Networking Technologies and Applications

Rolland Vida
BME TMIT

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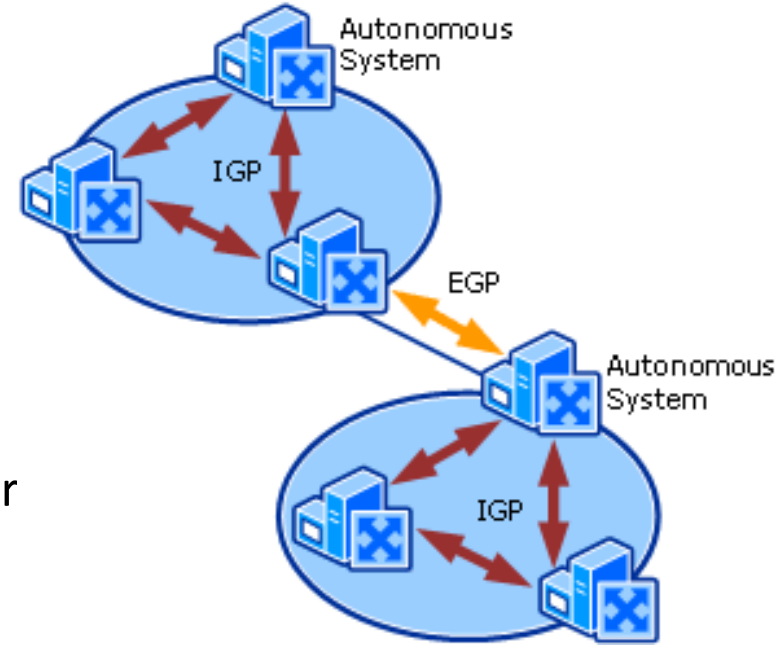
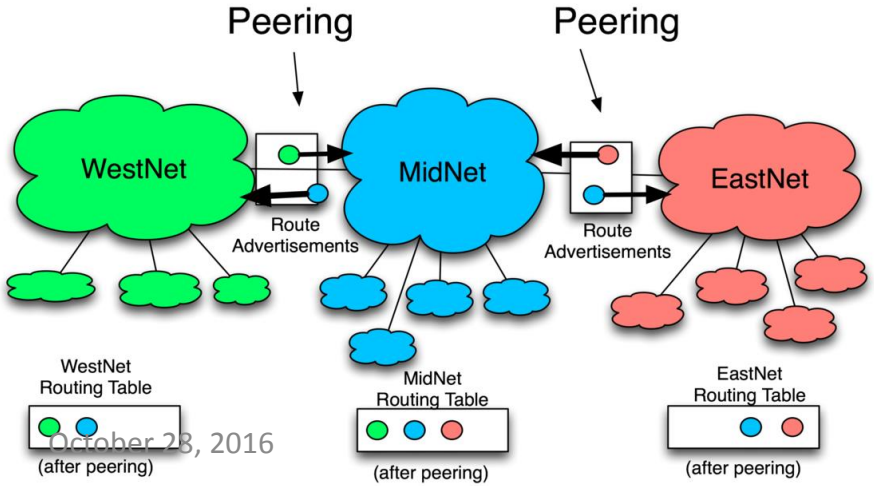
Autonomous sytsem

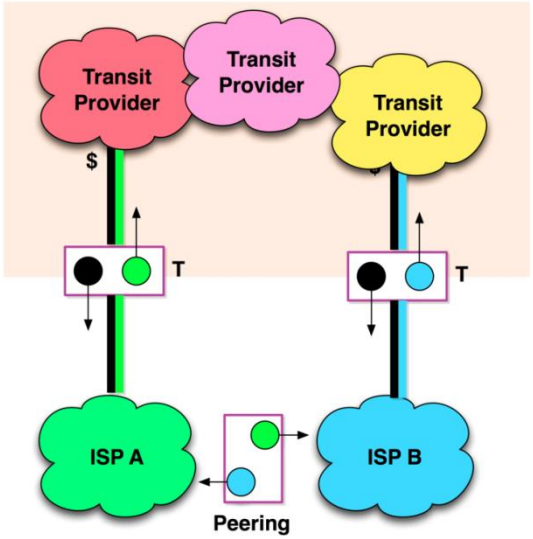
- **AS – autonomous system**
  - Set of routers inside a domain that is technically supervised by one entity
    - One ISP, one administration
  - Some IGP (Interior Gateway Protocol) protocol inside the AS
    - E.g., RIP, OSPF
  - Some Exterior Gateway Protocol (EGP) for inter-AS routing
    - E.g. BGP-4



