- Teleconferencing.
- Distance Learning

MULTICAST ROUTING

- To support multicast, a router must additionally have multicast forwarding tables that indicate, based on multicast address, which links to use to forward the multicast packet.
- Unicast forwarding tables collectively specify a set of paths.
- Multicast forwarding tables collectively specify a set of trees -Multicast distribution trees.
- Multicast routing is the process by which multicast distribution trees are determined.
- To support multicasting, routers *additionally* build multicast forwarding tables.
- Multicast forwarding table is a tree structure, known as ***multicast distribution trees.***
- Internet multicast is implemented on physical networks that support broadcasting by *extending* forwarding functions.

MULTICAST DISTRIBUTION TREES

There are two types of Multicast Distribution Trees used in multicast routing. They are

- **Source-Based Tree**: (DVMRP)
  - For each combination of (source , group), there is a shortest path spanning tree.
  - ***Flood and prune***
    - Send multicast traffic everywhere
    - Prune edges that are not actively subscribed to group
  - ***Link-state***
    - Routers flood groups they would like to receive
    - Compute shortest-path trees on demand
- **Shared Tree** (PIM)
  - Single distributed tree shared among all sources
  - Does not include its own topology discovery mechanism, but instead uses routing information supplied by other routing protocols
  - Specify rendezvous (meeting)point (RP) for group
  - Senders send packets to RP, receivers join at RP

- RP multicasts to receivers; Fix-up tree for optimization
- ***Rendezvous-Point Tree***: one router is the center of the group and therefore the root of the tree.

MULTICAST ROUTING PROTOCOLS

- Internet multicast is implemented on physical networks that support broadcasting by *extending forwarding functions.*
- Major multicast routing protocols are:
  1. Distance-Vector Multicast Routing Protocol (DVMRP)
  2. Protocol Independent Multicast (PIM)

1. Distance Vector Multicast Routing Protocol

- The DVMRP, is a routing protocol used to share information between routers to facilitate the transportation of IP multicast packets among networks.
- It formed the basis of the Internet's historic multicast backbone.
- Distance vector routing for unicast is extended to support multicast routing.
- Each router maintains a routing table for all destination through exchange of distance vectors.
- DVMRP is also known as ***flood-and-prune protocol.***
- DVMRP consists of two major components:
- A conventional distance-vector routing protocol, like RIP
- A protocol for determining how to forward multicast packets, based on the routing table
- DVMRP router forwards a packet if
- The packet arrived from the link used to reach the source of the packet
- If downstream links have not pruned the tree
- DVMRP protocol uses the **basic packet types** as follows:

  - DVMRP Probes
    - for DVMRP Neighbor Discovery
  - DVMRP Reports
    - for Multicast Route Exchange
  - DVMRP Prunes
    - for pruning multicast delivery trees
  - DVMRP Grafts
    - for grafting multicast delivery trees
  - DVMRP Graft Ack's
    - for acknowledging graft msgs

- The **forwarding table** of DVMRP is as follows:

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

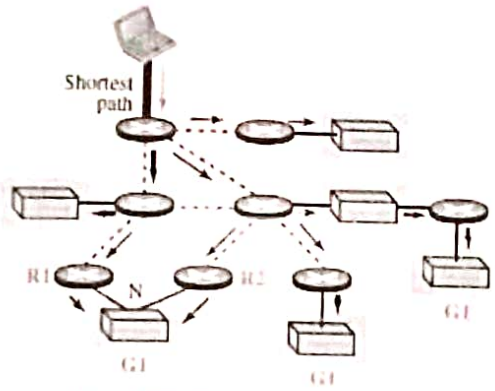
- Multicasting is added to distance-vector routing in four stages.
  - Flooding
  - Reverse Path Forwarding (RPF)
  - Reverse Path Broadcasting (RPB)
  - Reverse Path Multicast (RPM)

Flooding

- Router on receiving a multicast packet from source *S* to a Destination from NextHop, *forwards* the packet on all out-going links.
- Packet is flooded and looped back to *S*.
- The drawbacks are:
  - It floods a network, even if it has *no members* for that group.
  - Packets are forwarded by each router connected to a LAN, i.e., *duplicate flooding*

Reverse Path Forwarding (RPF)

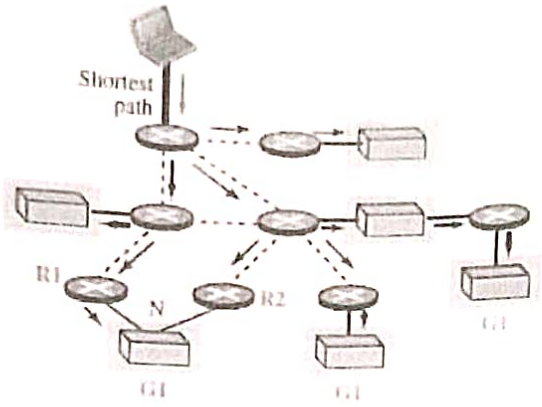
- RPF eliminates the looping problem in the flooding process.
- Only one copy is forwarded and the other copies are discarded.
- RPF forces the router to forward a multicast packet from one specific interface: the one which has come through the shortest path from the source to the router.
- Packet is flooded but not looped back to *S*.



