IPv6 Multicast

beyond link local
Agenda

• IP Multicast History
• Unicast - Broadcast - Anycast - Multicast
• Multicast in IPv6 Networks
• Case-Study DHCPv6
• Case-Study X11
• Case-Study NTP
• Case-Study DNS
• Conclusion
IP Multicast History

1969
- Birth of the ARPANET

1983
- RFC 1112 Host extensions for IP Multicasting
- TCP/IP “Flag-Day”

- Multicast Backbone (MBONE)
- Steve Deering P.h.d Thesis: Multicast Routing in a Datagram Internetwork

1997
- vBNS + Abilene
- RFC 2117 PIM-SM

1999
- RFC 4601 PIM-SM (revised)

2006
- RFC 4607 Source Specific Multicast

2010
- Multicast VPN networks
Definitions

• Unicast: Node to Node (1-1) communication
• Broadcast: Node to Network communication
• Anycast: Note to one Node from a group communication
• Multicast: Node to all Nodes from a group communication
Unicast
Broadcast
Multicast

Workstation 2001:db8:100::1

Workstation ff05::101

Workstation ff05::101

Workstation ff05::101
Multicast in IPv6 Networks

- Multicast is a mandatory part of IPv6

- IPv6 is using Multicast on the protocol level (e.g. Neighborhood Discovery)

- Use of IPv6 Multicast beyond the link-local scope requires a multicast routing protocol

- Official IANA Multicast IP Addresses:
  http://www.iana.org/assignments/ipv6-multicast-addresses/ipv6-multicast-addresses.xml
Multicast IPv6 Addresses

The structure of a multicast IPv6 address is as follows:

- **MC**: 8 bits
- **Group ID**: 32 bits
- **Group**: 112 bits

The 112-bit group field is divided into:

- **4 bits of flags**:
- **4 bits of scope**:

The flags and scope fields are used for various purposes in the multicast address space.
## Multicast Addresses: Flags

<table>
<thead>
<tr>
<th>Bit</th>
<th>Usage</th>
</tr>
</thead>
</table>
| 0   | Transient Flag:  
|     | 0 = permanent address (IANA assigned, well-known)  
|     | 1 = transient address |
| 1   | Prefix flag (RFC 3306/3307) |
| 2   | Rendezvous Point (RFC 3956) |
| 3   | undefined |
# Multicast Addresses: Scope

<table>
<thead>
<tr>
<th>Value (Hex)</th>
<th>Scope</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Interface/Node-local</td>
</tr>
<tr>
<td>2</td>
<td>Link-local</td>
</tr>
<tr>
<td>4</td>
<td>Admin-local</td>
</tr>
<tr>
<td>5</td>
<td>Site-local</td>
</tr>
<tr>
<td>8</td>
<td>Organization-local</td>
</tr>
<tr>
<td>E</td>
<td>Global</td>
</tr>
</tbody>
</table>
# Node local Scope

<table>
<thead>
<tr>
<th>Address</th>
<th>Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>ff01::1</td>
<td>all nodes address</td>
</tr>
<tr>
<td>ff01::2</td>
<td>all routers address</td>
</tr>
<tr>
<td>ff01::fb</td>
<td>mDNSv6</td>
</tr>
</tbody>
</table>
## Link local scope

<table>
<thead>
<tr>
<th>Address</th>
<th>Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>ff02::1</td>
<td>all nodes address</td>
</tr>
<tr>
<td>ff02::2</td>
<td>all routers address</td>
</tr>
<tr>
<td>ff02::fb</td>
<td>mDNSv6</td>
</tr>
<tr>
<td>ff02::F</td>
<td>UPnP Devices</td>
</tr>
<tr>
<td>ff02::1:1</td>
<td>Link Name</td>
</tr>
<tr>
<td>ff02::1:2</td>
<td>all DHCP agents</td>
</tr>
<tr>
<td>ff02::1:3</td>
<td>LLMNR</td>
</tr>
<tr>
<td>ff02::101</td>
<td>network time protocol (ntp)</td>
</tr>
<tr>
<td>ff02::1:ffXX::XXXX</td>
<td>Solicited-Node Address</td>
</tr>
<tr>
<td>ff02::2:ff00::/104</td>
<td>Node Information Queries</td>
</tr>
</tbody>
</table>
## Site-Local/variable Scope

<table>
<thead>
<tr>
<th>Address</th>
<th>Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>ff05::2</td>
<td>all routers address</td>
</tr>
<tr>
<td>ff05::fb</td>
<td>mDNSv6</td>
</tr>
<tr>
<td>ff05::1:3</td>
<td>all DHCPv6 Servers</td>
</tr>
<tr>
<td>ff0x::101</td>
<td>network time protocol (NTP)</td>
</tr>
</tbody>
</table>
Source Specific Multicast - SSM

• once a host joins a multicast group it will receive all traffic send from any machine to this group

• this can be misused in open networks

• SSM permits a host to select/deselect one or more multicast sources

• SSM is based on “Protocol Independent Multicast - Sparse Mode” (PIM-SM) and requires MLDv2 (RFC3810)
Multicast with multiple sender
Source Specific Multicast - SSM

Workstation 2001:db8:200::1

Workstation 2001:db8:100::1

Workstation ff05::101

Workstation ff35::101
SSM IPv6 Addresses

- MC: Multicast Control
  - 4 bits of flags = 3
  - 1111 1111
- 0
- PL: Prefix Length
  - 4 bits of scope
- Prefix
- Group ID
  - 32 bits
- Multicast Group
  - 112 bits

