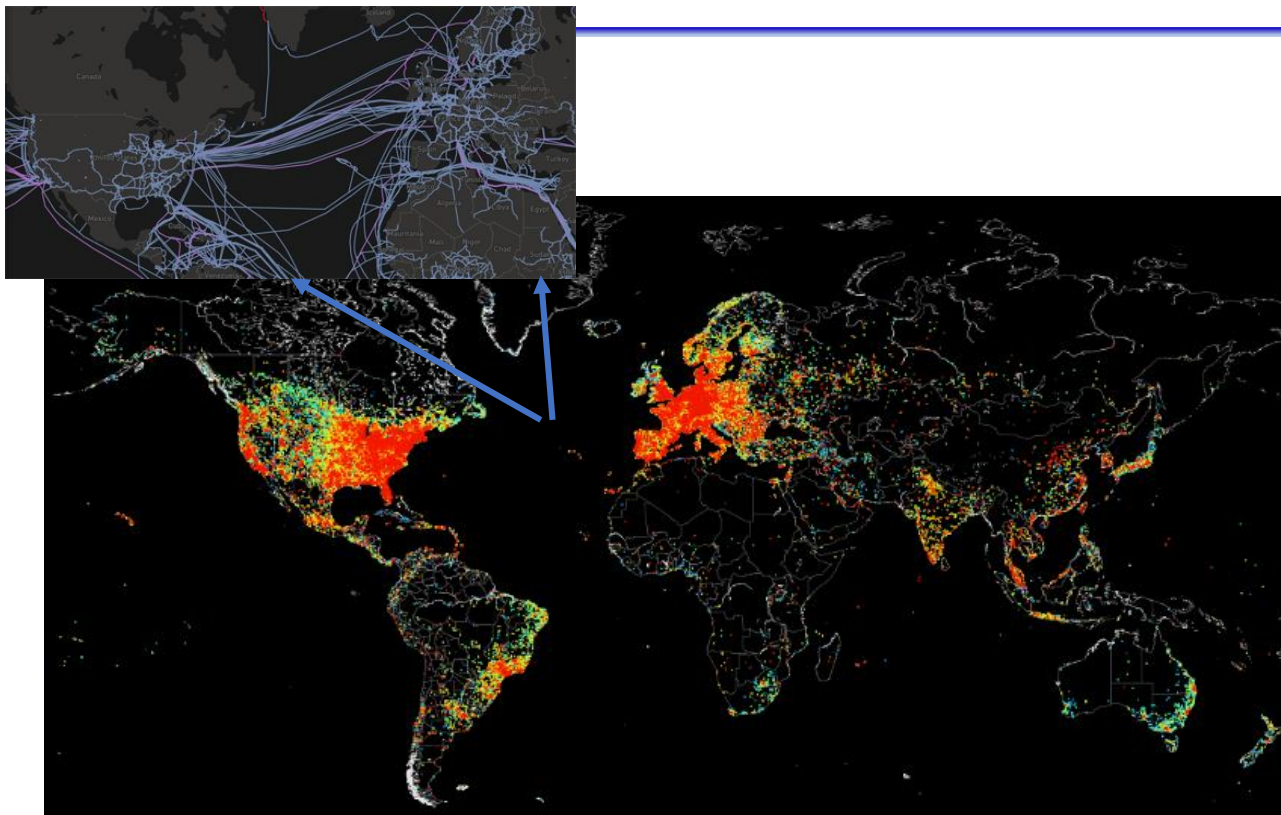- Global Internet
- Multicast
- Mobile IP

Goal:
- Master Firewall configuration
- Understanding the scalability of routing in the Internet
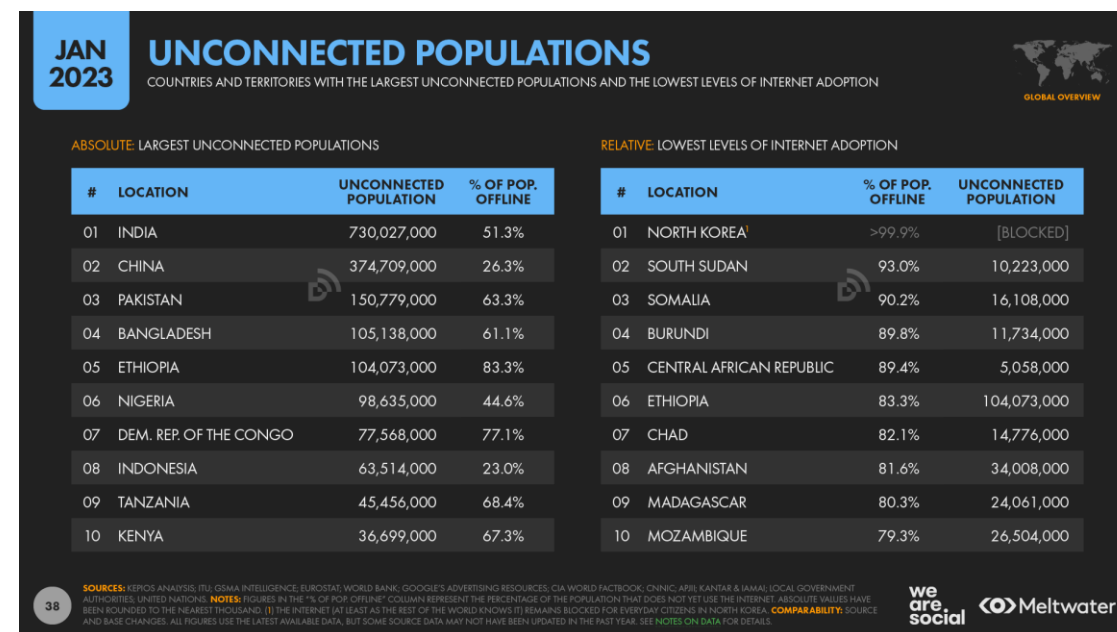- Understanding the concept of multicasting
- Discussing Mobile IP