Using RPF, N receives two copies.

Reverse-Path Broadcasting (RPB)

- RPB does not multicast the packet, it broadcasts it.
- RPB creates a shortest path broadcast tree from the source to each destination.
- It guarantees that each destination receives one and only one copy of the packet.
- We need to prevent each network from receiving more than one copy of the packet.
- If a network is connected to more than one router, it may receive a copy of the packet from each router.
- One router identified as parent called designated Router (DR).
- Only parent router *forwards* multicast packets from source *S to the attached network*.
- When a router that is not the parent of the attached network receives a multicast packet, it simply drops the packet.



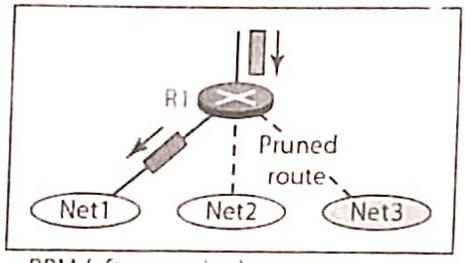
Using RPB, N receives only one copy.

Reverse-Path Multicasting (RPM)

- To increase efficiency, the multicast packet must reach only those networks that have active members for that particular group.
- RPM adds pruning and grafting to RPB to create a multicast shortest path tree that supports dynamic membership changes.

Pruning:

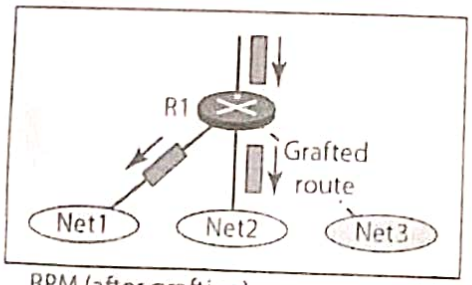
- Sent from routers receiving multicast traffic for which they have no active group members
- "Prunes" the tree created by DVMRP
- Stops needless data from being sent



RPM (after pruning)

Grafting:

- Used after a branch has been pruned back
- Sent by a router that has a host that joins a multicast group
- Goes from router to router until a router active on the multicast group is reached
- Sent for the following cases
  - A new host member joins a group
  - A new dependent router joins a pruned branch
  - A dependent router restarts on a pruned branch

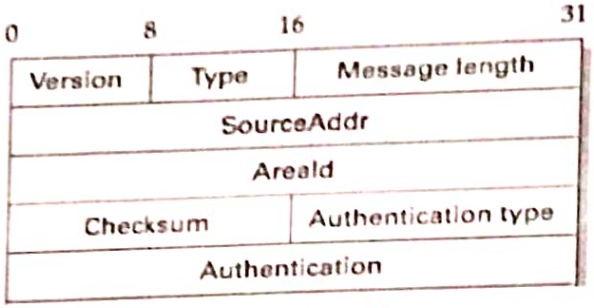


RPM (after grafting)

OPEN SHORTEST PATH FIRST PROTOCOL (OSPF)

- OSPF is a non-proprietary widely used link-state routing protocol.
- OSPF Features are:
  - **Authentication**—Malicious host can collapse a network by advertising to reach every host with cost 0. Such disasters are averted by authenticating routing updates.
  - **Additional hierarchy**—Domain is partitioned into areas, i.e., OSPF is more scalable.
  - **Load balancing**—Multiple routes to the same place are assigned same cost. Thus traffic is distributed evenly.

Link State Packet Format



- ***Version*** — represents the current version, i.e., 2.
- ***Type*** — represents the type (1–5) of OSPF message.
  Type 1 - "hello" message, *Type 2* - request, *Type 3* – send ,
  Type 4 - acknowledge the receipt of link state messages ,
  Type 5 - reserved
- ***SourceAddr*** — identifies the sender
- ***AreaId*** — 32-bit identifier of the area in which the node is located
- ***Checksum*** — 16-bit internet checksum
- ***Authentication type*** — 1 (simple password), 2 (cryptographic authentication).
- ***Authentication*** — contains password or cryptographic checksum

Difference Between Distance-Vector And Link-State Algorithms

Distance vector Routing	*Link state Routing*
Each node talks only to its directly connected neighbors, but it tells them everything it has learned (i.e., distance to all nodes).	Each node talks to all other nodes, but it tells them only what it knows for sure (i.e., only the state of its directly connected links).