- 8 bits
- 8 bits
- 64 bits
- 112 bits
Example SSM IPv6 Address (with unicast prefix)

ff35:0040:2001:db8:100:0:534e:9ff0
Case Studies

- the case-studies look only at site/organization/admin local Multicast

- not global Internet-Multicast

- controlled network like enterprise or university campus networks
DHCPv6

• DHCPv6 is often deployed using relay-agents

  • relay-agents can use unicast or multicast

  • unicast configurations have scalability issues in case of a renumbering of DHCPv6 server or once new DHCPv6 servers are introduced

  • a multicast configuration scales without configuration-changes on the relay-agents
DHCPv6 using an unicast relay

static DHCPv6 relay using 2 unicast addresses

Workstation 2001:db8:200::1

Workstation 2001:db8:100::1

DHCP Server 2001:db8:200::547

DHCP Server 2001:db8:300::547
DHCPv6 using an unicast relay

new DHCPv6 server: all relay agents need a configuration change

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DHCPv6 using an unicast relay

- Workstation 2001:db8:100::1
- DHCP Server 2001:db8:200::547
- DHCP Server 2001:db8:300::547
- DHCP Server 2001:db8:800::547
- Workstation 2001:db8:200::1
DHCPv6 using multicast relay

DHCPv6 relay agent with one multicast address (ff05::1:3)
DHCPv6 using multicast relay

new DHCPv6 server: no configuration change needed

Workstation 2001:db8:200::1

Workstation 2001:db8:100::1

DHCP Server ff05::1:3

DHCP Server ff05::1:3

DHCP Server ff05::1:3
Case-study X11

• XDMCP - finds remote X11 applications (clients)
  • uses broadcast on IPv4
    • inefficient
  • only works in a local subnet
    • workaround: “chooser” machines that need configuration
  • XDMCP can use IPv6 Multicast
X11 and IPv6 Multicast

X11 Chooser provides all remote X11 clients/applications
Case-study NTP

• NTP = Network Time Protocol

• NTP can use IPv6 multicast to distribute time information
  • new time sources can be added at any time without reconfiguration
NTP using Multicast

NTP Client can use all available time sources

Workstation 2001:db8:100::1

Workstation 2001:db8:200::1

NTP Timesource ff05::101

NTP Timesource ff05::101

NTP Timesource ff05::101
Case-study NTP Manycast

• NTP Manycast turns NTP-clients into NTP-Server (or sources)

  • the NTP-Protocol dynamically finds the best (most reliable/most accurate) time sources

• every host is both multicast-client and -server

• the NTP-Jargon calls this “Manycast”
NTP using Manycast

NTP Client selects the best time sources
DNS using IPv6 Multicast

- this is experimental and not an Internet standard
  - more a “hack-that-works”
- don’t confuse with mDNS (Multicast DNS aka Apple Bonjour or Avahi)
- classic DNS communication between Stub-Resolver and DNS caching-server
- solves the problem of client DNS failover:
  - no extra Fail-Over or Load-Balancer necessary
DNS using Unicast

Workstation 2001:db8:100::1

resolv.conf:
nameserver 2001:db8:200::53
nameserver 2001:db8:300::53

caching DNS Server 2001:db8:200::53

caching DNS Server 2001:db8:300::53
DNS using Unicast

Workstation 2001:db8:100::1

resolv.conf:
nameserver 2001:db8:200::53
nameserver 2001:db8:300::53

caching DNS Server 2001:db8:200::53
caching DNS Server 2001:db8:300::53
DNS using Unicast

Workstation 2001:db8:100::1

2001:db8:200::53 TIMEOUT!
DNS using Unicast

Workstation 2001:db8:100::1

caching DNS Server 2001:db8:300::53
DNS using Unicast

Workstation 2001:db8:100::1

Caching DNS Server 2001:db8:200::53

Caching DNS Server 2001:db8:300::53
Classic load-balancer solution
DNS and loadbalancing cluster

• DNS loadbalancing cluster:
  • additional costs
  • higher complexity
DNS using Multicast

resolv.conf:
nameserver ff05::114
nameserver 2001:db8:200::53
nameserver 2001:db8:300::53

[Diagram showing workstation and caching DNS servers connected through multicast]
DNS using Multicast

resolv.conf:
nameserver ff05::114
nameserver 2001:db8:200::53
nameserver 2001:db8:300::53
DNS using Multicast

Workstation 2001:db8:100::1

resolv.conf:
nameserver ff05::114
nameserver 2001:db8:200::53
nameserver 2001:db8:300::53

2001:db8:200::53
ff05::114

caching DNS Server
2001:db8:200::53
ff05::114

caching DNS Server
2001:db8:300::53
ff05::114

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DNS using Multicast

resolv.conf:
nameserver ff05::114
nameserver 2001:db8:200::53
nameserver 2001:db8:300::53

Workstation 2001:db8:100::1

caching DNS Server 2001:db8:200::53 ff05::114

caching DNS Server 2001:db8:300::53 ff05::114
DNS over Multicast - Limits

• Fallback to TCP on large answers (EDNS0 / DNSSEC)

• Security (can be solved with SSM-Multicast)

• look for the “mcdnsProxy” Project
  https://github.com/dnsworkshop/mcdnsProxy
Conclusions

• Multicast can be used to simplify network configuration and designs in IPv6 networks

• knowledge on IPv6 Multicast-Routing is required
  • check on multicast support in your hardware (!)
  • but that is not much harder than IPv6 :)

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Thank you!

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