SAINT 2003 IPv6 Workshop - January 28, 2003

MLDv2 Protocol Design, Implementation and Evaluation for Source-Specific Multicast over IPv6

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Today’s Presentation

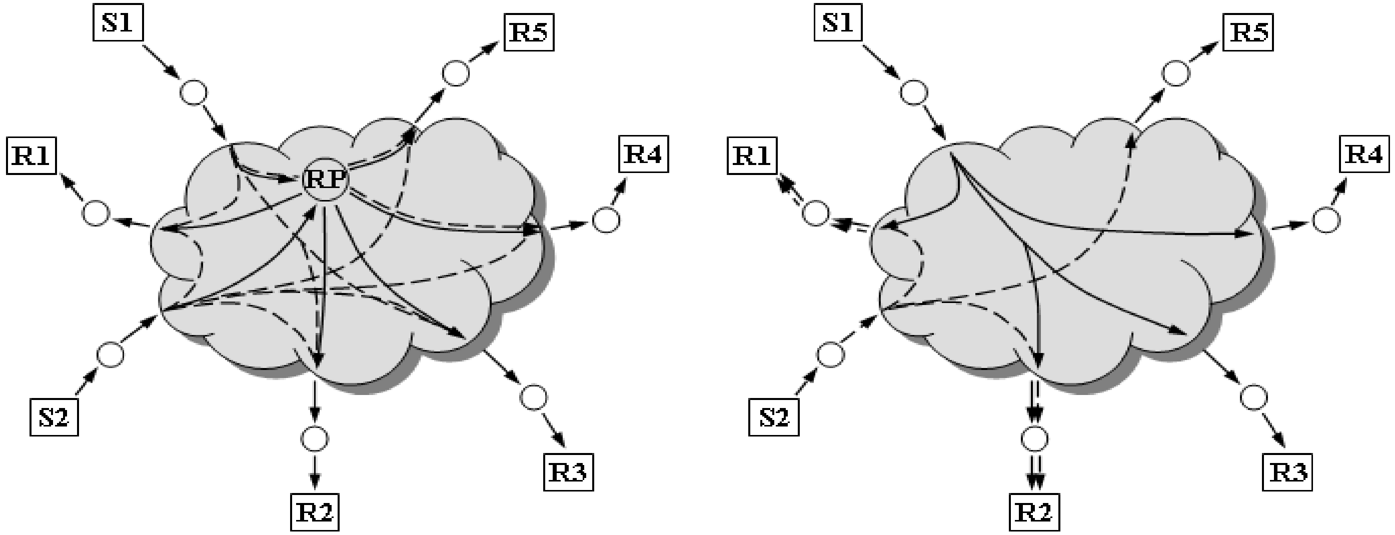
- Source-Specific Multicast (SSM)
- Multicast Listener Discovery version 2 (MLDv2) specification
- Host-side kernel implementaion of MLDv2
  - MSF implementation and its evaluation

Multicast Communication Deployment

- PIM-SM/MSDP/MBGP
  - Current Inter-domain multicast routing protocols for IPv4
  - Any-Source Multicast (ASM) support (aka (*,G) join/leave)
- Scalability
  - 3rd-party dependency problem
  - Traffic concentration problem
  - Flood MSDP Source Active (SA) message
- Complexity
  - Manage both RPT and SPT
  - Need MSDP peer RPF check

Motivation

- If we can construct/maintain only SPT, multicast routing tree becomes pretty simple!



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Source-Specific Multicast (SSM)

- If we consider inter-domain multicast service, ...
  - One-to-many or few-to-many communication model is feasible
  - Each source address can be recognized beforehand
- If each source address is known by each multicast listener, ...
  - SPT can be constructed directly

    → No need to create and maintain RPT

    → RP and MSDP are not required by routing protocols

    → ASM’s complexity and scalability problems are eliminated

Source-Specific Multicast (SSM) is the solution

SSM Deployment

- Host-side implementation
  - Purpose
    - Specification of interesting source address(es) as well as multicast address (aka (S,G) join/leave)
    - Summarizing and reporting (S,G) information
  - Kernel implementation
    - IGMPv3 for IPv4 and MLDv2 for IPv6
    - MSF APIs
  - Application implementation
    - MSF APIs
- Router-side implementation
  - Purpose
    - Translation of reported (S,G) information
    - Constructing SPT from initial phase
  - Routing protocol implementation
    - IGMPv3 for IPv4 and MLDv2 for IPv6

