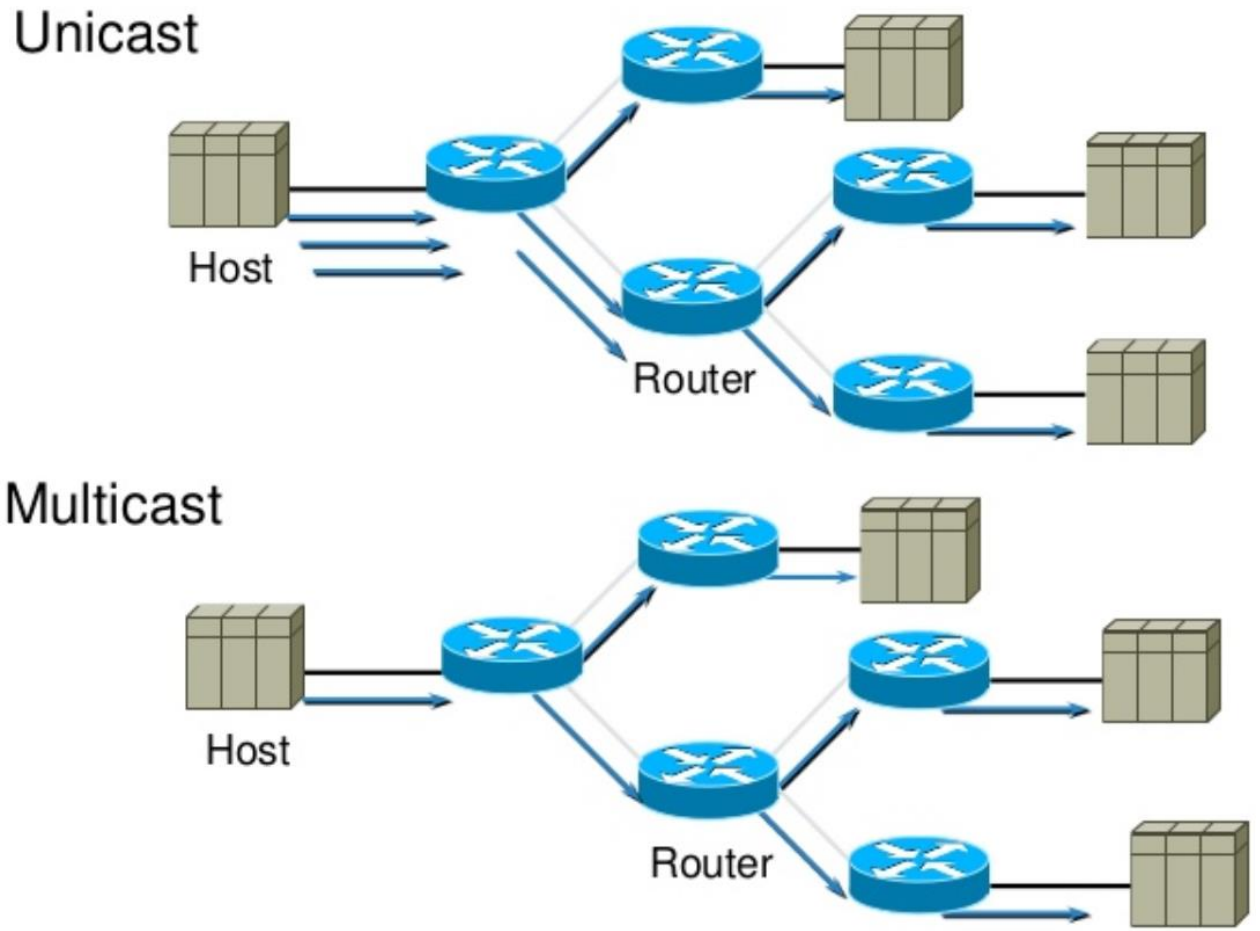
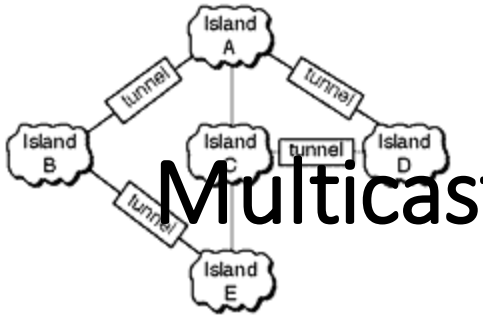
Distance Vector Multicast Routing Protocol (DVMRP)

- Multicast routing protocol, **RFC1075** (1988).
- Used in first internet multicast backbone (**MBONE**, 1992).
- IPv4 address types: unicast, broadcast, **multicast**.
- **Not connection-oriented**, best-effort delivery (IP).
- Not guarenteed to reach all group members.
- Hosts are **free to join or leave** a group at any time.
- Sender need to be aware of group members.
- Multicast **conserves bandwidth** by forcing network to do packet replication.

