Multicast Protocols

IGMP - IP Group Membership Protocol
DVMRP - DV Multicast Routing Protocol
MOSPF - Multicast OSPF
(see notes pages for some slides!)
IGMPv2 - Internet Group Management Protocol implements Group Membership

<table>
<thead>
<tr>
<th>Type</th>
<th>Max Resp Time</th>
<th>Checksum</th>
<th>Group Address</th>
</tr>
</thead>
<tbody>
<tr>
<td>0x11</td>
<td></td>
<td></td>
<td>0x11 = Membership Query [General(GA=0)/Group spec]</td>
</tr>
<tr>
<td>0x16</td>
<td></td>
<td></td>
<td>0x16 = v2-Membership Report [Group]</td>
</tr>
<tr>
<td>0x12</td>
<td></td>
<td></td>
<td>0x12 = v1-Membership Report</td>
</tr>
<tr>
<td>0x17</td>
<td></td>
<td></td>
<td>0x17 = Leave Group[all routers mc g=224.0.0.2]</td>
</tr>
</tbody>
</table>

- IGMP runs directly on IP as protocol nr 2.
- TTL == 1 in all IGMP msges
- Host will wait random[0...Max Resp Time] prior to response and will suppress its response if it sees another response to the same group

All syst MC group 224.0.0.1
IGMPv3 adds selective reception from sources within a Group

Variants:
- General query: GA=0 and Nrof sources=0.
- Group specific query: GA=/=0, Nrof sources=0
- Group and source specific Query

0x22 = V3 Membership Report

Can exclude listed sources within a Group or include only listed sources within a Group
Experimental routing protocols have been developed for MBone - an overlay MC Internet

<table>
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* Relies on Unicast routing protocol to locate MC-sources
Those that don’t, can route MC on routes separate from unicast routes.
Distance Vector Multicast Routing Protocol (DVMRP) is used for MC routing in the MBone

DVMRP header

<table>
<thead>
<tr>
<th>Type</th>
<th>Code</th>
<th>Checksum</th>
</tr>
</thead>
<tbody>
<tr>
<td>0x13</td>
<td>Reserved</td>
<td>Minor vers = 0xff</td>
</tr>
</tbody>
</table>

[all-dvmrp-routers] [IP protocol=2=IGMP, TTL=1, TOS=internwrk cntrl]

‘DVMRP Probe’ [Code=1] for Neighbor discovery

‘DVMRP Report’ [Code=2] for route exchange

‘DVMRP Prune’ [Code=7] - cut a branch of MC tree

‘DVMRP Graft’ [Code=8] (join) - MC tree expansion

‘DVMRP Graft Ack’ [Code=9] - ack of graft reception

DVMRP is similar to RIP except that sources are like destinations in RIP
Probes are used for neighbor discovery

'DVMRP Probe’ [list of neighbors on this i/f]

- Probes are exchanged on tunnel and phys. i/fs
- Mcasts are not exchanged until two-way neighbor relationship is established
- Routers see each others versions -> compatibility
- Keepalive --> fault detection, restart detection
  - sent each 10s, timeout set at 35s
- If list of neighbors is empty - this is leaf ntwrk managed by IGMP

Unicast [whole DVMRP routing table]

My address on list first time

Yes
Route reports are used to build the source based trees

Each DVMRP router periodically (60s) bcasts to its neighbors
- the list of pairs (source, metric)
- source aggregation according to CIDR may be used

- The receiving MC router calculates the previous hop on each sources Mcast path = the DVMRP router that reports shortest distance from the source
- If equal distance --> choose smallest IP address

'DVMRP Report' [ inf<metric<2*inf]
cmp. poisonous reverse, inf=32.

Designated forwarder

Known neighbor
yes

Downstream Dependent neighbor
Reports are processed:

Router

DVMRP Report

[S, metric]

Other interfaces

Adjusted metric = metric + interface cost
If Metric < inf & Adjust metric ≥ inf
    Set adjusted metric to inf
If Route is new and Adj metric < inf
    Add route to RT
    Delete prune state of more general route
Elseif Route exists
    If Received metric < inf
        Check if Designated forwarder status for (S,G) changes
        If Adjusted metric > existing metric
            From same neighbor: update metric, Sch flash update for route
        Elseif Adj.metric < existing metric
            Update metric for the route
            If sender was different, update RT, schedule flash updates
        Elseif Adj.metric = existing metric: refresh route ...
    Elself Received metric = inf ...
    Elseif Inf < Received Metric < 2 * inf ...
    Elseif Received metric = inf ...
    Elseif Inf < Received Metric < 2 * inf ...
Multicast algorithm

RPF - reverse path forwarding

Multicast [from=S, to=G]

• At first mcast from RPF i/f a Forwarding Cache Entry [S,G]: (u,list...) is created using the DVMRP routing table
• List contains all downstream routers that have reported dependency on S
• Router is designated forwarder for downstream nodes
• If Designated forwarder becomes unreachable, Router assumes role of designated until it hears from a better candidate
List of dependent neighbors is used to minimise the MC tree

Multicast [from=S, to=G]

u=RPF i/f(S,G)

Cache= [S,G]: (u,list)

• Initially list may contain all mc i/fs but the upstream i/f
• Downstream address is removed from list if
  - =leaf network and G \notin IGMP DB for this phys. network
  - downstream node has selected another designated forw
  - Prune received from all dependent neighbors on this i/f

Empty list

Prune [S, G, lifetime]