Internet topology

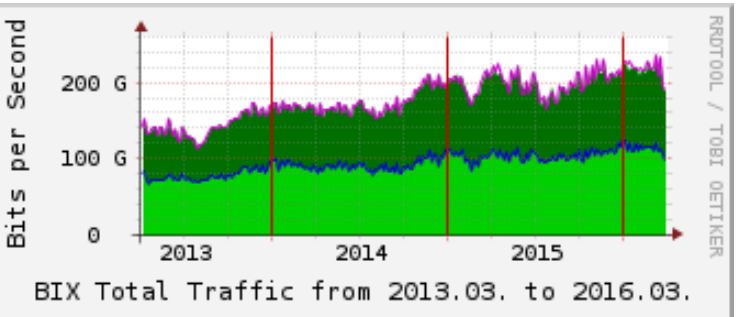
- Network of autonomous systems
  - Customer-provider relation
    - **Transit relation** – connecting to the global network
  - **Peering relation** - two equal rank ASs, between two equal rank providers
    - Not transitive

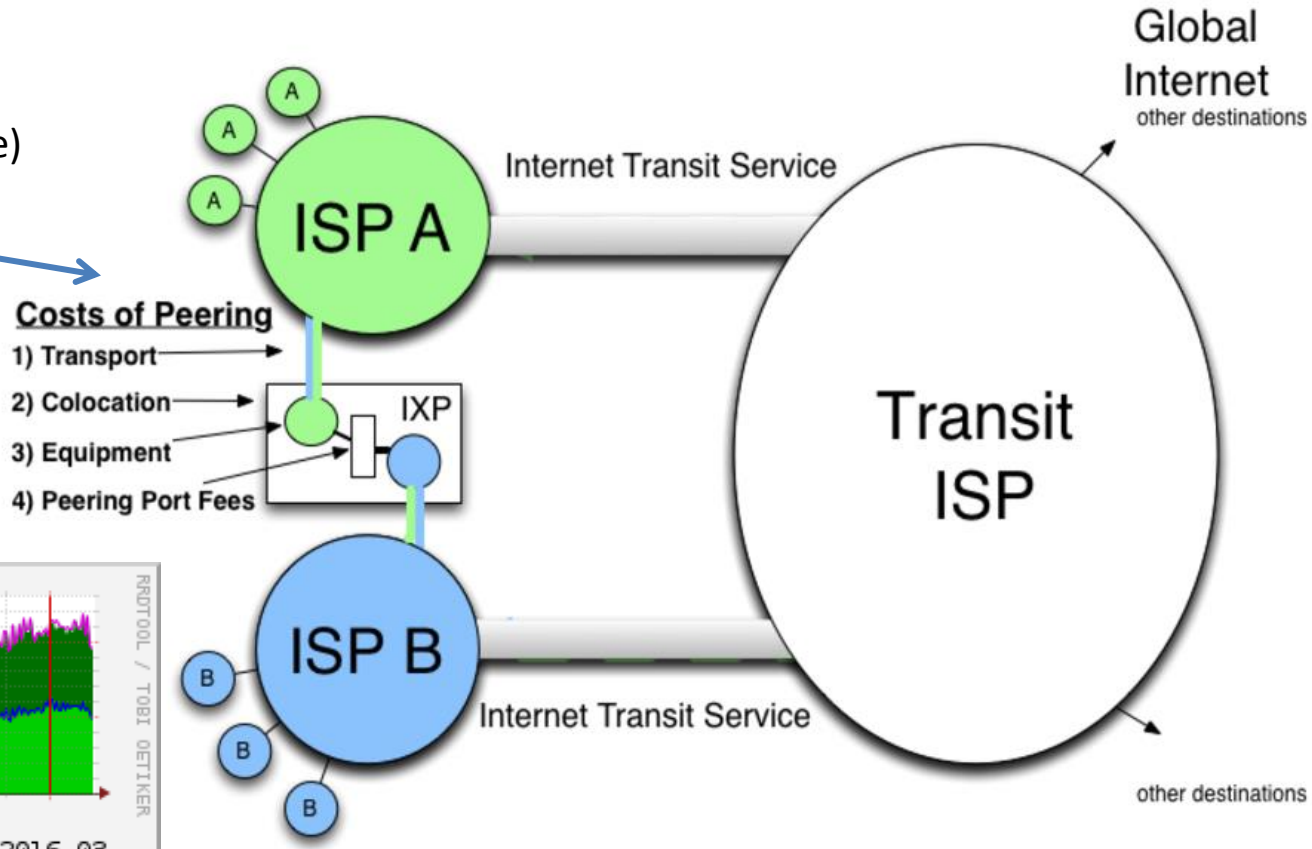




Tranzit vs. Peering

BIX2
(Budapest Internet Exchange)
210 Gbit/s (2014)





Internet topology

- Advantages of the IGP-EGP hierarchy
  - Scalability for large networks
    - Fewer prefixes to be sent
    - Faster convergence
  - Limits error propagation
  - Administrative autonomy
    - Inside each AS an IGP protocol of choice

IGP vs. EGP

- In IGP automatic neighbor discover
- In EGP specially configured peers