- Radio / VIdeo broadcasts, Video conferencing, Distance learning
- Shared applications, Multiplayer gaming, Chat rooms
- Advertisements, Stocks, Distributed databases



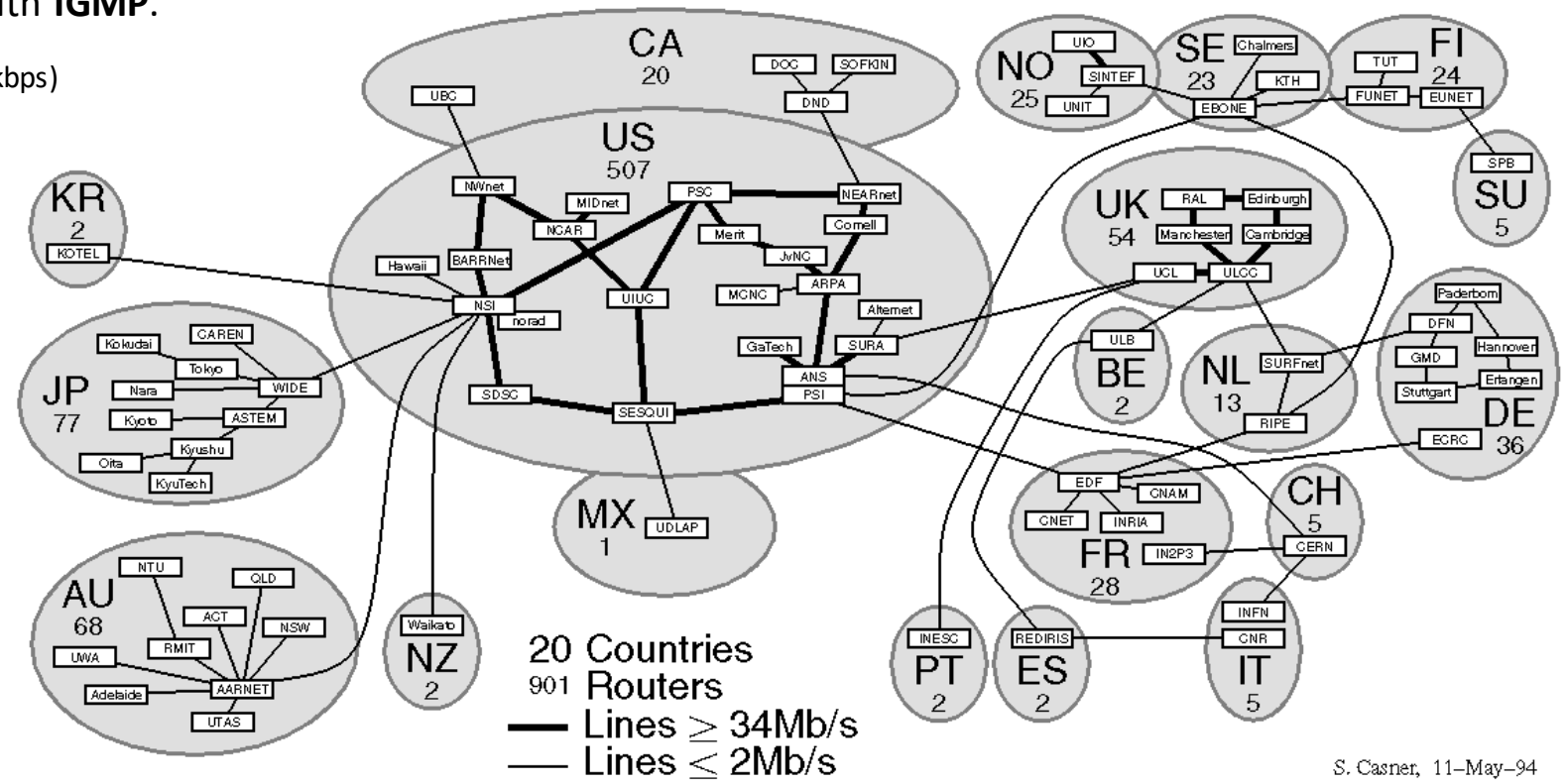


Multicast Backbone (MBONE)

- Interconnected subnetworks and **multicast routers**.
- Created by Jacobson, Deering, Casner (1992).
- Uses **tunnels** for connecting through unicast routers.
- Uses **DVMRP**, MOSPF for routing along with **IGMP**.
- IP Address: 224.2.0.0 (audio 64kbps, video 120 kbps)

- IETF meetings, US House & Senate sessions
- NASA Space shuttle missions, Satellite weather photos
- **1992**: 40 subnets in 4 countries
- **1993**: Live band performance by Severe Tire Damage
- **1995**: M-bone links in Russia, Antarctica
- **1996**: 2800 subnets in 25 countries
- **2008**: Virtual video conferencing system in use