Remove Cache Entry

Router
On Probe timeout Caches are flushed

- All routes learned from A -> hold-down
- All downstream dependencies ON A are removed
- If A was designated forwarder, a new one is selected for each source, group pair
- Forw cache entries based on A are flushed
- Graft acks to A are flushed.
- Downstream dependencies are removed. If last, prune sent upstream --->

Diagram:

- Router A
- ‘DVMRP Probe’
- Probe timeout
- Router
Route hold-down is a state prior to deleting the route

- Routes expire on Report timeout or when an infinite metric is received
- An alternate route (that in RIP caused temporary loops) may exist
- Routers continue to advertise the Route with inf metric for 2 report intervals - this is the hold-down period
- All Forw Cache entries for the Route are flushed
- During hold-down, the route may be taken back, if (<inf and = SAME) metric is received from SAME router
Prunes minimise the Mcast tree

If Known dependent neighbor
  If mask and mask=sent mask with (S,G)
    Prune all sources in network (S, mask)
  If prune is already active
    reset timeout to new value
  If all dependent neighbors have sent prunes
    If no group members on the mc-interface
      Remove u from all Forwarding Cache entries
  If last u

If Mcasts keep arriving (3s)
  Resend Prune with exponential backoff = double interval each time
  Remove Cache Entry

Prune [S, (netmask), G, Lifetime]
Grafts are used to grow the tree when a new member joins the Group

Graft is
- always acknowledged => if no MCast, nobody is sending
- if no Ack, is resent with exp. backoff retransmissions
- forwarded upstream if necessary
Multicast routing example
Source based trees for G1

Tree for source S1

Tree for source S2

Tree for source S3
Shared Multicast tree for G1

192.5.1/24

G1

192.5.2/24

G1

R5

R6

R3

R4

R7

R1

R2

R8

R11

S2

S3

192.7.1/24

G1

Rendezvous Point in PIM
Core in CBT
Mbone overlay is based on WSs running DVMRP

Tunneling is used to bypass unicast sections of the Internet
MOSPF (Multicast Extensions to OSPF)

- is an extension of OSPF, allowing Multicast to be introduced into an existing OSPF unicast routing domain
- unlike DVMRP, MOSPF is not susceptible to the normal convergence problems of Distance Vector algorithms.
- limits the extent of multicast traffic to group members, something e.g. DVRMP cannot always do. Restricting the extent of multicast datagrams is desirable for high-bandwidth multicast applications or limited-bandwidth network links (or both).
MOSPF can be deployed gracefully

- Introduces multicast routing by adding a new type of LSA to the OSPF link-state database and by adding calculations for the paths of multicast datagrams.
- The introduction of MOSPF to an OSPF routing can be gradual - MOSPF will automatically route IP multicast datagrams around those routers incapable of multicast routing, whereas unicast routing continues to function normally.
- MOSPF can be, and is in isolated places, deployed in the MBONE. A MOSPF domain can be attached to the edge of the MBONE, or can be used as a transit routing domain within the MBONE’s DVMRP routing system.
An MOSPF Routing Domain

E.g. G1 = 226.1.7.6
E.g. expanding ring search (TTL).
Group m-LSA created and flooded when e.g. host on 128.186.4.0 joins G1.
Group-membership-LSA is created and flooded when an IP user joins an MC-group using IGMP

<table>
<thead>
<tr>
<th>LS Age</th>
<th>Options</th>
<th>LS Type</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>E-bit. LS Type 6 (group-membership-LSA)</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>226.1.7.6 (group G1)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>128.186.4.1 (router E)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0x80000001</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0x3da9</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2 (network)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>28 bytes</td>
</tr>
<tr>
<td></td>
<td></td>
<td>128.186.4.1 (128.186.4.0/24)</td>
</tr>
</tbody>
</table>
MOSPF calculates Shortest-path trees on demand

- Result is stored in MC Forwarding Cache Entry
- When network conditions change paths are recalculated
- Hierarchy reduces the number of calculations

Lines with label A are pruned when removing redundant shortest paths.
Lines with label B are pruned when removing links that do not lead to G1
Forwarding Cache Entry stores MC path routing info

Source network, Group -->

<table>
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<th>Router or network for mcast reception</th>
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<td>List of Interfaces, mcasts must be sent</td>
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A Cache Entry may be deleted at any time -> will be recalculated on demand

Cache entries must be deleted, when changed LSAs are received
- Router-LSA, Network-LSA (on router or link failure or cost change) =>
  delete all entries since can’t tell which are affected
- Group-m-LSA: delete entries of that group
- Hierarchy => the farther away the change is the fewer cache entries are deleted
On demand route calculations use Dijkstra’s SPF-algorithm

- Calculation is rooted on the source not the router as for unicast
- For a new mcast, every router performs the same calculation
- Stub networks do not appear in MOSPF calculation (e.g. router F)
- Tiebreaks for equal cost routes - previous hop router that has highest address is chosen (e.g. G over E)
Two level hierarchy aggregates both sources and group addresses

- In aggregation some info is lost --> sometimes mcasts are sent needlessly: C->G:to G1
- Presence of sources is reported by summary-LSA with MC -bit set: F to H-> S3+S4 entry
- Area border router advertise Group-m-LSAs to bbone (B: G1, D,E,F:G1, C,D,E:G2) - no exact location
- Routers in non-bbone do not know location of group memrs

![Diagram](image-url)
### Summary of Multicast Protocols for the Internet

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* Rely on Unicast routing protocol to locate MC-sources.
- Those that don’t, can route MC on routes separate from unicast routes.
- For Shared tree protocols an additional step of finding the Core or Rendesvouz Point must be performed.
- Directories are useful on service management level.