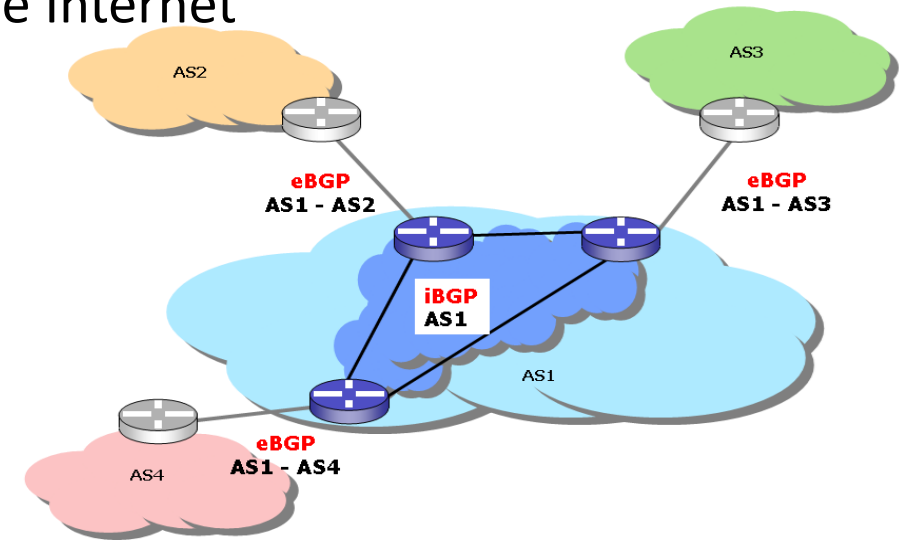
- In IGP you trust the routers
- In EGP you have limited trust in connections with other networks

- In IGP prefixes are distributed inside the entire network
- In EGP prefix distribution is administratively limited

- IGP connects routers of the same AS
- EGP connects the routers of different ASs

Border Gateway Protocol

- One of the main building blocks of the Internet
- BGP chronology
  - Initial standard – BGP – RFC 1105 (’89)
  - BGP-3 – RFC 1267 (’91)
  - BGP-4 – RFC 1771 (’95)
  - Last version – RFC 4271 (’06)



- External BGP (eBGP)
  - BGP connection with a neighbor router from a different AS
- Internal BGP (iBGP)
  - BGP connection with a neighbor router from the same AS