      (Currently, PIM-SSM is only the routing protocol to support SSM architecture)

MLDv2 Specification

- MLDv2 for IPv6
  - draft-vida-mld-v2-06.txt

- Main functions of MLDv2
  - Source address filtering
  - New API -
    IPMulticastListen(socket, interface, multicast-address, filter-mode, source-list)
  - New type of Query and Report message
  - Robustness variable
  - Version compatibility mode
  - New destination address of Report message
  - No Report message surpression mechanism

  etc.

Source Address Filtering

- Filter-mode is either "INCLUDE" or "EXCLUDE"
  - INCLUDE indicates that reception of packets sent to the multicast address is requested only from the specified source addresses.
  - EXCLUDE indicates that reception of packets sent to the multicast address is requested from all source addresses except the specified source addresses.
- Socket state
  - (i, m, filter-mode, source-list)
- Interface state
  - (m, filter-mode, source-list)
  - Initial interface state is (null, INCLUDE, null)

Interface State Transition

- Interface state is calculated as below
  - If all sockets request a filter-mode of INCLUDE, then interface state is INCLUDE with the union source lists.
  - If any sockets request a filter-mode of EXCLUDE, then interface state is EXCLUDE with the intersection of all EXCLUDE source lists subtracting the union of all INCLUDE source lists.

- Action on change of interface state

Old State	New State	State-Change Record Sent
INCLUDE(A)	INCLUDE(B)	ALLOW(B-A), BLOCK(A-B)
EXCLUDE(A)	EXCLUDE(B)	ALLOW(A-B), BLOCK(B-A)
INCLUDE(A)	EXCLUDE(B)	TO_EX(B)
EXCLUDE(A)	INCLUDE(B)	TO_IN(B)

Multicast Source Filter (MSF) APIs

- Socket Interface Extensions for Multicast Source Filters
  - draft-ietf-magma-msf-api-03.txt

- Used to change a socket state
- Basic API
  - Used with setsockopt()
  - Used to join/leave a single channel
- Advanced API
  - Used with ioctl()
  - Used to join/leave a single or multiple channel(s), e.g., ((S1,S2,S3),G1)
  - Used to change a filter-mode of socket state without leaving joined channel

Basic API Usage

- A part of a sample application code

```
bcopy(&grp, &gsr.gsr_group, grp.sin6_len);
bcopy(&src, &gsr.gsr_source, src.sin6_len);

if (setsockopt(socket, IPPROTO_IPV6, MCAST_JOIN_SOURCE_GROUP,
                (char *)&gsr, sizeof(gsr)) < 0)
      perror("cannot listen group");
```

Advanced API Usage

- A part of a sample application code

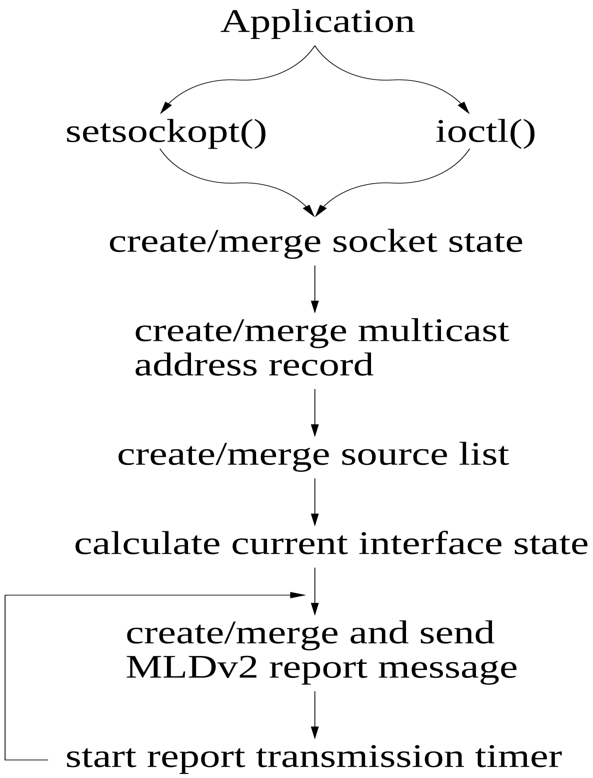
```
if ((gf = malloc(GROUP_FILTER_SIZE(numsrc))) == NULL)
      perror("memory allocation error");

bzero(gf, GROUP_FILTER_SIZE(numsrc));
gf->gf_interface = index;
gf->gf_fmode = mode;
gf->gf_numsrc = numsrc;
bcopy(&grp, &gf->gf_group, grp.sin6_len);
for (i = 0; i < numsrc; i++)
      bcopy(&src[i], &gf->gf_slist[i], src[i].sin6_len);

if (ioctl(socket, SIOCSMSFILTER, gf) != 0)
      perror("cannot listen group");
```