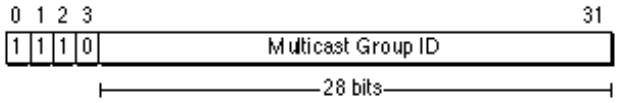
Major MBONE Routers and Links

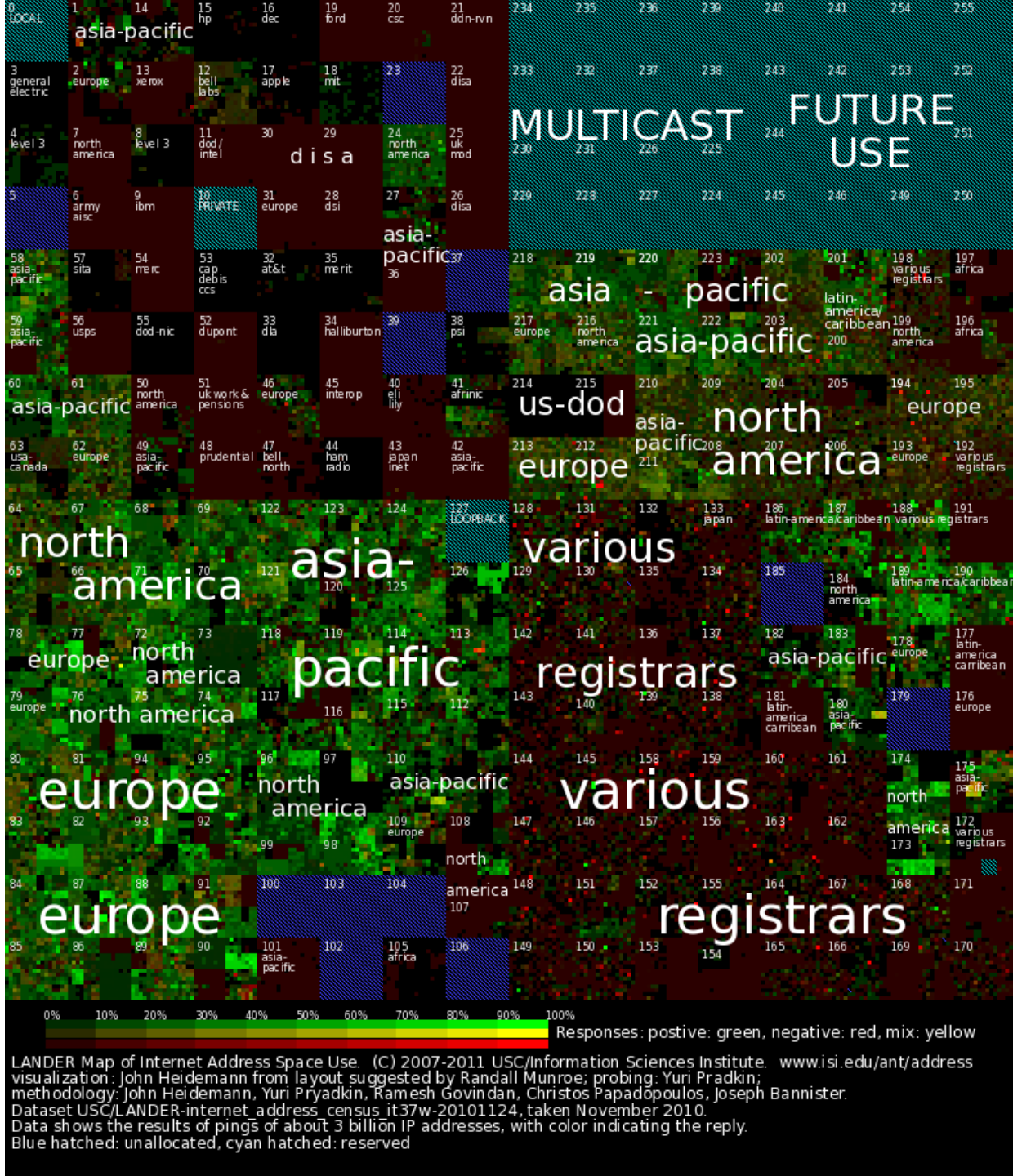


Multicast Addressing

- **Class D** IP addresses are used for multicast.
- Start with "**1110**" followed by **28-bit group ID**.
- **Fixed** vs **Transient** multicast IP (**logical address**).

- 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

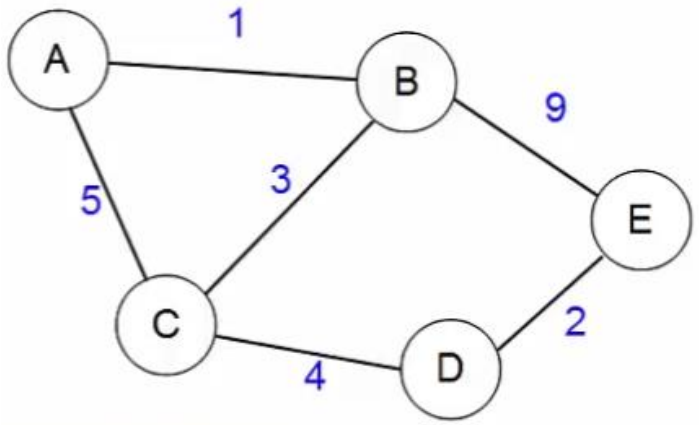




Distance Vector Routing (eg. RIP)