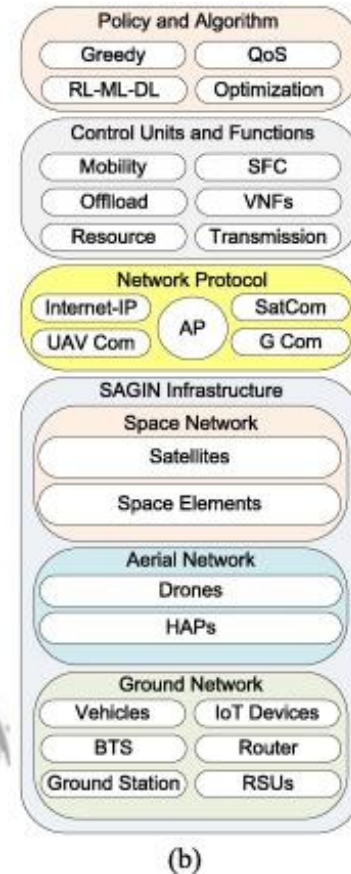# Global Internet

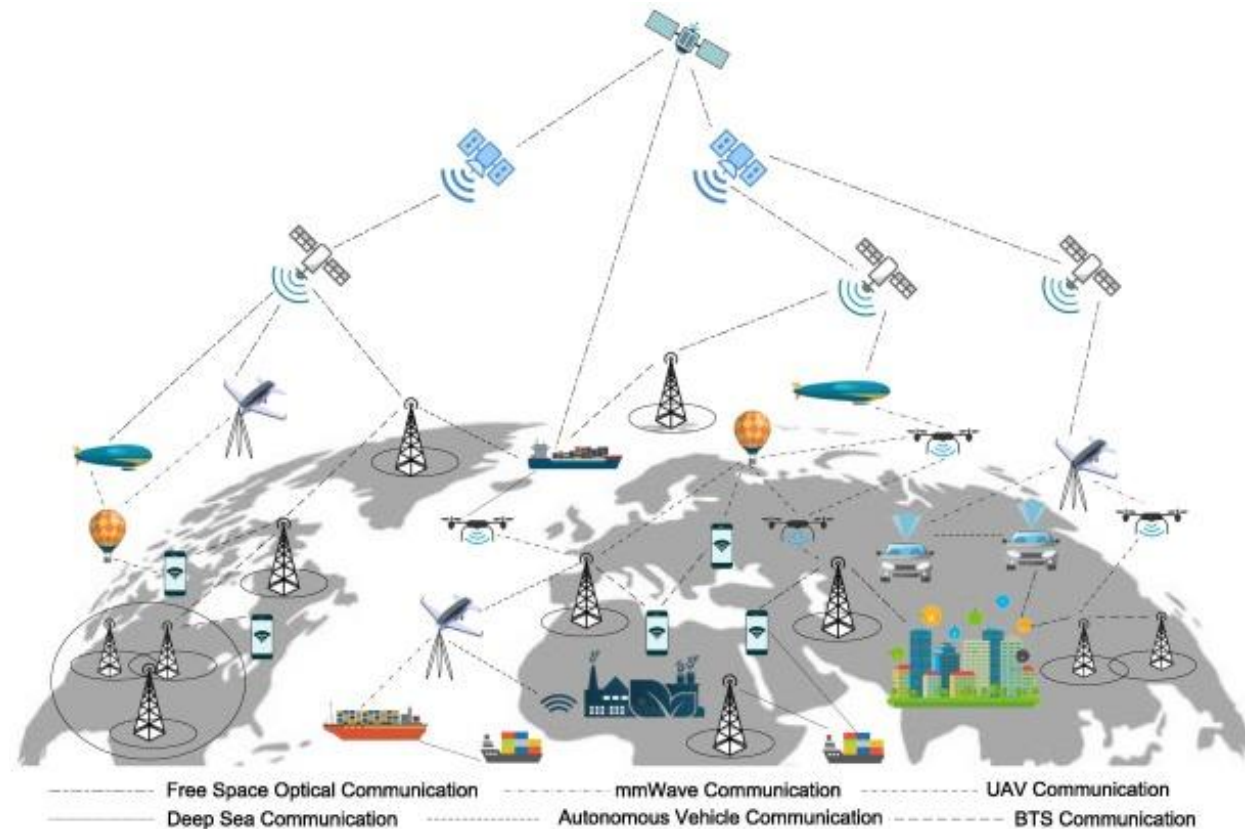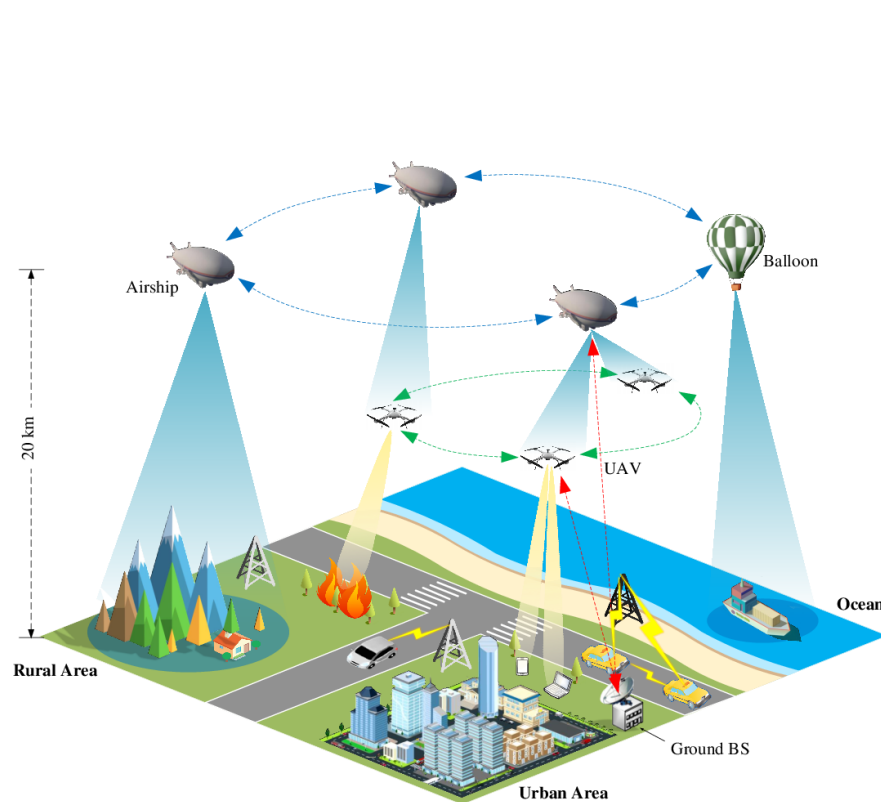# The Global Internet in a glance
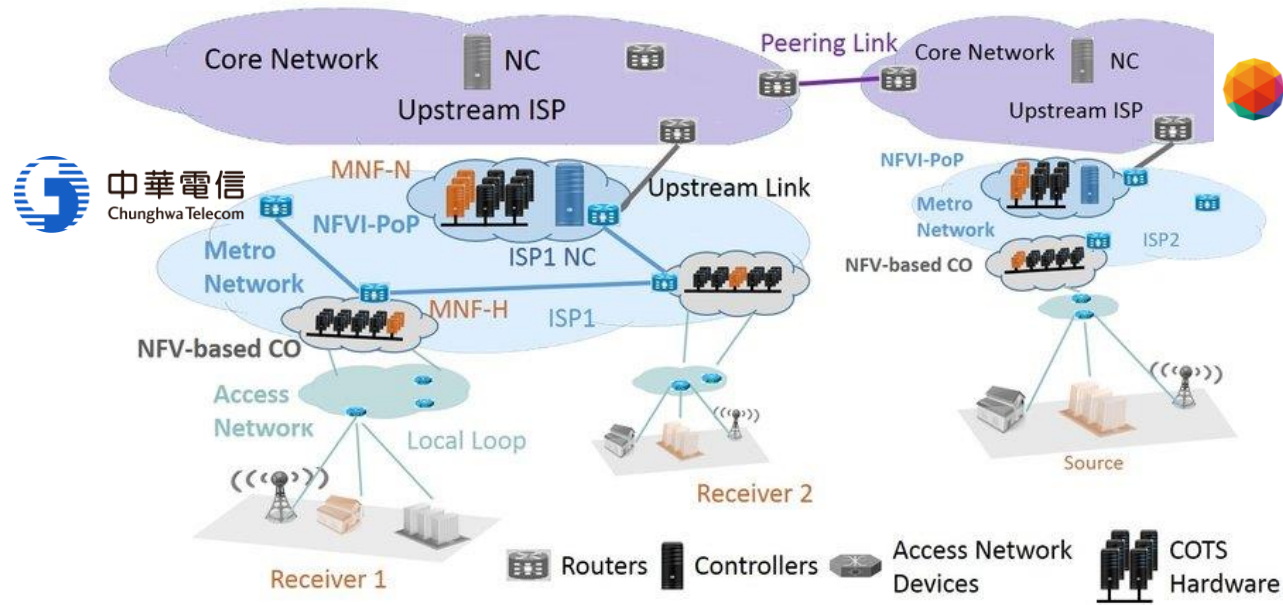
Global Internet structure in 2023