MSF Kernel Implementation

- Socket state migration and interface state transition
- State-Change report transmission


Application
setsockopt()
ioctl()
create/merge socket state
create/merge multicast address record
create/merge source list
calculate current interface state
create/merge and send MLDv2 report message
start report transmission timer

Source Address Comparison

- Linear search algorithm
  - Advantage
    - Easy to understand the logic
    - Easy to maintain the code
  - Disadvantage
    - May cause low performance if the number of source addresses is highly increased

      → It is quite rare that so many multicast applications use a same multicast address for each different channel.

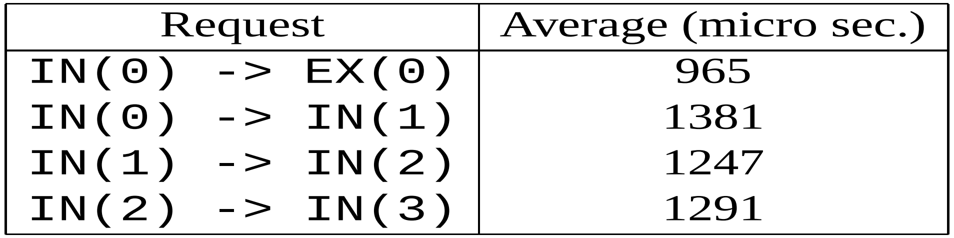
      e.g., (S1,G1), (S2,G1), (S3,G1), ... (S1000,G1), ...

Implementation Evaluations

- Evaluation on NetBSD-current (1.6I)
  - 1GHz Pentium III PC with 512MB memory
- Conditions are ...
  - The number of sampling data is 100 for each request
  - Multicast address - fixed
  - Source address - randomly created

Average Response Time of Basic API

- E.g., Request to change INCLUDE with null source address to INCLUDE with one source address
- Response time is proportional to the number of source addresses of the list



Request	Average (micro sec.)
`IN(0) -> EX(0)`	965
`IN(0) -> IN(1)`	1381
`IN(1) -> IN(2)`	1247
`IN(2) -> IN(3)`	1291

Average Response Time of Advanced API

- Advanced API requires complex implementation
  - Need source address validation/duplication check before merging source address list etc.
  - First entry shows an initial INCLUDE join request in which five source addresses were specified.
  - Second entry and third entry are for the same request, but third one uses Basic API

Request	Average (micro sec.)
IN(0) -> IN(5)	2256
IN(5) -> EX(1)	1637
IN(5) -> EX(1)(*)	1512

Available MLDv2 Implementations

- Kernel
  - NetBSD-current
    - http://www-sop.inria.fr/planate/Hitoshi.Asaeda/mldv2
    - IGMPv3 implementation is prerequisite
      (Enabling IGMPv3 is NOT required.)
  - FreeBSD-4.7, NetBSD-1.6, OpenBSD-3.2
    - http://www.kame.net
- Router
  - pim6sd
    - ftp://ftp.kame.net/pub/kame/misc
  - Hitachi GR2000
    - http://www.internetworking.hitachi.com
  - 6Wind
    - http://www.6wind.com
- Applications and utilities
  - mcastread
    - http://www.kame.net

Thank you.