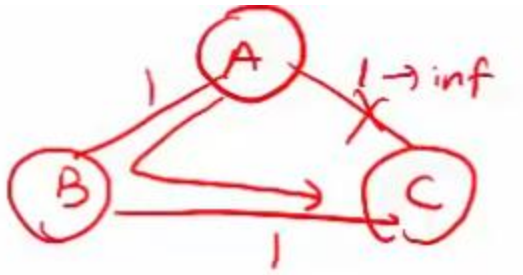
Dest	Cost	Next Hop
A	1	A
C	3	C
E	9	E

Initial Routing table at B



Dest	Cost	Next Hop
A	1	A
C	3	C
D	7	C
E	9	E

Final Routing table at B



Periodic update helps when a route becomes invalid

$$d_x(y) = \min_v\{c(x,v) + d_v(y)\}$$

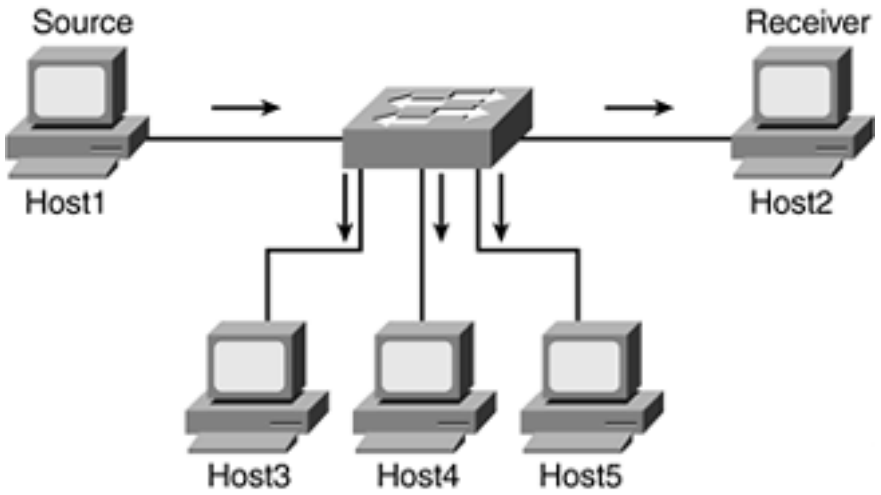
Bellman-Ford distance update equation

- Find the **least cost path** between 2 nodes.
- Also called **Bellman-Ford** algorithm (distributed).
- Each node maintains a routing table.
- Originally used in **ARPAnet, RIP** (now used rarely).

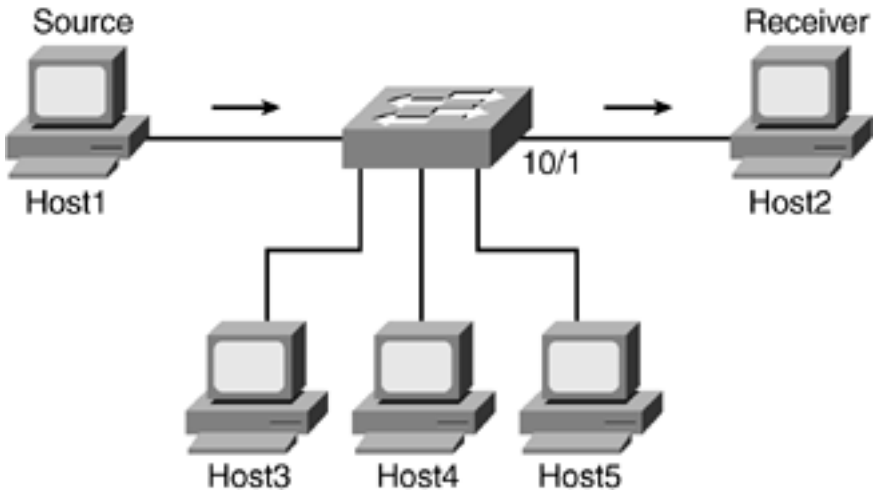
- **Initial**: Distance (cost) to its neighbours is known.
- **Goal**: Distance to all neighbours & next-hop known.
- Routing table info is shared with neighbours (except next-hop).
- On receiving message, routing table updated with min-cost path.
- After N rounds, N+1 hop paths become known.

- **Triggered update**: link / node failure or cost change
- **Periodic update**: Still alive, update DV if some route becomes invalid