BGP properties

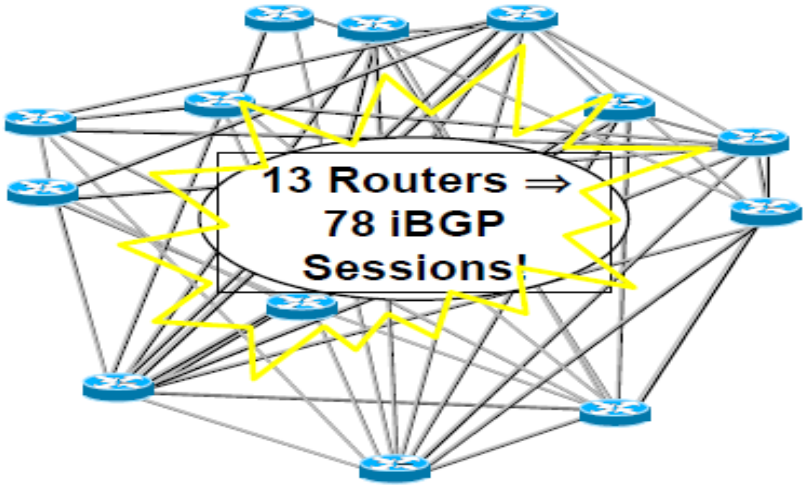
- **CIDR (Classless Inter-Domain Routing)** support
  - Variable length prefixes
  - Efficient address aggregation
- Manual neighbor configuration
  - No automatic discovery
- No periodic updates – hard state
  - Explicit UPDATE messages – NLRI records
    - Network Layer Reachability Information
      - (Destination prefix, AS path, next hop)
    - Loops can be avoide by listing the ASs
  - If a route becomes unavailable, it is also advertised explicitely

iBGP

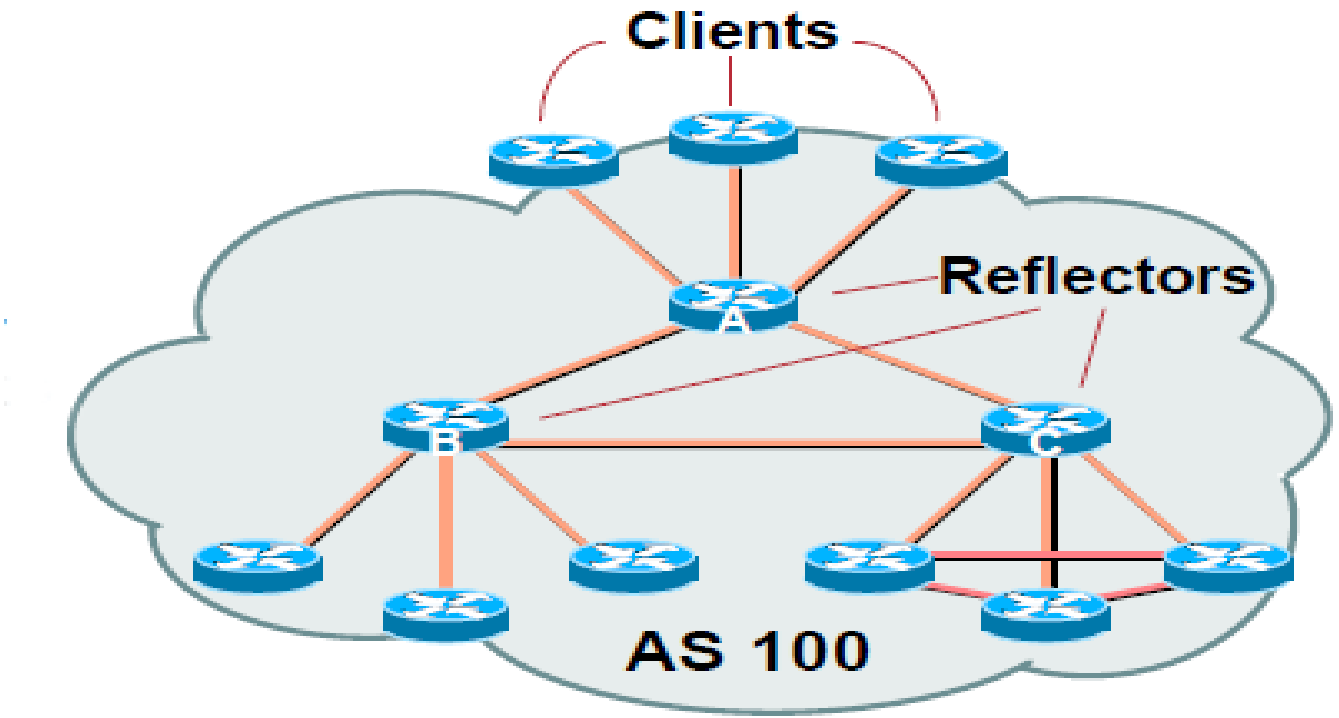
- Distributes prefixes from eBGP neighbors
- iBGP nodes – full mesh
  - No iBGP routing
- Drawback – a full mesh is not scalable
  - If n=1000,

