Layer 2 Multicasting

- Multicast in LANs
- Address Mapping
- Multicast Frame Distribution
- Multicast Discovery
- Multicast over ATM
- Multicast in Wireless
  - 802.11 WLAN
  - 802.16 WIMAX
  - 3GPP – MBMS
  - DVB-H/IPDC
Multicast in Local Area Networks

LANs combine Router, Switches and Hubs as data forwarders.
Most likely the LAN backbone distribution is achieved by large ’Switching Clouds‘.

The following issues arrive:

- IP-layer multicast addresses need translation into L2 addresses
- Multicast data streams must be recognized as such
- Data distribution at Layer 2 should follow multicast laws
Broadcasting on Layer 2

- Simplest approach
- No Layer 2 intelligence needed (Hubs)
- Causes network flooding (may significantly disturb)

An efficient solution requires L2 and L3 intelligence
IPv4 Multicast Address Mapping

Layer 3 IPmc Address Mapping onto Layer 2 Multicast Addresses (FDDI and Ethernet)

Caveat: Causes 5 Bit address overlap!
Multicast Address Overlap

32 - IP Multicast Addresses

224.1.1.1
224.129.1.1
225.1.1.1
225.129.1.1
... 
238.1.1.1
238.129.1.1
239.1.1.1
239.129.1.1

1 - Multicast MAC Address

0x0100.5E01.0101
IPv6 Multicast Address Mapping

- RFC2464
- Example: FF05:1::5 → 33:33:0:0:0:5
- More than 1 trillion IPv6 multicast address will map to the same MAC address (80 bits are lost)
Layer 3 IPmc address will be mapped to Token Ring Broadcast address

(Shown in Token Ring, non-canonical format)

Token Ring bound to multicast flooding!
Multicast Frame Distribution

Devices at the Network Access Layer need to perform an appropriate distribution of MAC Frames:

Layer 1 – Forwarding to all HUB users

Layer 2 (Dumb) – Distribution as Broadcasts

Layer 2 (Multicast) – Learning of group members, specific forwarding

There are switches which block Multicast frames
Multicast Discovery

Problem: How does a Switch learn about group membership?

Solution 1 – Analyse IGMP messaging (IGMP-Snooping)
- Switches listen to IGMP packets (join, leave)
- This requires Layer 3 intelligence in asics

Solution 2 – Layer 2 Signalling
- Router translates IGMP operations into Layer 2 signals
- But: only proprietary protocols available (e.g., Cisco CGMP)
IGMP Snooping

1st Join

LAN Switch (IGMP Snooping Enabled)

Router A

IGMP Report 224.1.2.3

CPU

CAM Table

MAC Address 0100.5e01.0203 Ports 0, 1, 2

Entry Added

Host 1

Host 2

Host 3

Host 4

Switching Engine

0

2

3

4

5
IGMP Snooping

2nd Join

LAN Switch (IGMP Snooping Enabled)

CPU

CAM Table

MAC Address 0100.5e01.0203  Ports 0,1,2,5

Port Added

Switching Engine

Router A

IGMP Report 224.1.2.3

Host 1
Host 2
Host 3
Host 4
IGMP Snooping: Pure L2 Switch

1.5Mbps !!! Choke, Gasp, Wheeze!!

MAC Address 0100.5e01.0203  
Ports 0, 1, 2, 5

CAM Table

Switching Engine

1.5Mbps MPEG Video

Router A

Host 1 (MPEG Server)  
Host 2  
Host 3  
Host 4

(IGMP Snooping Enabled)
## IGMP Snooping: L3 Switch

**Diagram Description:**
- **LAN Switch** (IGMP Snooping Enabled)
  - **CPU**
  - **CAM Table**
  - **Switching Engine (w/L3 ASICs)**

**Network Diagram:**
- **Router A** connected via port 1 to the LAN Switch.
- **Hosts 1, 2, 3, 4** connected to ports 2, 3, 4, and 5 respectively.

**CAM Table:**
<table>
<thead>
<tr>
<th>MAC Address</th>
<th>L3</th>
<th>Ports</th>
</tr>
</thead>
<tbody>
<tr>
<td>0100.5exx.xxxx</td>
<td>IGMP</td>
<td>0</td>
</tr>
</tbody>
</table>

**IGMP Processing Entry:**
- MAC Address: 0100.5exx.xxxx
- L3: IGMP
- Ports: 0
IGMP Snooping: L3 Switch

1st Join

LAN Switch (IGMP Snooping Enabled)

CPU

CAM Table

Switching Engine (w/L3 ASICs)

Router A

IGMP Report 224.1.2.3

MAC Address   L3  Ports
0100.5exx.xxxx  IGMP  0
0100.5e01.0203  !IGMP  1,2
IGMP Snooping: L3 Switch

2nd Join

Router A

1

IGMP Report

224.1.2.3

LAN Switch (IGMP Snooping Enabled)

CPU

Switching Engine (w/L3 ASICs)

CAM Table

MAC Address | L3 | Ports
---|---|---
0100.5e01.0203 | IGMP | 1,2,5

Port Added

Host 1

Host 2

Host 3

Host 4
IGMP Snooping: L3 Switch

No Load on CPU

Ahhh, That’s more like it!