Multicast Flooding

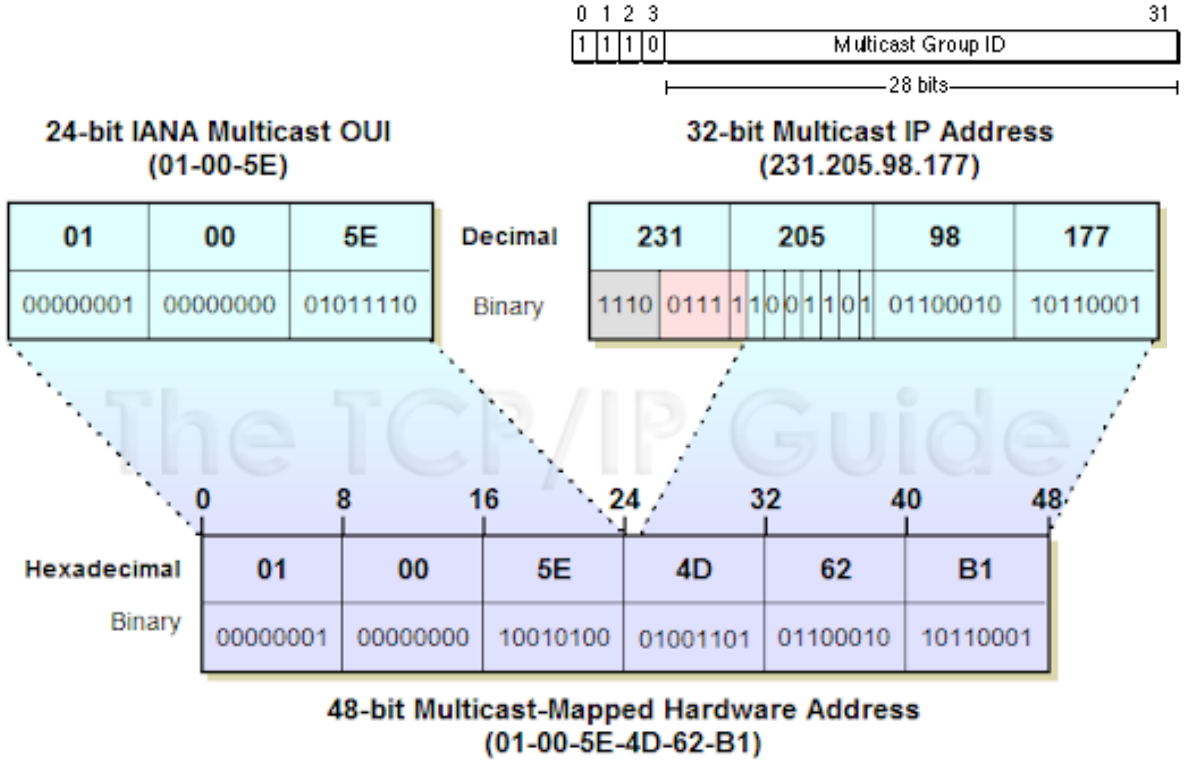


Each Host Receives the Multicast Stream

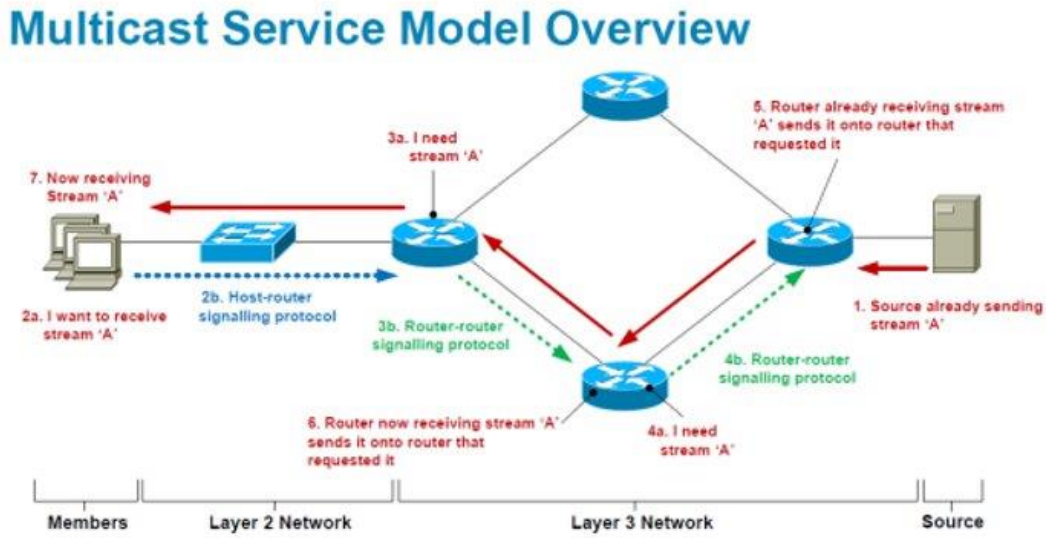


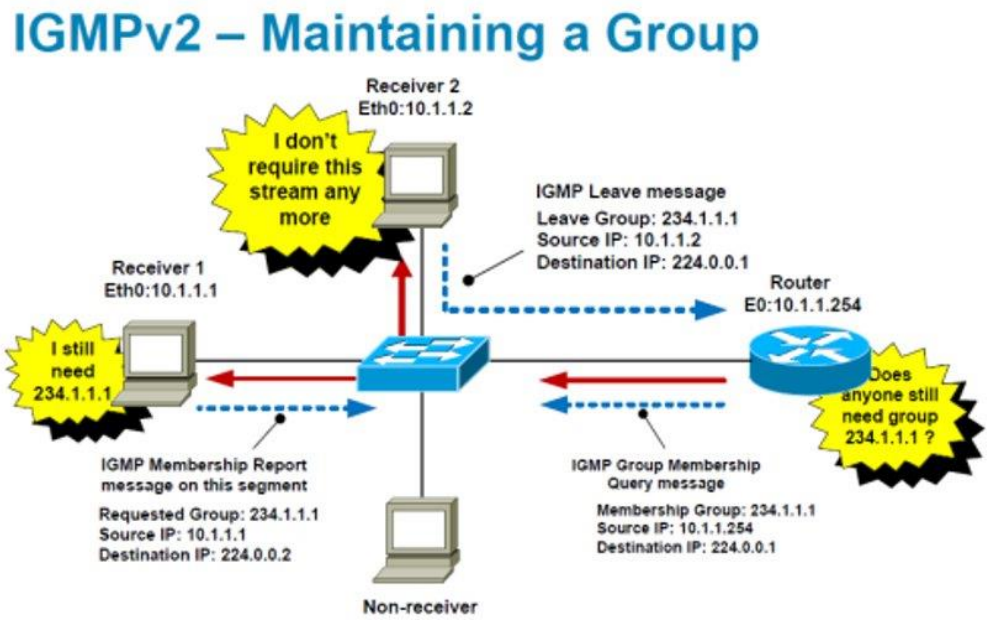
Multicast Stream is filtered by Switch through Multicast MAC address

- Router / Host sends packet on **all interfaces**.
- If router has been seen packet before, its discarded.
- Used on **local network** for multicast communication.
- Filtering can be done with **Multicast MAC address**.