    n(n-1)/2 = 499.500

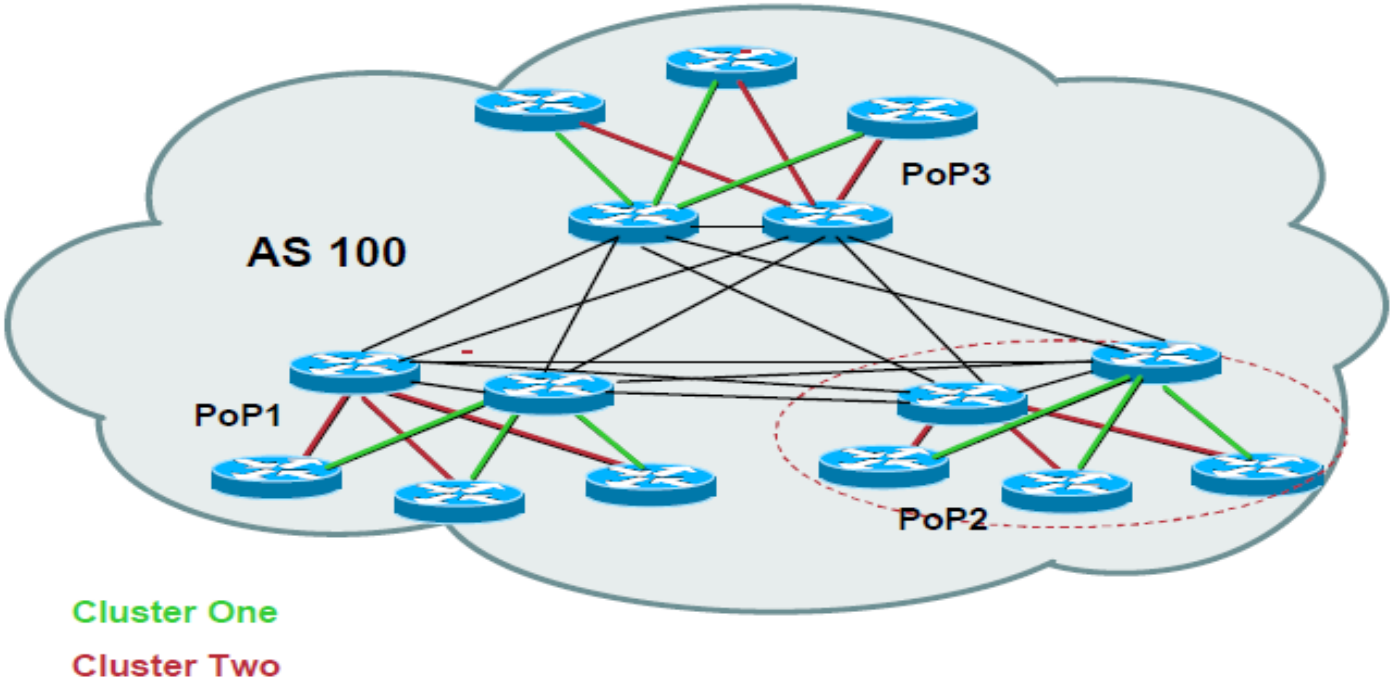
    iBGP sessions



Route reflector



Route reflector redundancy



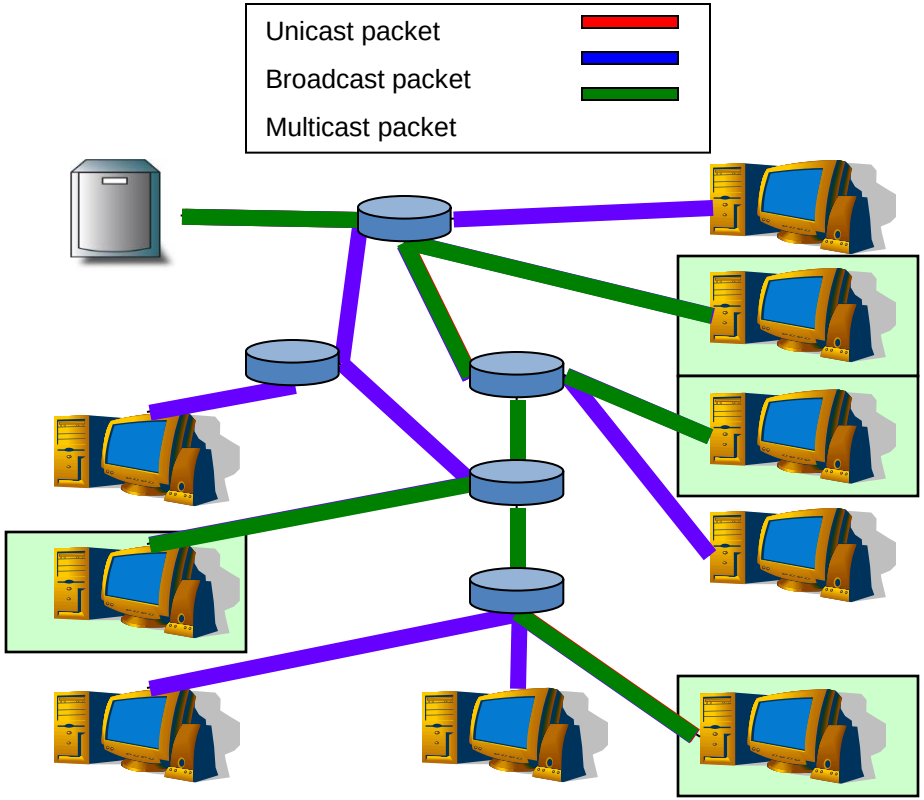
Group communication

- Goal: instead of a single destination node, communicate with a group of nodes
  - „natural” extension of the point-to-point communication (unicast)

- **Multicast**

What is multicast?

- **Unicast**
  - Point – to - point
  - Destination address: the address of one specific receiver
- **Broadcast**
  - Point – to – everyone
  - Destination address: address of the (sub)network
- **Multicast**
  - (Multi)point – to – multipoint
  - Destination address: group address



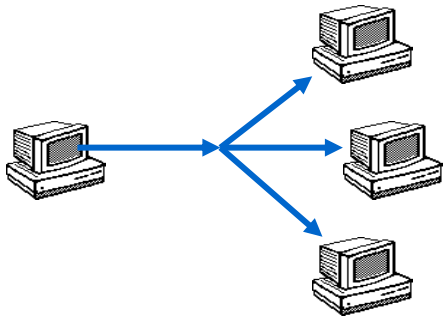
Group communication

- Packets have to be sent to all members of a group, not just a single destination
  - Group membership can be dynamic

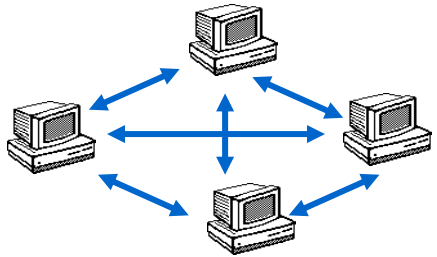
- Basic principle: once a group is created…
  - Interested receivers join the group
  - The network maintains the group and handles data delivery

Multicast applications

- Many applications are not point-to-point
  - Point-multipoint
    - Remote learning
    - Cache update
    - Video on demand



  - Multipoint-to-multipoint
    - Videoconferences, Audio conferences, Chat,
    - Distributed networking games
    - Cooperative applications



Requirements

- No one size fits all solution

- Requirements are different
  - Depending on the application needs
  - Depending on group size
  - Depending on network services / support
  - Depending on member heterogeneity

Participation rules

- Membership control
  - Open group: anybody can join
  - Closed group: limited membership

- Source control
  - Anybody can send a packet to the group
  - Only a group member can be a source
  - Just a selected source can send data

Reliability requirements

- Point-to-point communication
  - Reliable or best-effort (no guarantees)
  - The destination checks the packet: OK, or not
- Point-to-multipoint communication
  - Each receiver perceives the service differently
- Different reliability levels
  - 0-reliability: no receiver is guaranteed reliable transmission
  - 1-reliability: at least 1 receiver will reliably receive the packets
  - k-reliability: at least k receivers will reliably receive the packets
  - Total reliabiliy: all receivers will reliably receive the packets

Multicast at different layers

- The multicast service can be implemented in different layers
  - Data link layer
    - E.g. Ethernet multicast
  - Network layer
    - E.g. IP multicast, Xcast
  - Application layer
    - E.g. Narada, TBCP
- Which solution is the best?
  - It depends, no general solution

Multicast at different layers