Hierarchical PathQoS on a QoS-based Multicast Protocol SRSVP

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Background

- Key technologies for the next-generation Internet
  - Quality of Service
  - **Scalable Multicasting**
- Application of multicasting
  - Internet Broadcasting
    - Pay-per-View TV
  - Per-flow QoS is needed
IP Multicasting

- Sender transmits one packet, and intermediate routers duplicate it.
  - Efficient use of bandwidth
- Existing multicast routing protocols are
  - DVMRP, MOSPF, PIM,…
- All these are
  - best-effort, no QoS
  - Poor in scalability
IP Multicast + QoS

- The “Leaf-initiated Join” Problem
  - How a leaf receiver collects knowledge about the already constructed multicast tree for the target flow?
A Case Study

- Receiver R wants to join a flow transmitted by sender S (multicast),
- And at the same time wants to keep bandwidth of 5Mbps from S to R (QoS)
- How to choose a path from S to R?
Approach 1

- Receiver R collects no knowledge about the multicast tree of the flow,
  - R does not know where the existing multicasting tree has reached.

- There looks no path that can assure 5Mbps bandwidth.

ATM Forum’s P-NNI v.1
Approach 2

- Receiver R have complete information about the existing multicast tree.

- R can choose the shortest path to the tree
  - Efficient utilization of bandwidth

QOSPF (Internet Draft)
Each router always floods information about multicast flows

- Broadcast is done at each change of the state of a flow
- Poor Scalability
  - Large-scale network, or
  - A number of flows
Receiver R collects flow-specific information partially about the multicast tree, when it is needed.
- Query is done along the best-effort route.
Then R computes and chooses a route that can guarantee the required bandwidth

- This path consumes more resource than the path by Approach 2, but can find a route with 5Mbps bandwidth
Our Framework for QoS Multicast Routing

- **HQLIP**
  - QoS-based unicast routing protocol
  - An extension of OSPF with QoS
  - Hierarchical networks with multiple levels of areas.

- **SRSVP**
  - QoS-based multicast routing protocol
  - Integration of RSVP (resource reservation) and PIM-SM (multicast routing)
  - Collects flow-specific information via PQ

**In this work**
- Collecting PQ on a hierarchical network
PQ

- PQ (Path QoS)
  - Flow-specific precise QoS information on links along a path
- PQ Collection
  - Each router sends a signaling Path message with adding PQ
  - Receiver calculates a QoS route using QoS route information, originally by HQLIP and modified via PQ.
R requests S Path message for a multicast flow
Hierarchical Network

- **Area** – is a substitution of several routers
  - Area conceals the routers inside and the topology among them
    - OSPF (2 layers),
    - P-NNI, **HQLIP** (multiple layers)

- **Routing among areas**
  - on large-scale networks
Hierarchy in HQLIP

Areas of Level 0  Areas of Level 1
Hierarchical Routing in HQLIP

• First computes a sequence of areas from the destination to the source

• Next computes a sequence of sub areas in the last area

• Repeat this recursively
Co-operation of SRSVP and HQLIP

In order to make SRSVP work on hierarchical network operated by HQLIP, we need PQ among areas (Hierarchical PQ), instead of PQ among routers.
Hierarchical PQ

- When a Path message is going out of area B, the border router of B generates PQ(B←A), where A is the previous-hop area of B.
Example of Generating Hierarchical PQ

Link-state information by HQLIP

PQ
Example of Generating Hierarchical PQ (cont.)

Link-state information by HQLIP

PQ
Cases in PQ Generation Process

PQ from area A to B

- **Case 1**
  - Levels of the both areas is 0

- **Case 2**
  - B is Level 0, and
  - A is Level 1 or greater

- **Case 3**
  - Both A and B are Level 1 or greater
Details of the algorithm

- The processes for Case 3 are repeated as many times as the number of areas the path goes out from at the router.
  - In each process, the previous-hop area, from which the Path message comes from, must be investigated for each area the path goes out.

```
AB PQ(B ← A)
PQ(B2 ← B1)
```

```
PQ  PQ  PQ  PQ  PQ  ...
```

Path message

Scanned every time
Improvement

- Each router can find all previous-hop areas by scanning the Path message only once, from tail to head.

Generation of \(PQ(B \leftarrow A)\)  Generation of \(PQ(B2 \leftarrow B1)\)

\(\triangledown\) scan \(\triangledown\) scan

\[
\begin{array}{cccccccc}
  PQ & PQ & PQ & PQ & PQ & PQ & PQ & \ldots \\
\end{array}
\]

\(\triangledown\): Generation of Hierarchical PQ
Implementation

- SRSVP+HQLIP daemon – RICD.
- Hierarchical PQ Collection is implemented on RICD code.
Summary

- Design of an algorithm for computing hierarchical PathQoS collection
- Implementation on a SRSVP+HQLI P daemon