Population without Internet
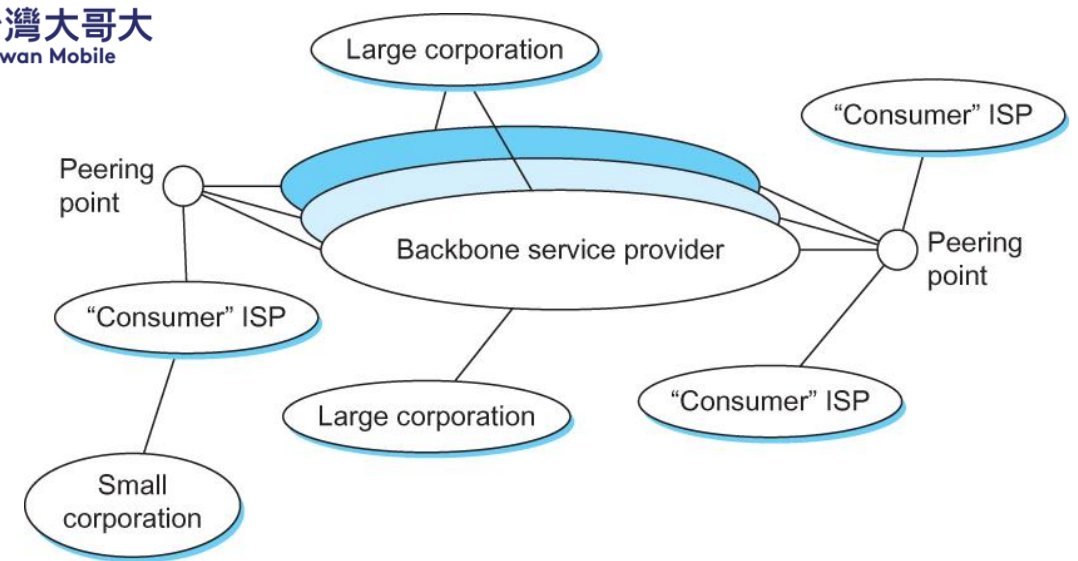
Next-generation Network (NGN)

Src: A review on 6G for space-air-ground integrated network: Key enablers, open challenges, and future direction

Multi-provider Internet

A simple multi-provider Internet

Interdomain Routing (BGP)

- Internet is organized as autonomous systems (AS) each of which is under the control of a single administrative entity

- Autonomous System (AS)
  - corresponds to an administrative domain
  - examples: University, company, backbone network

- A corporation's internal network might be a single AS, as may the network of a single Internet service provider
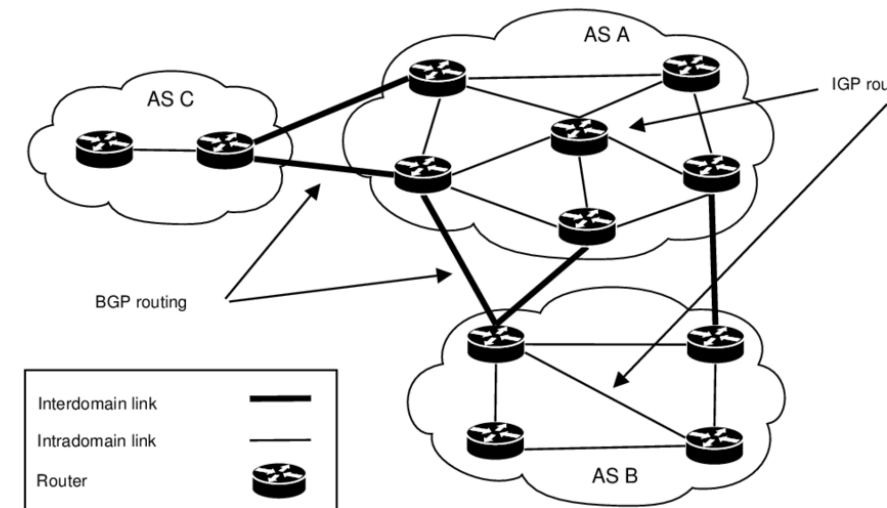
A network with two autonomous system

Route Propagation

- Idea: Provide an additional way to hierarchically aggregate routing information is a large internet.
  - Improves scalability

- Divide the routing problem in two parts:
  - Routing within a single autonomous system
  - Routing between autonomous systems

- Another name for autonomous systems in the Internet is routing domains
  - Two-level route propagation hierarchy
    - Inter-domain routing protocol (Internet-wide standard)
    - Intra-domain routing protocol (each AS selects its own)
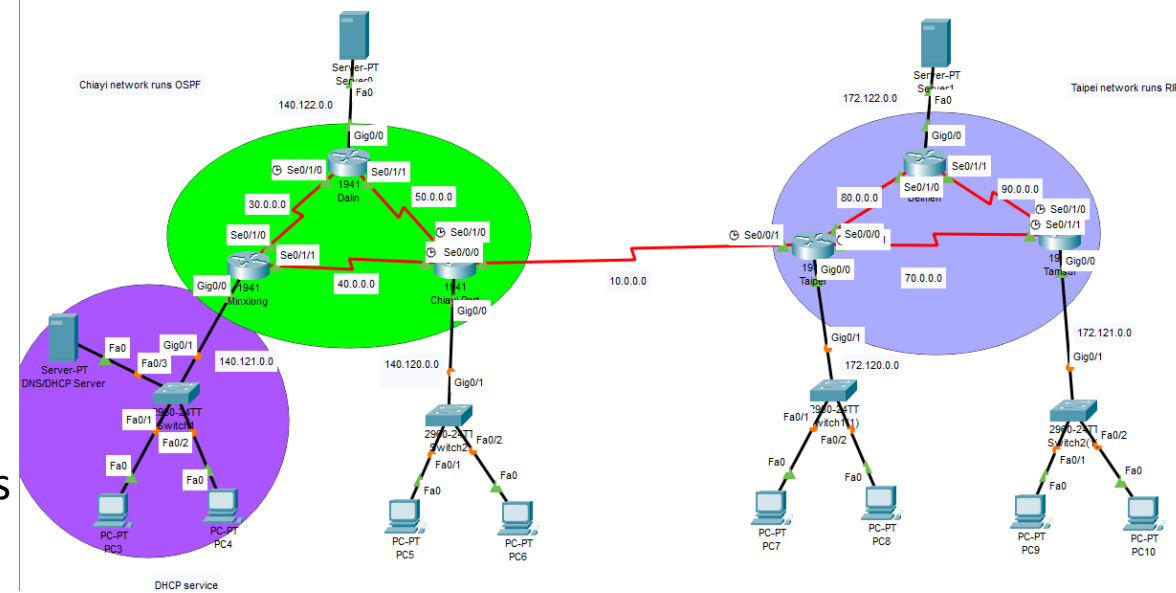
Routing Areas

