Internet Group Communication: IP Multicasting

- Introduction
- Why to Talk in Groups?
- Aspects of Group Communication
- IP-Multicasting
- Addressing
- The Internet Group Protocol
Motivation

Current Situation: Use of the Internet penetrates new areas:

• Multimedia Information Services
• Gaming
• Synchronous Network Information Services
• Group Communication Tools

⇒ A Transport Infrastructure is needed for Group Communication Services
Requirements

• Must fit into current IP Infrastructure
• Location Transparancy
• Efficiency in Data Distribution
• Utmost Independence of Specific Hardware
• Independent Open Standards
• Interoperability
Example: Video Streaming

- High Requirements of Bandwidth and Server Performance
- Continuous Data Streams
- Real-Time Synchronisation
- Global Distribution (Web-TV, Video-Conferencing)
Issues:

- Internet Group Communication Fundamentals
  - Group Communication, Multicasting, Adressing, IGMP/MLD

- Layer 2 Multicasting
  - Local Networks, Adress-Mapping, Framing, Discovery, ATM

- Multicast Routing
  - Specialities, Algorithms, Protocols

- New Developments
  - IPng, SSM, Multicast Mobility
Why to Talk in Groups?

Internet based communication steadily gains importance, quantitatively as well as qualitatively. New communication forms arise, old services spread rapidly:

• Multimedia Distribution
• 'Broadcasting' - Offers
• Telecommunication Services

⇒ Scalable Communication Paths needed to Distribute Data in Parallel
Ineffective Group Communication

Unicast

Broadcast
Effective Group Communication

Multicast
Group Communication Differs

Classical TCP/IP Communication Model:

• Client/Server Principle

• Individual Communication Channels
  – Initiated by client
  – Server answers individually
  – Server speaks on many point-to-point channels

• Exception for unspecific message distribution:
  Broadcasts
Examples

IRC – Client-to-Client Communication via Server

NTP – many Clients ask one Server

Routing (RIPv1) – Broadcast of Routing Tables

Multisource Webpage – Client asks many Server

Internet Server Farm – one Client asks one of many Servers
**Group Communication Modes**

**Broadcast** – one Sender to all Members of the Subnet

**Concast** – one Receiver of a Group of Senders

**Multicast** – one Sender Addresses a Group of Receivers

**Multipeer** – a Group of Senders to a Group of Receivers

**Anycast** – Communication Partner selected from a Group of potential Partners (Unicast)
Aspects of Group Communication

• **Openness:** Support of open and closed groups
• **Dynamic:** Change of group membership
• **Reliability:** Securing of data transport
• **Flow Control:** Adapting data streams to buffers
• **Group Management:** Mechanisms of addressing and membership control
Openness & Dynamic

Relevant Mechanisms

• Identification/Announcement in a group/ with the sender
• Authorisation in closed Groups
• Management of send/receive allowances
• Registration & deregistration, definition of group composition
• Definition of group lifetime
Reliability

A securing layer requests for some acknowledgements

ACK:
• Group members need to register with sender
• results in ACK-‘Implosion’

NACK:
• Retransmission for one may disturb the entire group
• Last loss may be unseen
Ack Implosion
Flow Control

Window based:

- uses positive acknowledgements for sliding the window
  ⇒ unsuitable

Rate based:

- Adjust source intensity (Burst Rate)
- May be announced by receiver with membership registration
Group Management

Addressing

• Address scheme for a group
• Address allocation (centralised or decentralised)

Signaling

• Registration/Deregistration
• Member management (centralised or decentralised)
IP Multicasting

Method for Transfering IP Datagrams to Host-Groups

- RFC 1112 (S. Deering et.al., 1989)
- Addresses a host group by one group address
- Client Protokoll for registration (IGMP/MLD)
- Routing throughout the Internet (Multicast Routing)
- Address translation into Layer 2
Main Advantage of IP Multicasting

- Omits redundant network traffic
- Reduces network and server load

Example: 8 Kbps Audio Streaming

[Graph showing multicast and unicast traffic with # Clients on the x-axis and Traffic Mbps on the y-axis.]
Aspects of IP Multicasting