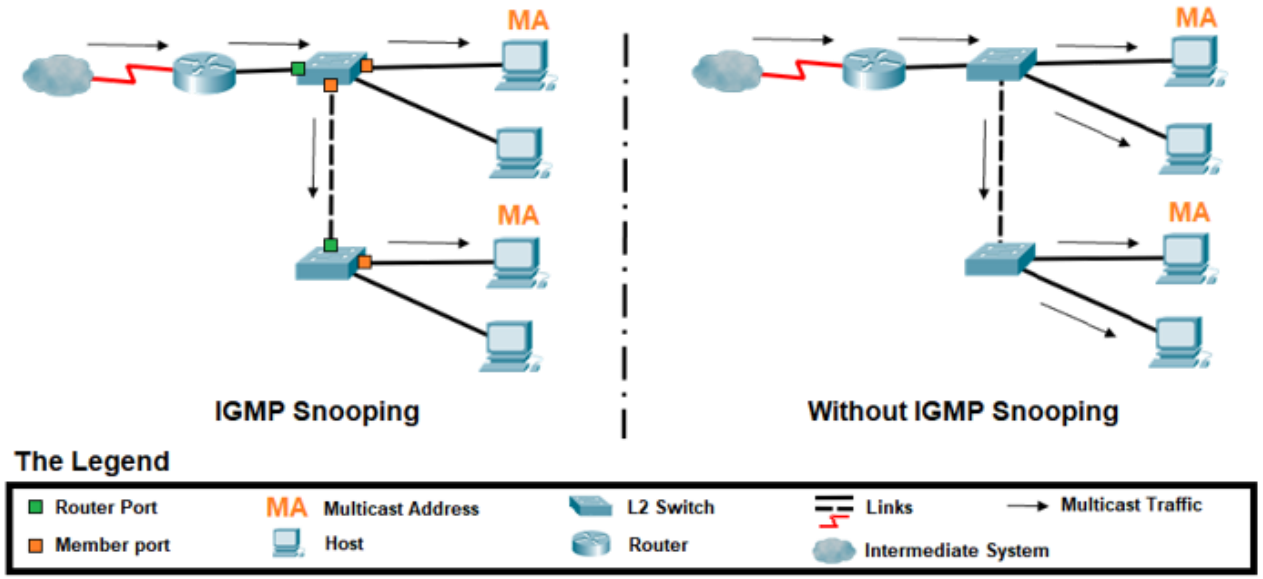
Internet Group Management Protocol (IGMP)



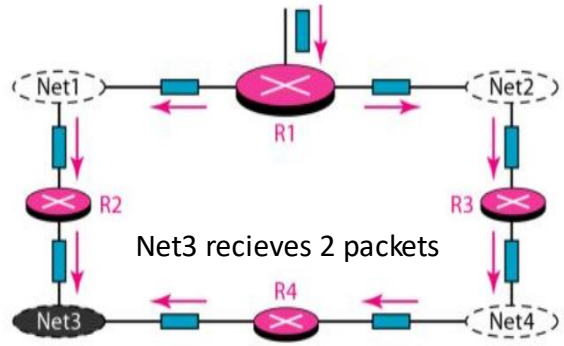


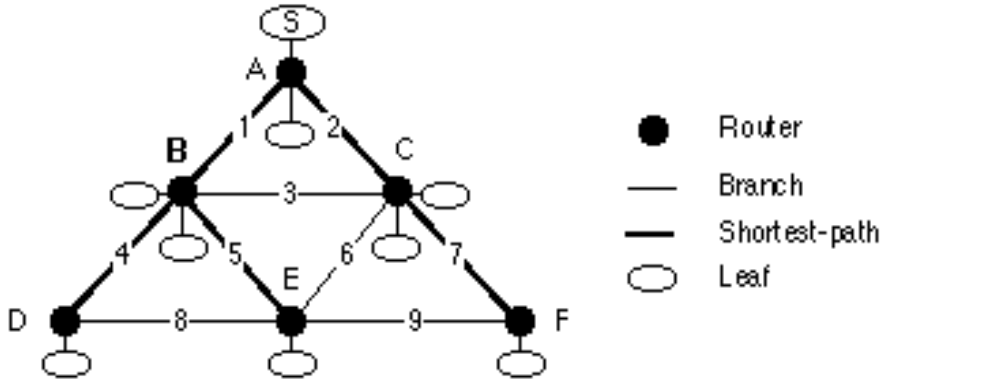
- Hosts tell router about group membership (RFC 1112).
- Router uses this to help route multicast packets.
- Filtering can be done with **IGMP snooping** by switch.

- **Report**: Host says to router, "I want to receive multicast data for X.X.X.X".
- **Query**: Router asks hosts, "Is anone still interested in data for X.X.X.X"?
- Report is sent to address X.X.X.X, and received by other members & router.



Reverse Path Multicasting (RPM)