Backbone area

Area border router (ABR)
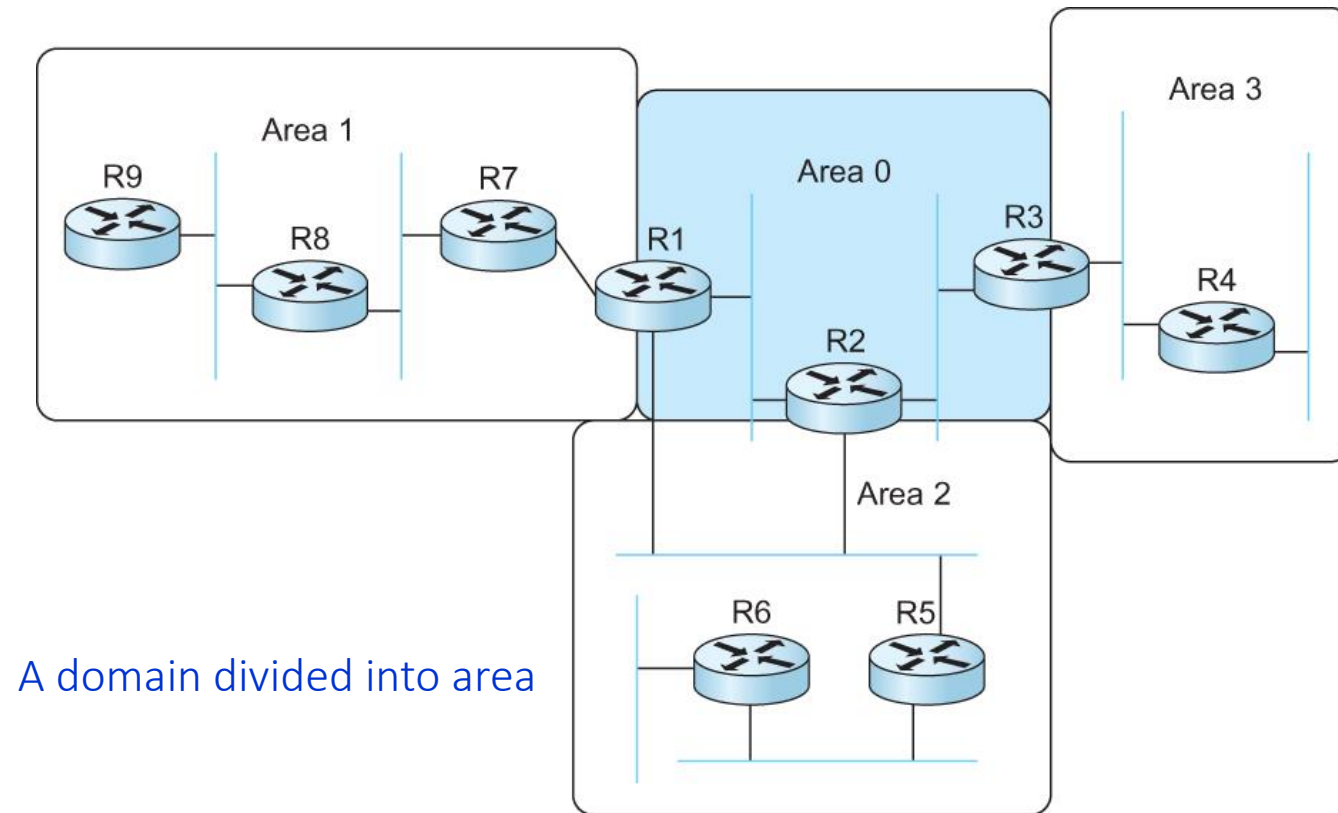
A domain divided into area

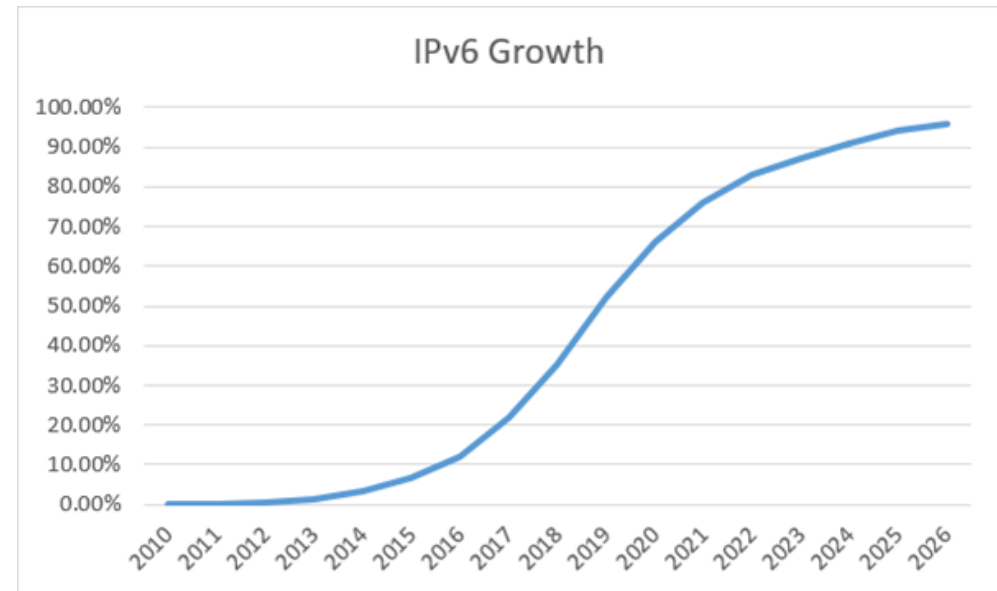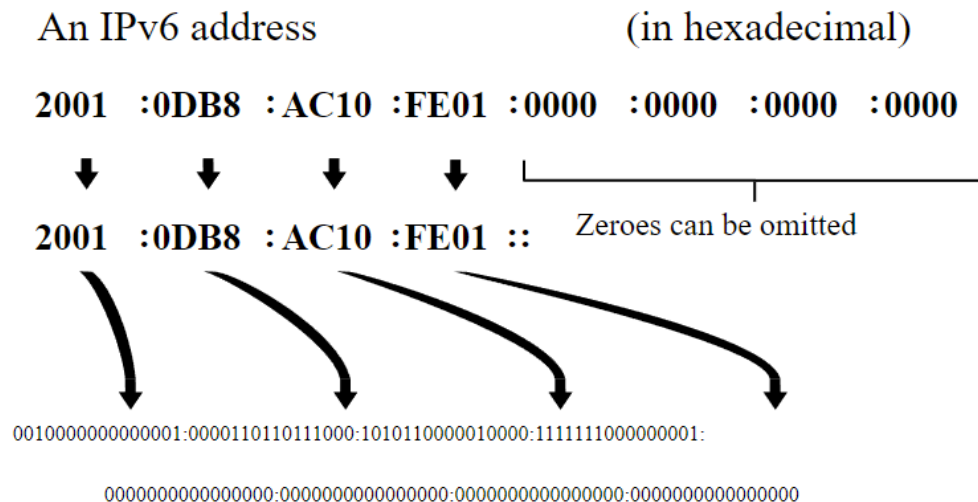# Next Generation IP (IPv6)

- 128-bit addresses

- Multicast

- Real-time service

- Authentication and security

- Auto-configuration

- End-to-end fragmentation

- Enhanced routing functionality, including support for mobile hosts

IPv6 Growth

IPv6 Addresses

- Classless addressing/routing (similar to CIDR)

- Notation: x:x:x:x:x:x:x:x (x = 16-bit hex number)
  - contiguous 0s are compressed: 47CD::A456:0124
  - IPv6 compatible IPv4 address: ::128.42.1.87

- Address assignment
  - provider-based
  - geographic

An IPv6 address   (in hexadecimal)

2001 :0DB8 :AC10 :FE01 :0000 :0000 :0000   :0000

2001 :0DB8 :AC10 :FE01 ::   Zeroes can be omitted

0010000000000001:0000110110111000:1010110000010000:1111111000000001:

0000000000000000:0000000000000000:0000000000000000:0000000000000000

IPv6 Header

- 40-byte "base" header
- Extension headers (fixed order, mostly fixed length)
  - fragmentation
  - source routing
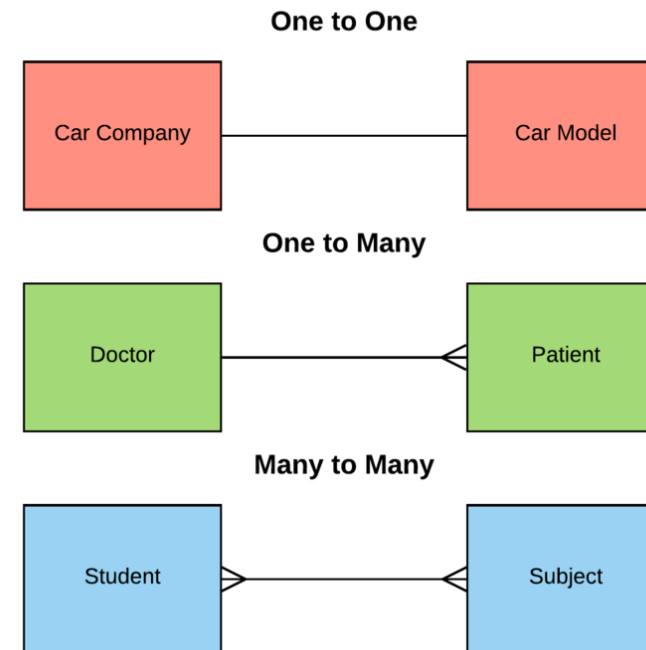 - authentication and security
  - other options
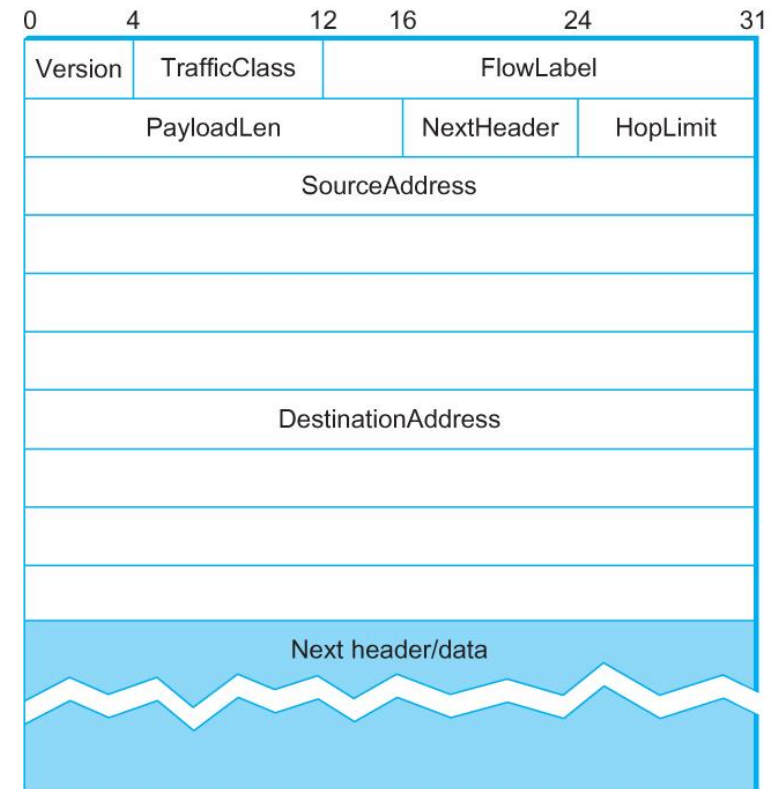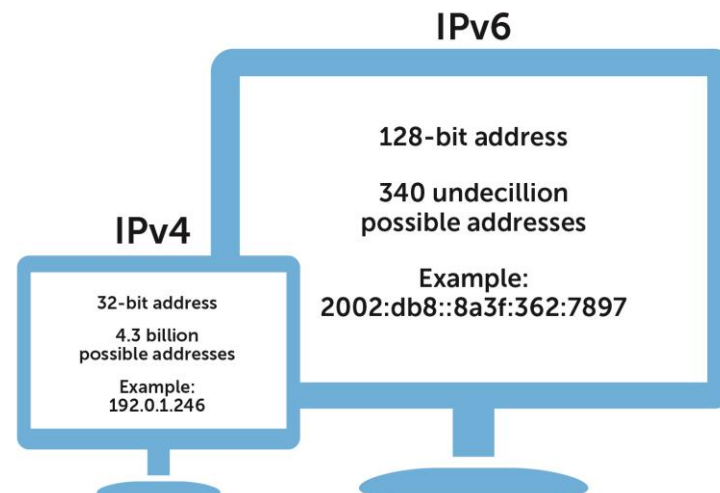
Internet Multicast

Overview

- One-to-many
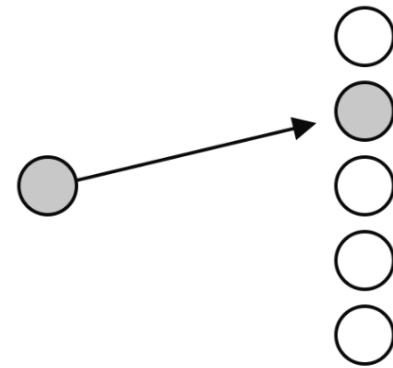 - Radio station broadcast
  - Transmitting news, stock-price
  - Software updates to multiple hosts

- Many-to-many
  - Multimedia teleconferencing
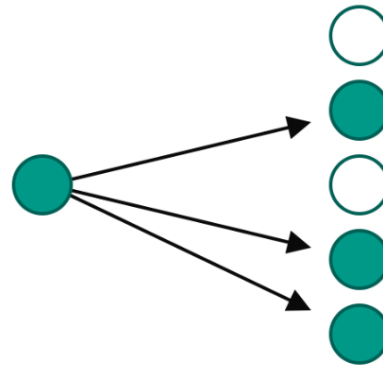 - Online multi-player games
  - Distributed simulations

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What is multicast?

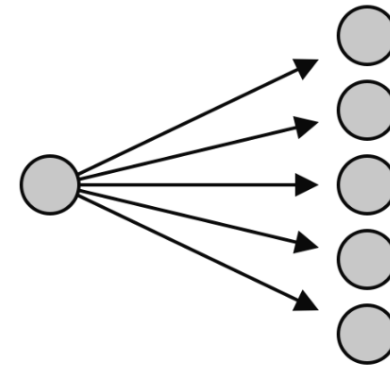- Definition: group communication where data transmission is addressed to a group of destination computers simultaneously
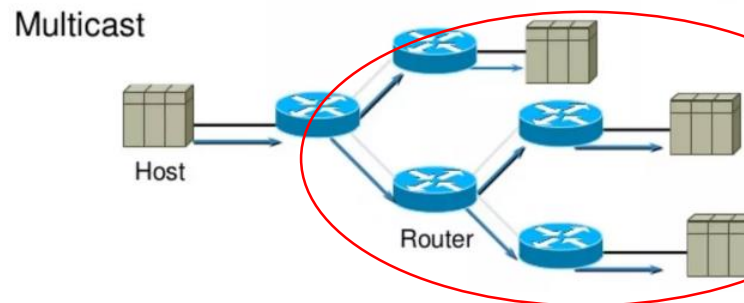

Multicasting

Without support for multicast

When I have an emergency message (e.g., Class is off today 今天休息):