1.5Mbps MPEG Video

Host 1

Host 2

Host 3

Host 4

MAC Address | L3 | Ports
---|---|---
0100.5e01.0203 | !IGMP | 1,2,5
0100.5e01.0203 | IGMP | 0

Router A

Switching Engine (w/L3 ASICs)

LAN Switch (IGMP Snooping Enabled)
Multicast over ATM

ATM (UNI 3.1) offers point-to-multipoint services

- Sender oriented: every sender knows its receivers and initiates corresponding connections

IP-Multicasting

- Receiver oriented: a sender does not know about its receivers

ATM Network Solution: Translation service - ATM MARS
Multicast Address Resolution Server

- RFC 2022 (1996)
- Maps IP Multicast addresses on ATM addresses
- MARS server combines group members to Clusters
- Registration and deregistration similar to IGMP
- All Cluster members obtain group information via Multicast cluster control channels
- MARS concept independent of IP
MARS Model

ClusterControl VC

lokales Netz

MARS-Server
Multicast on Wireless Transmission

- Wireless transmission is key technology for mobile systems & applications
- Efficient (group) communication of enhanced relevance due to few, limited frequency bands
- Specific problems of wireless transmission:
  - Air is always a shared medium
  - Signal strength inhomogeneous (hidden/exposed terminal)
  - Reliability of transmission significantly decreased
- The Counterpart of IP-Layer Mobility
Multicast over 802.11 WLAN

- Broadcast network of Ethernet type, including multicast addressing
- An Access Point operates as repeater (infrastructure mode)
- A mobile Station sends multicast data to an AP in point-to-point channel (ToDS bit on)
  - Treated as acknowledged unicast
- The AP repeats multicast frames to the BSS and propagates them to the ESS
  - Treated as unacknowledged broadcasts
Issues with 802.11 Multicast

- Limited Reliability
  - increased probability of lost frames from interference, collisions, or time-varying channel properties

- Delayed Distribution
  - AP buffers multicast packets and waits for DTIM, if Stations are using power saving mode

- Congestion Threat
  - Distribution System experiences multicast as flooding
  - Replicate mcast packets over all APs in same IP subnet
802.16 WiMAX

- Point-to-Point or Point-to-Multipoint (no ad hoc mode)
- Connection oriented radio transmission
  - Channel management: Base Station (BS) assigns Channel IDs (CIDs) within Service Flows (SFIDs) to Subscriber Station (SS)
  - no autonomous packet addressing
- Separates uplink and downlink channel
  - Downlink fully controlled by BS
  - Uplink by admission control of BS
  - Automatic Repeat Request (ARQ) optional per Service Flow – operates go-back-N in Sliding Window
WiMAX Multicast

- BS may initiate downlink multicast distribution
  - Assigns common CID to all group members (SSs)
  - ARQ not applicable
- On reception SS cannot distinguish multicast from unicast stream
- SS sends multicast data to BS as point-to-point stream
- BS operates as L2 Switch and may support IGMP snooping (even IGMP proxying in 802.16e)
Multimedia Broadcast and Multicast Services (MBMS) in 3GPP

- 3GPP mobile telecommunication networks are designed to provide both, voice and data services
- Part of the 3GPP Model is the *IP Multimedia Subsystem* (IMS), which is capable of MBMS (UMTS Rel. 6)
  - Distinct control and data planes
  - Controller: Broadcast Multicast - Serving Center (BM-SC)
  - Signalling to first hop gateway by L2 protocol
    - Subscription/Service announcement
    - Joining/multicast mode bearer set up/transfer/leaving
3GPP MBMS Gateway Architecture

Local router forks multicast packets to all interfaces registered to receive them (in this case multiple SGSNs)

GGSN relays multicast packet on to a single GTP tunnel for that target multicast address. The "to" field in the IP packet carrying the GTP is a multicast address

Encapsulated user data
GPRS transport protocols

IP packet
"to"=IP target m'cast addr
GTP
TID = pt to multipoint GPRS conn
IP packet
"to"=Gn Multicast Address

GPRS backbone IP network
SGSN1
SGSN2
Router

IP network
IP multicast server
GGSN
DVB-H / DVB-I PDC

- ETSI standard for IP Datacast service
- Offers high downstream data rates up to 15 Mbit/s
- Physical layer specification for the transmission of digital TV
- Transmits multicast and broadcast data in bursts
  - Allows for power saving time slots at receivers
Layer 2 Multicast Resume

Standard LAN Technologies:

- Address collisions
- Layer 3 intelligence essential

Wireless Technologies:

- Multicast distribution on broadcast media
- Flooding threats in scarce resource of radio spectrum
- Full multicast capabilities: datacast distribution

Multicast Mobility:

- Complex interplay of Internet and network access layer
References

- www.rfc-editor.org
- www.dvb.org