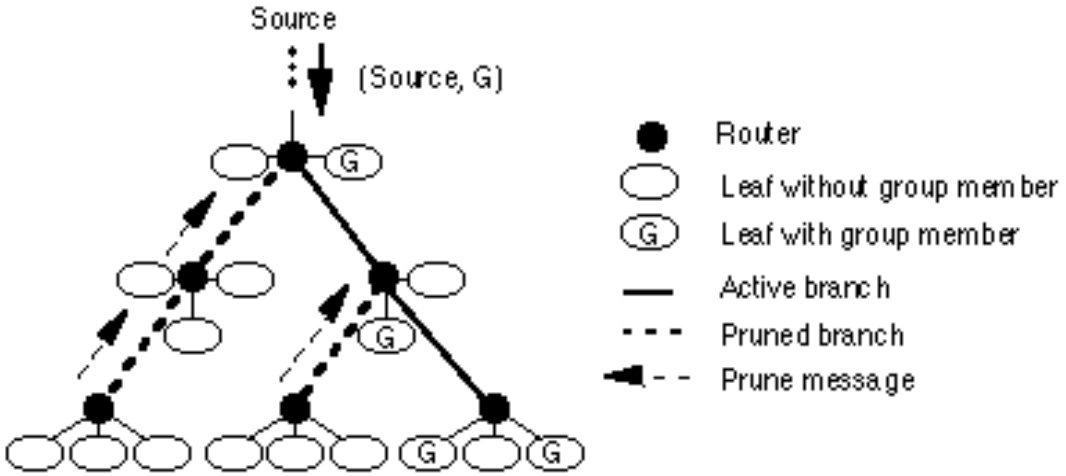




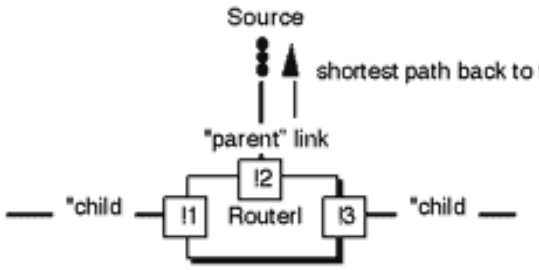
Opt. Reverse Path Broadcasting (**RPB**)

- Forward packet that arrives on **shortest path to source**.
- Router discards packet if it arrives on any other interface. **RPB**
- Delivery tree is **truncated** if leaf subnet has no members. **TRPB**
- **Prune message** is sent if all child links are truncated. **RPM**

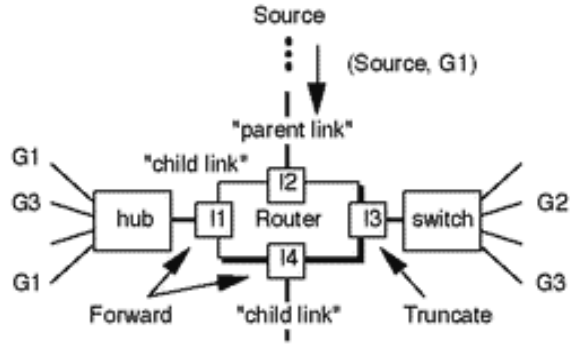
- **Opt**: Forward only if on downstream router's shortest path. **RPB**
- **Duplicates are possible** since shortest path is source-based.



Reverse Path Multicasting (**RPM**)

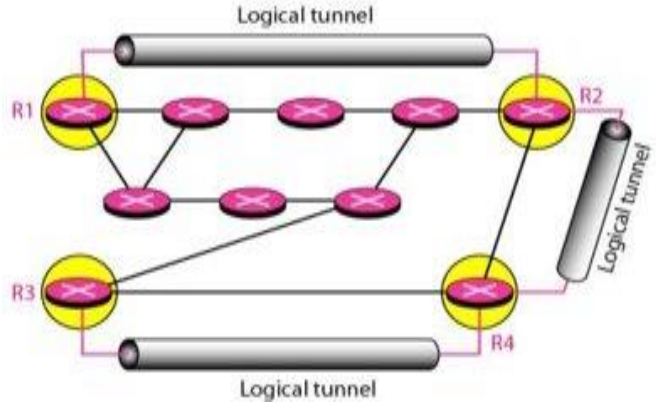


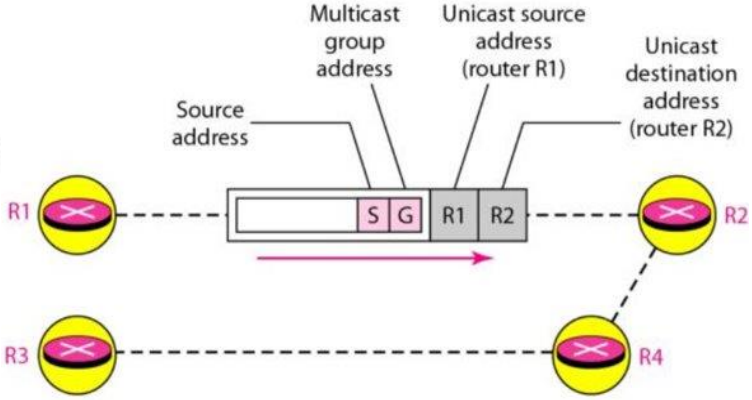
Reverse Path Broadcasting (**RPB**)



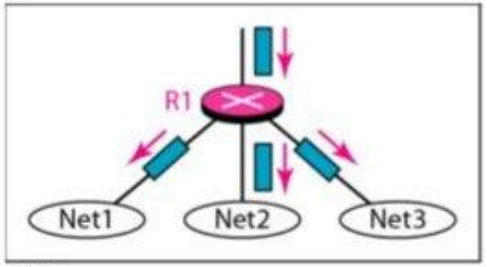
Truncated Reverse Path Broadcasting (**TRPB**)

DVMRP

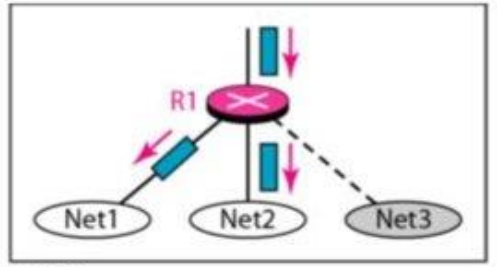




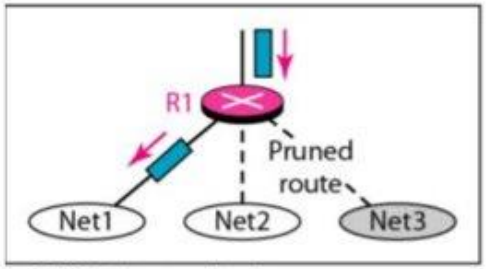
- It is a **distance vector** multicast protocol, like RIP.
- Suitable for use **within** autonomous system.
- **Tunnels** are used between non-multicast routers.
- Routers need to run a unicast protocol too.
- Reverse path multicasting (**RPM**) used between routers.