1. I send the message to the LINE group/Ecourse2 of our class
2. I send the message to each of you

Which method is faster?
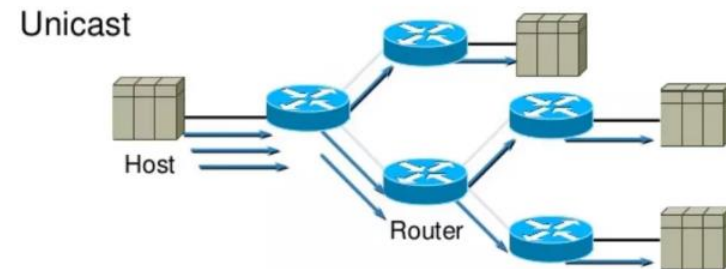
You must join this group
Or use this group address

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Without support for multicast

- A source needs to send a separate packet with the identical data to each member of the group
  - ❑ This redundancy consumes more bandwidth
  - ❑ Redundant traffic is not evenly distributed, concentrated near the sending host
  - ❑ Source needs to keep track of the IP address of each member in the group
    - Group may be dynamic

Src: NetworkLesson
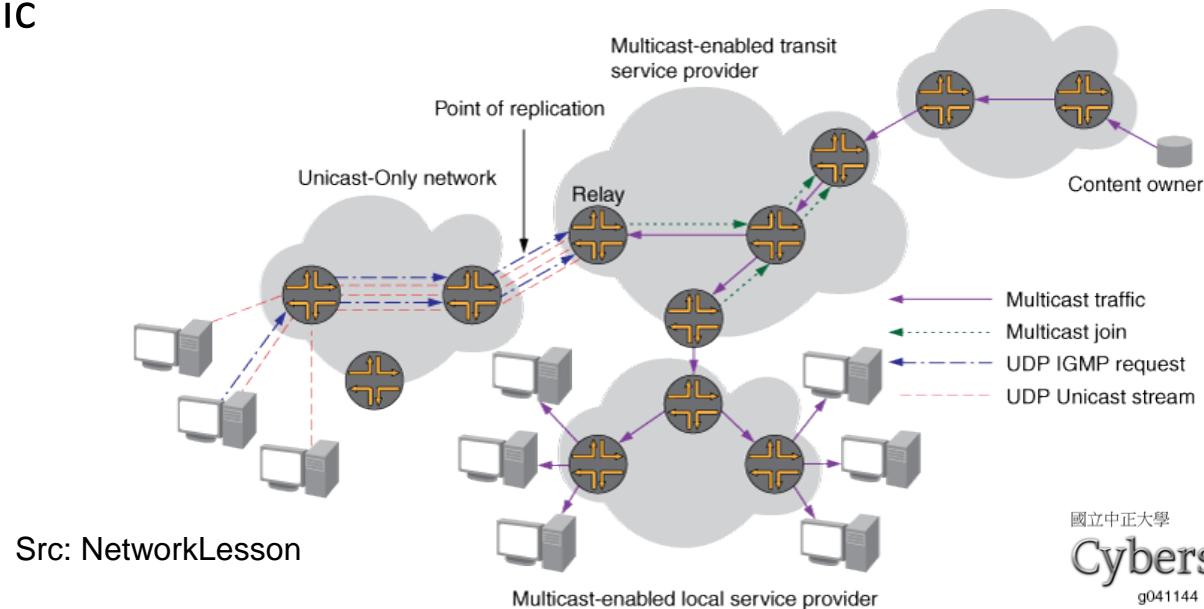
IP multicast

- Basic IP multicast model is many-to-many based on multicast groups
  - Each group has its own IP multicast address
  - Hosts that are members of a group receive copies of any packets sent to that group's multicast address
  - A host can be in multiple groups
  - A host can join and leave groups
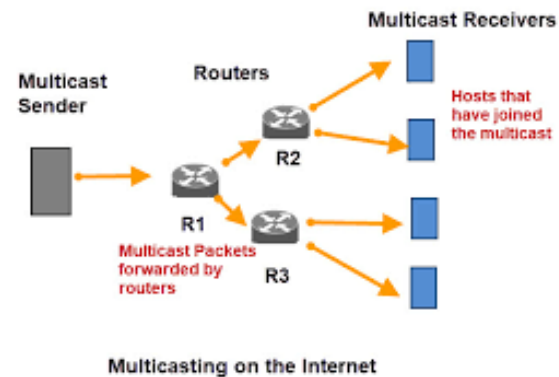
Src: NetworkLesson

IP multicast

- One-to-many multicast
  - Source specific multicast (SSM)
  - A receiving host specifies both a multicast group and a specific sending host

- Many-to-many model
 - Any source multicast (ASM)

Use for multicast →

Name	Purpose	Address Range
Class A	Unicast addresses for large networks	1.0.0.0 - 127.255.255.255
Class B	Unicast addresses for medium networks	128.0.0.0 - 191.255.255.255
Class C	Unicast addresses for small networks	192.0.0.0 - 223.255.255.255
Class D	Multicast addresses	224.0.0.0 - 239.255.255.255
Class E	Reserved	240.0.0.0 - 255.255.255.254

- 224.0.0.0: Reserved Class D
- **224.0.0.1**: All multicast devices
- **224.0.0.2**: All multicast routers
- **224.0.0.4**: All DVMRP routers
- **224.0.0.5**: All OSPF routers
- 224.0.1.11: IETF-1-Audio
- 224.0.1.12: IETF-1-Video
- 224.0.0.255: Last reserved for routing
- 239.0.0.0: Site-local applications
- 239.255.255.255: Last Class D

Src: NetworkLesson

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IP multicast

= you are asked to join our class LINE group to receive notification?

- A host signals its desire to join or leave a multicast group by communicating with its local router using a special protocol
  - In IPv4, the protocol is Internet Group Management Protocol (IGMP)
  - In IPv6, the protocol is Multicast Listener Discovery (MLD)

- The router has the responsibility for making multicast behave correctly with regard to the host


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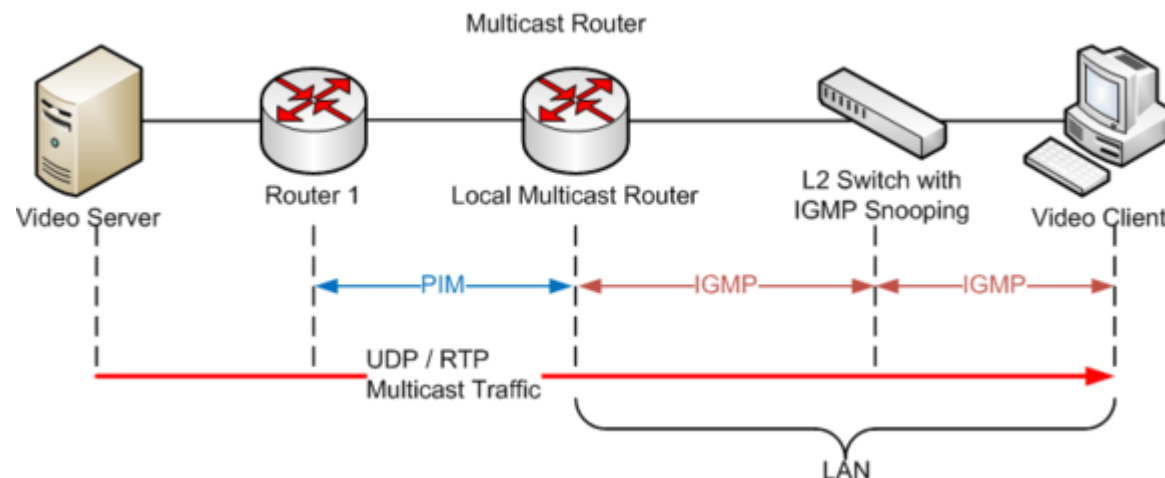
Multicast Routing

