Revisiting IP Multicast

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Why IP Multicast?

1990s

HTML/Text/Images

HTML/Text/Images
Why IP Multicast?

2000s

HTML/Text/Images + Audio/Video/Internet Games
Why IP Multicast?

Maybe in the near future
Agenda

- IP Multicast
  - Introduction
  - Class D IP Addresses
  - MBone

- IP Multicast Algorithms
  - Group Membership Advertisement
  - Routing (PIM, MOSPF, DVMRP)

- FRM
  - Group Membership Advertisement
  - Forwarding
  - Overhead
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Routing Schemes

- Broadcast
- Unicast
- Multicast
Routing Schemes

- Broadcast
- Unicast
- Multicast
Routing Schemes

- Broadcast
- Unicast
- Multicast
## Class D IP Addresses

<table>
<thead>
<tr>
<th>Prefix</th>
<th>Description</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>CLASS A</td>
<td>(0.0.0.0 - 127.255.255.255)</td>
</tr>
<tr>
<td>1 0</td>
<td>CLASS B</td>
<td>(128.0.0.0 - 191.255.255.255)</td>
</tr>
<tr>
<td>1 1 0</td>
<td>CLASS C</td>
<td>(192.0.0.0 - 223.255.255.255)</td>
</tr>
<tr>
<td>1 1 1 0</td>
<td>CLASS D</td>
<td>(224.0.0.0 - 239.255.255.255)</td>
</tr>
<tr>
<td>1 1 1 1</td>
<td>Reserved</td>
<td></td>
</tr>
</tbody>
</table>
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Prerequisites

Two important factors of IP multicast

- Group membership advertisement
- Packet routing
Group Membership Protocol: IGMP

IGMP aims to manage membership of multicast groups

Between hosts and an adjacent router
Routing Protocol: MOSPF, DVMRP

MOSPF and DVMRP are routing protocols for IP multicast use.

How can R4 avoid unnecessary packets from R3?
Routing Protocol: PIM

PIM-SM

PIM-DM

R1

RP

R2
R3

R4

B
C

D
E

Revisiting IP Multicast
Routing Protocol: PIM

PIM-SM

PIM-DM

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Why FRM?

Current IP Multicast is too complex

- IGMP
- MOSPF
- DVMRP
- PIM

FRM
Group Membership Advertisement

FRM extends BGP

Destination  AS_PATH  GRP_BF  (Group Membership Advertisement)

Bloom Filter Encoding
Group Membership Advertisement

Centralized computation at the origin border router

A joins group G1

Network diagram showing routers (R1, R2, R3, R4, R5) and devices (A, B, C, D, E) connected.
Group Membership Advertisement

Exploitation of knowledge of unicast BGP routes

Diagram showing network nodes and arrows indicating BGP (Border Gateway Protocol) traffic.
Group Membership Advertisement

Exploitation of knowledge of unicast BGP routes

Diagram showing network routers and computers connected with BGP routes.
Group Membership Advertisement

Exploitation of knowledge of unicast BGP routes

<table>
<thead>
<tr>
<th>BGP RIB (R4)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prefix</td>
</tr>
<tr>
<td>--------</td>
</tr>
<tr>
<td>A</td>
</tr>
</tbody>
</table>
Tree information (TREE_BF) is also encoded with bloom filter
For Forwarding

BGP RIB (R1)

<table>
<thead>
<tr>
<th>Prefix</th>
<th>AS_PATH</th>
<th>Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>R5-&gt;R3-&gt;B</td>
<td>G1</td>
</tr>
<tr>
<td>D</td>
<td>R2-&gt;R4-&gt;D</td>
<td>G1</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
<td>...</td>
</tr>
</tbody>
</table>

Tree information (TREE_BF) is also encoded with bloom filter
Tree information (TREE BF) is also encoded with bloom filter
Tradeoff

Simple mechanism
Easy control from ISP
Easy configuration

Storage overhead
Bandwidth cost
Overhead

Storage consumption due to membership advertisement

Assumption:
- One million simultaneously active groups
- Ten groups per user

Evaluation:
- 3GB of route processor memory is required

Storage overhead [0]
Storage consumption due to packet forwarding

- \( A \) -- number of groups with sources in the local domain
- Zipfian group popularity with a minimum of 8 domains per group
- 25 groups have members in every domain (global broadcast)

256 MB of line card memory enables fast-path forwarding for \( \sim 200000 \) active groups
Bandwidth consumption due to membership advertisement

Assumption:
- GRP_BF encoding uses five hash functions
- Bit positions are represented as 24-bit values
- Each advertisement for membership change costs approx. 15 bytes
- 200000 prefixes in BGP RIB
- Each prefix updates at least one time a second

Evaluation:
- The required bandwidth due to incoming GRP_BF update traffic at the border router is approximately 3MBps
Overhead

Bandwidth consumption due to packet forwarding

**Assumption:** The size of shim header is 100 bytes

**Evaluation:** The numbers are slightly bigger than in ideal multicast

<table>
<thead>
<tr>
<th>Group Size</th>
<th>Ideal Multicast</th>
<th>FRM</th>
<th>per-AS unicast</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>28</td>
<td>28</td>
<td>38</td>
</tr>
<tr>
<td>1,000</td>
<td>158</td>
<td>158</td>
<td>246</td>
</tr>
<tr>
<td>10,000</td>
<td>1,000</td>
<td>1,012</td>
<td>1,962</td>
</tr>
<tr>
<td>100,000</td>
<td>4,151</td>
<td>4,233</td>
<td>9,570</td>
</tr>
<tr>
<td>1,000,000</td>
<td>8,957</td>
<td>9,155</td>
<td>21,754</td>
</tr>
<tr>
<td>10,000,000</td>
<td>15,353</td>
<td>15,729</td>
<td>39,229</td>
</tr>
</tbody>
</table>

*Total-tx:* total number of packet transmissions [0]
Conclusion

- FRM (Free Riding Multicast) is a new approach to make the deployment of IP multicast easier

- FRM extends BGP

- FRM encodes its routing information and group membership with the bloom filter

- According to current memory technology, the cost from the storage overhead is quite acceptable

- The bandwidth consumption due to the membership advertisement is very small
Any questions?