• Offers to sender a data delivery service to a distributed unknown group of receivers (multipoint access)

• UDP-based

• Best Effort Transport

• Securing and flow control left to application

• No closed groups

• No restriction on senders

• Applications may react Source-Adress sensitive
Multicast Network

Multicast application protocol (e.g., video conference, multicast file transfer)

Addressing: source port and destination port, sender address (unicast) and multicast receiver address

Legend:
- Hosts in MC group
- MR is a MC-Enabled Router

Sender's subnet

MR

A Receiver's subnet

MR

MR

Multicast-Enabled Internetwork
Applications of IP Multicasting

• Multimedia
  – Streaming video and audio (broadcasting)
  – Teleteaching
  – Conferencing

• Financial information services (stock price ticker,...)

• Netzwerk information services

• Arbitrary data distribution services (Pusch Apps)
Example:

Mbone-Tools

SDR
Example: Mbone-Tools Rendez-Vous
Multicast Addressing

• IP Multicast Group addresses
  – 224.0.0.0–239.255.255.255
  – Class “D” Address Space
  – denote delocalised host groups

• Permanent Addresses assigned by IANA
  – RFC 1700: Assigned Addresses
  – “http://www.iana.org/assignments/multicast-addresses” lists reserved Multicast addresses

• IPv6: scoped multicast addresses

• Dynamic Addresses
  – independent of local IP-address space (IPv4)
  – Unicast based Multicast addresses (IPv6)
Internet Address Classes

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=> max. 16.777.216 Hosts, IP-Adresse 1.x.y.z bis 127.x.y.z

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=> max. 65.536 Hosts, IP-Adresse 128.x.y.z bis 191.x.y.z

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=> max. 255 Hosts, IP-Adresse 192.x.y.z bis 223.x.y.z

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Klasse E

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für zukünftige Entwicklungen
Private Multicast Addresses

• Officially not routed address range
  – 239.0.0.0–239.255.255.255
  – Private Address Space
    • Similar to RFC1918 Unicast Addresses
    • Unused for global Internet Traffic
    • Limits Multicast Traffic to own Institution
    • Same Addresses may be globally re-used
  – Example
    • Local range: 239.253.0.0/16
    • Organisation-wide range: 239.192.0.0/14
Reserved Multicast Addresses

• Permanent IP Multicast Group Addresses
  – 224.0.0.0–224.0.0.255
  – Examples:
    • 224.0.0.1 All Systems of Subnet
    • 224.0.0.2 All Routers of Subnet
    • 224.0.0.4 All DVMRP Router
    • 224.0.0.5 All OSPF Router
    • 224.0.0.9 All RIP(v2) Router
    • 224.0.0.13 All PIMv2 Router
    • 224.0.1.1 NTP
    • 224.0.1.9 Multicast Transport Protocol (MTP)

• TTL – Standards in MBONE
  • TTL = 1: This Subnet
  • TTL = 15: This Site
  • TTL = 63: This Region
  • TTL = 127: This Internet
IPv6 Multicast Addresses

- **Flag field**: lower bit indicates permanent (=0) respectively transient (=1) group, rest is reserved (==0)
- **Scope field**: 1 - node local
  2 - link-local
  5 - site-local
  8 - organisation local
  B - community-local
  E - global (other values reserved)
IPv6 Unicast Based Multicast Addresses (RFC 3306)

- Solves the old IPv4 address assignment problem: *How can I get global IPv4 multicast addresses (GLOB, ..?)*

- In IPv6, if you own an IPv6 unicast address prefix you implicitly own an RFC3306 IPv6 multicast address prefix:

```
8 4 4 8 8 64 32
```

```
FF | Flags | Scope | Rsvd | Plen | Network prefix | Group id
```

```
FF3E:0040:3FFE:0C15:C003:1109:0000:1111
```

- 3 hex
  Uni-pfx

- 40 hex
  Prefix=64

- 8 hex
  Global

Flags = 00PT, P = 1, T = 1=> Unicast based address
Dynamic Multicast Addressing

• Dynamic Assignment of Group addresses:
  – Until now: SDR Application
  – Sessions/Groups announced via well-known multicast groups
  – Address assignments and collisions are managed within initiation process
  – Brings up severe scaling issue