- To support multicast, a router must additionally have multicast forwarding tables that indicate based on multicast address

- Multicast forwarding tables collectively specify a set of trees
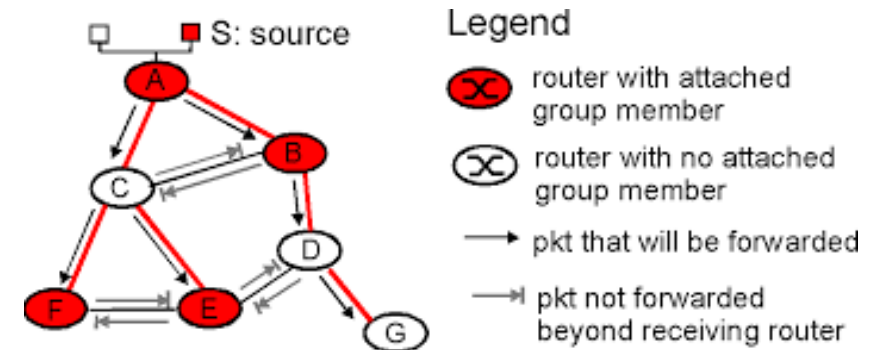 - Multicast distribution trees

Live streaming
Game streaming

Src: NetworkLesson
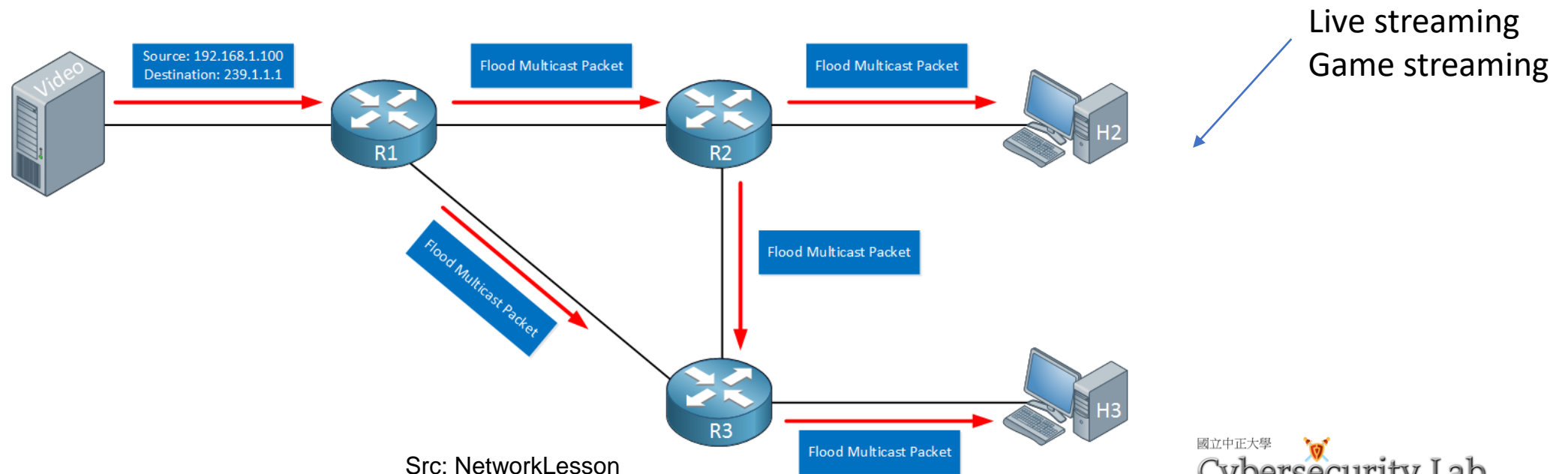
Configure Multicast routing in Packet Tracer

- This is for the CCNP level (for professional+)

Src: IPCisco
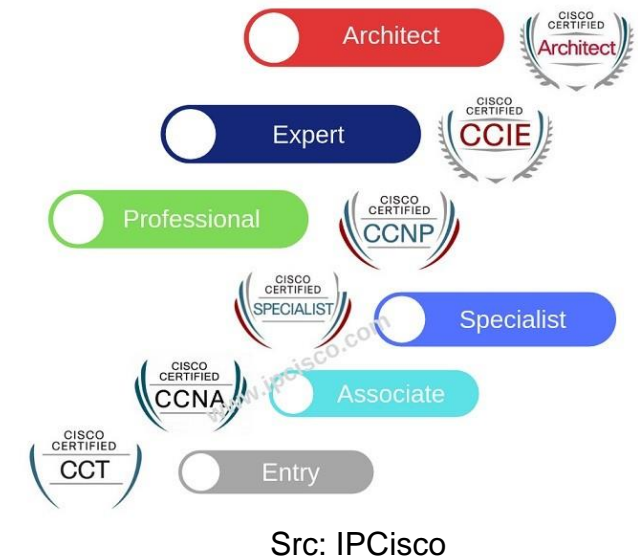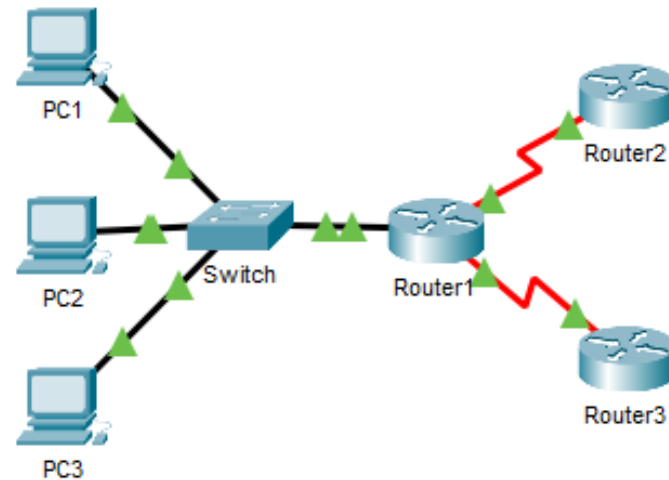
Distance-Vector Multicast

- Each router already knows that shortest path to source S goes through router A.

- When receive multicast packet from S, forward on all outgoing links (except the one on which the packet arrived), if packet arrived from A.