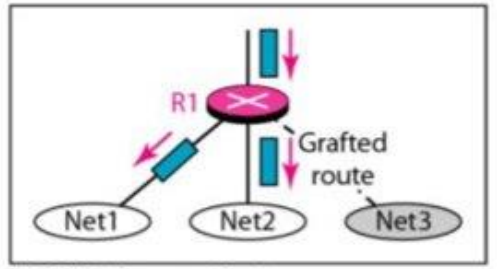
a.RPF



b. RPB



c. RPM (after pruning)



d. RPM (after grafting)

- Intially (S,G) packet is broadcasted using **TRPB**.
- **IGMP** is used to find group members in subnets.
- Routers send **prune** message to parent if subnet has no group member.
- Routers send **graft** message to parent if subnet has new group member.
- **DVMRP**, MOSPF, PIM: within Autonomous System
- MBGP: between Autonomous Systems

Source Subnet	Subnet Mask	From Gateway	Metric	Status	TTL	InPort	OutPorts
128.1.0.0	255.255.0.0	128.7.5.2	3	Up	200	1	2,3
128.2.0.0	255.255.0.0	128.7.5.2	5	Up	150	2	1
128.3.0.0	255.255.0.0	128.6.3.1	2	Up	150	2	1,3
128.4.0.0	255.255.0.0	128.6.3.1	4	Up	200	1	2

DVMRP Routing table

Source Subnet	Multicast Group	TTL	InPort	OutPorts
128.1.0.0	224.1.1.1	200	1 Pr	2p 3p
	224.2.2.2	100	1	2p 3
	224.3.3.3	250	1	2
128.2.0.0	224.1.1.1	150	2	2p 3

DVMRP Forwarding table

DVMRP Datagrams

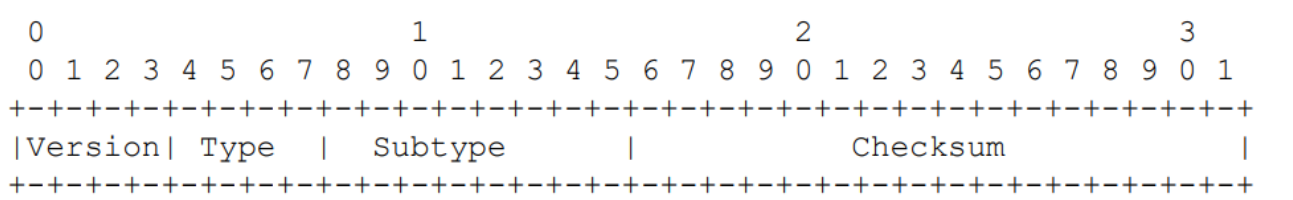
- DVMRP uses **IGMP** to exchange routing datagrams (type 3).
- Message is a stream of **tagged data** (key=value, … max 512B).
- Routers provide **periodic** and **triggered** updates.
- Messages sent to multicast address **224.0.0.4** (TTL=1).

Subtypes

- **Request**: request route to sources
- **Response**: provide route to sources
- **Non-membership report**: prune path for T seconds (no member)
- **Non-membership cancellation**: graft path (new member)

Commands

- NULL, Flags0, Infinity, Metric
- Address Family Indicator (AFI), Subnet mask
- Destination Address (DA)
- Requested Destination Address (RDA)
- Non Membership Report (NMR)
- Non Membership Report Cancel (NMR Cancel)



DVMRP header

```
Subtype 1,
AFI 2,  Metric 2, Infinity 16, Subnet Mask 255.255.255.0
{2} {2} {4} {2}   {6} {16}     {3} {1} {255} {255} {255} {0}

DA Count=1 [128.2.251.231]
{7} {1} {128} {2} {251} {231}
```

Response of route for **128.2.251.231** with metric **2**, INF=16, SM=255.255.255.0

```
Subtype 1,
AFI 2,  Metric 2, Infinity 16, Subnet Mask 255.255.255.0
{2} {2} {4} {2}   {6} {16}     {3} {1} 255} {255} {255} {0}

DA Count=2 [128.2.251.231] [128.2.236.2]
{7} {1} {128} {2} {251} {231} {128} {2} {236} {2}
```

Response of route for **128.2.251.231** & **128.2.236.2** with metric **2**, INF=16, SM=255.255.255.0

```
Subtype 2, AFI 2,  RDA Count = 0
           {2} {2} {8} {0}
```

Request all routes (to source).

```
Subtype 3,
AFI 2,  NMR Count = 3 [224.2.3.1, 20]
{2} {2} {10} {3} {224} {2} {3} {1} {0} {0} {0} {20}

[224.5.4.6, 20] [224.7.8.5, 40]
{224} {5} {4} {6} {0} {0} {0} {20} {224} {7} {8} {5} {0} {0} {0} {40}
```

NMR for groups **224.2.3.1** & **224.5.4.6** (20s), **224.7.8.5** (40s)