• Future Techniques and Planning:
  – Multicast Address Set-Claim (MASC)
    • Hierarchical, dynamical address allocation scheme
    • Difficult and far
  – MADCAP
    • Similar to DHCP
    • Needs own Protocol stack and application integration!
Internet Group Management

Internet Group Management Protocol (IGMP)

- Client Protocol to initiate, preserve and terminate group membership
- Local Router collect and monitor information
- IGMP v1 RFC 1112
- IGMP v2 RFC 2236 – implemented almost everywhere
- IGMP v3 RFC 3376
- IPv6: Multicast Listener Discovery Protocol (MLD)
  MLDv1 (RFC 2710) – analogue to IGMPv2
  MLDv2 (IDraft) – starting from IGMPv3
IGMP

Process Layer
- PING
- rlogin/rsh
- FTP
- TFTP
- NFS
- RPC
- SMTP
- TELNET
- DNS
- SNMP
- RIP
- RPC

Host-to-Host Layer
- TCP
- UDP

Internet Layer
- EGP
- Hello
- OSPF
- IP (plus ICMP and IGMP)
- ARP
- RARP

Network Access Layer
IGMP Protocol Architecture

IGMP works like ICMP with Queries:

- General Membership
- Group specific Membership
- Version 2 Membership Report
- Leave Query
- Version 1 Membership Report
IGMP Kommunikation

IGMP report, TTL = 1,
IGMP group addr = group address
dest IP addr = group address
src IP addr = host's IP addr

IGMP report, TTL = 1,
IGMP group addr = 0
dest IP addr = 224.0.0.1
src IP addr = router's IP addr
Members joining a group do not have to wait for a query to join. They send an unsolicited report indicating their interest.
IGMP Host-Router Signalling

Group Membership Preservation

- Router sends periodic queries to 224.0.0.1
- One group member per subnet answers
- Others suppress answer
IGMP Host-Router Signalling

Terminate Group Membership (IGMPv1)

- Host 3 leaves group quietly
- Router queries remain unanswered
- Group terminate on timeout (up to 3 min)
IGMP Host-Router Signalling

Terminate Group Membership (IGMPv2)

- Host sends Leave Message to 224.0.0.2
- Router sends group query to 224.1.1.1
- Timeout ~ 3 seconds for group 224.1.1.1
IGMP v3

Source = 1.1.1.1
Group = 224.1.1.1

Source = 2.2.2.2
Group = 224.1.1.1

• H1 wants to receive from S = 1.1.1.1 but not from S = 2.2.2.2
• With IGMP, specific sources can be pruned back - S = 2.2.2.2 in this case

IGMPv3:
Join 1.1.1.1, 224.1.1.1
Leave 2.2.2.2, 224.1.1.1

H1 - Member of 224.1.1.1
Limits of IGMP

IGMP Concept has no Group Directory

- Hosts not answering on Membership Queries remain unseen
- Closed groups impossible
- Undiscovered listener part of the concept

IGMP is relatively slow

- Time to reaction in the order of seconds
- Unsuitable for flow control or congestion avoidance
- Initiation or change of a non-local group tardy
Berkeley Sockets set/getsockopt():

- **IP_ADD_MEMBERSHIP** to join a multicast group on a specific interface
- **IP_DROP_MEMBERSHIP** to leave a multicast group (no protocol action initiated with IGMP v1, but there is with IGMP v2)
- **IP_MULTICAST_IF** to set or get default interface for use with multicast sends
- **IP_MULTICAST_LOOP** to disable loopback of outgoing multicast datagrams
- **IP_MULTICAST_TTL** to set the IP time-to-live of outgoing multicast datagrams.
Class MulticastSocket

with Methods

• `public void joinGroup(InetAddress mcastaddr)`

• `public void leaveGroup(InetAddress mcastaddr)`
Reading

• R. Wittmann, M. Zitterbart: Multicast Communication, Morgan Kaufmann, 2001