- Eliminate duplicate broadcast packets by only letting
  - "parent" for LAN (relative to S) forward
    - shortest path to S (learn via distance vector)
    - smallest address to break ties

Distance-Vector Multicast

S: source

Legend
router with attached group member
router with no attached group member
→ pkt that will be forwarded
→ pkt not forwarded beyond receiving router

Reverse Path Broadcast (RPB)

- Goal: Prune networks that have no hosts in group X

- Step 1: Determine of LAN is a *leaf* with no members in X
  - leaf if parent is only router on the LAN
  - determine if any hosts are members of X using IGMP

- Step 2: Propagate "no members of X here" information
  - augment **`<Destination, Cost>`** update sent to neighbors with set of groups for which this network is interested in receiving multicast packets.
 - only happens when multicast address becomes active.
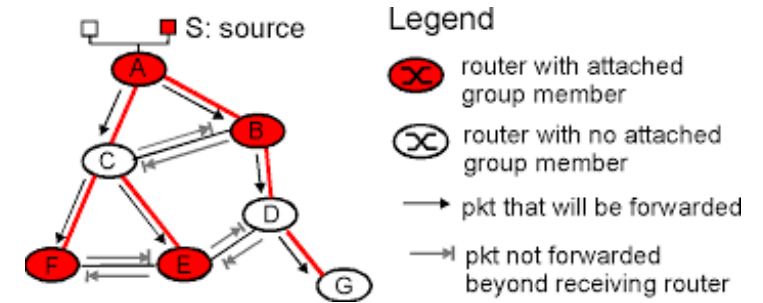
Inter-domain Multicast

Multicast Source Discovery Protocol (MSDP)
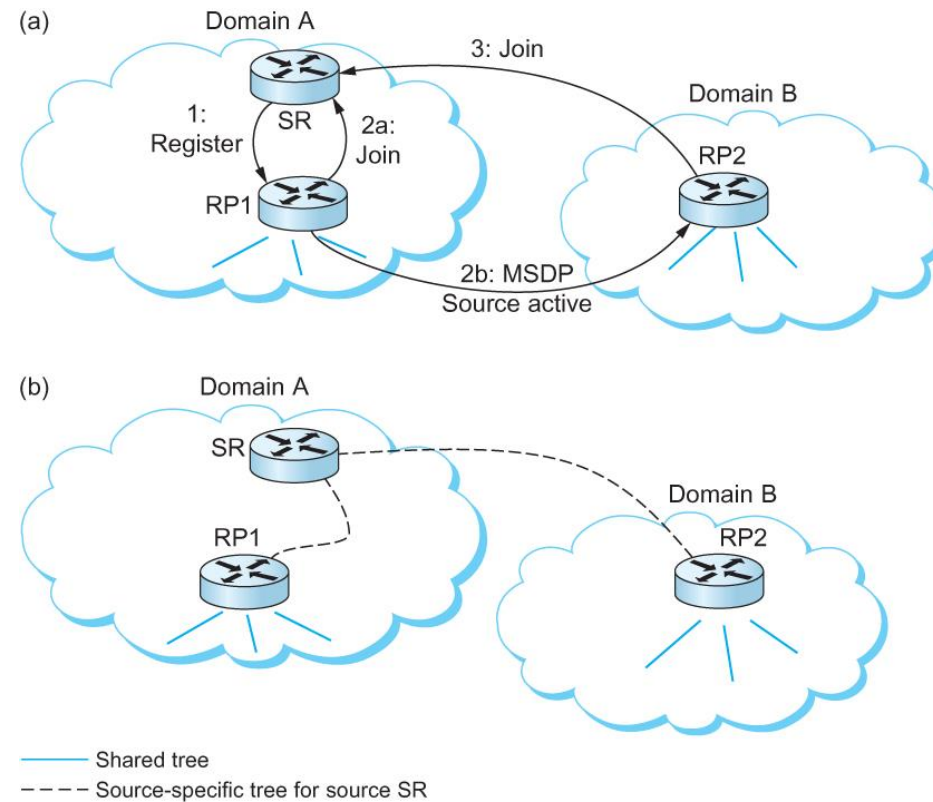
Routing for Mobile Hosts

- Mobile IP
  - *home agent*
    - Router located on the home network of the mobile hosts
  - *home address*
    - The permanent IP address of the mobile host.
    - Has a network number equal to that of the home network and thus of the home agent
  - *foreign agent*
    - Router located on a network to which the mobile node attaches itself when it is away from its home network
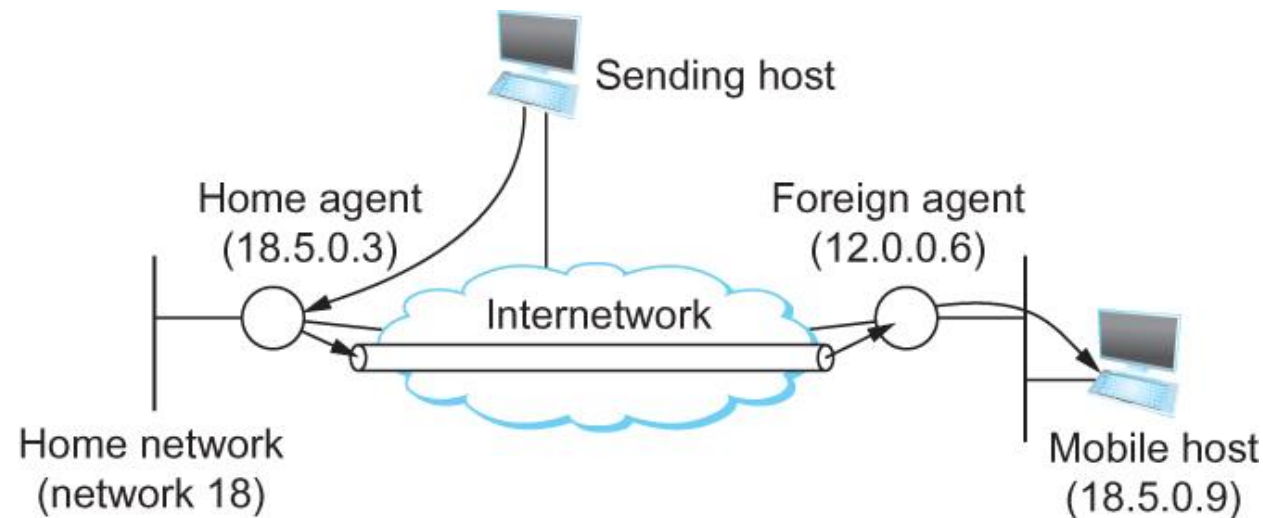
Routing for Mobile Hosts

- Problem of delivering a packet to the mobile node
  - How does the home agent intercept a packet that is destined for the mobile node?
    - Proxy ARP
  - How does the home agent then deliver the packet to the foreign agent?
    - IP tunnel
    - Care-of-address
  - How does the foreign agent deliver the packet to the mobile node?
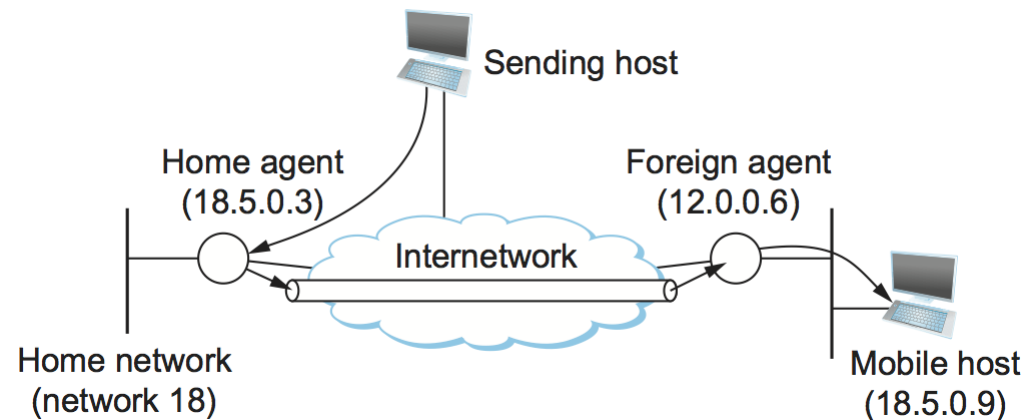
Summary

- Internet infrastructure is so complicated
  - ✓ We can split it into many segments and use inter-domain routing protocols

- BGP is a popular inter-domain routing protocol

- Multicast is useful in some specific applications, e.g., streaming, gaming