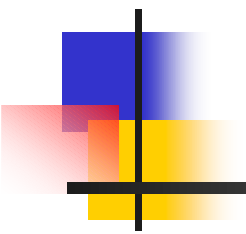
Hierarchical PathQoS on a QoS-based Multicast Protocol SRSVP



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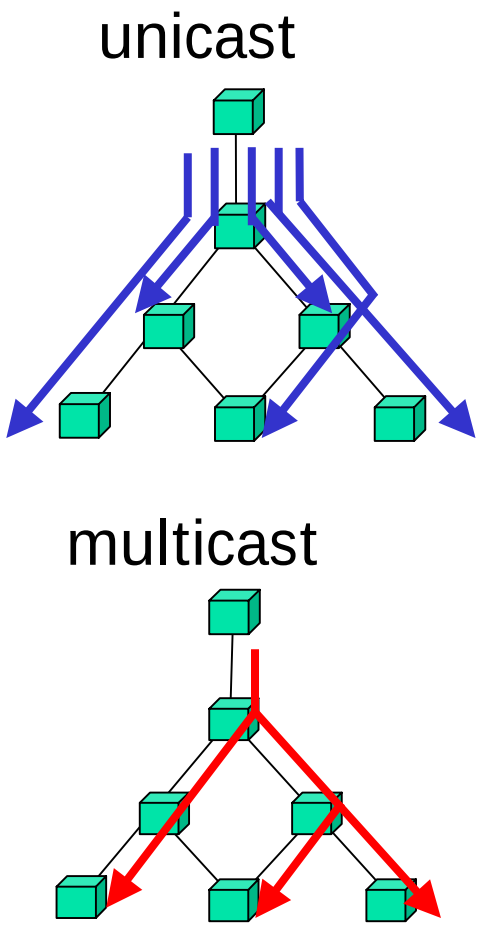
Background

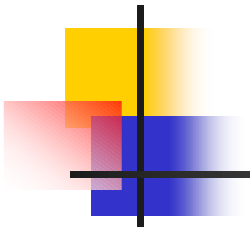
- Key technologies for the next-generation Internet
  - Quality of Service
  - **Scalable Multicasting**
- Application of multicasting
  - Internet Broadcasting
    - Pay-per-View TV

⇨ 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



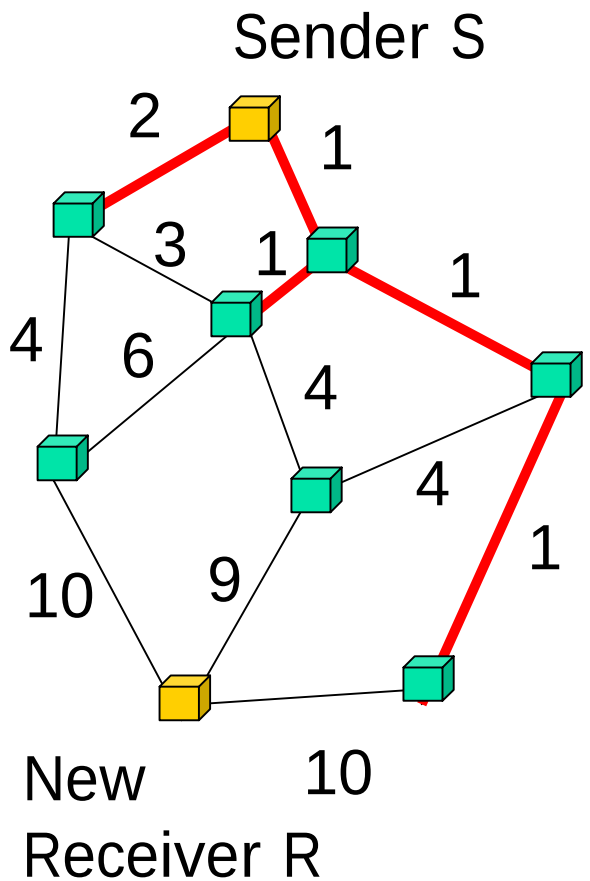


IP Multicast + QoS

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

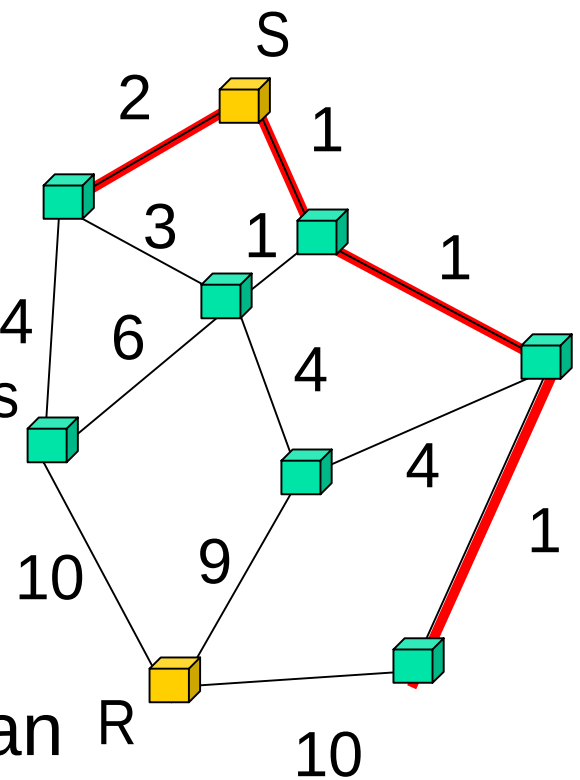
A Case Study

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



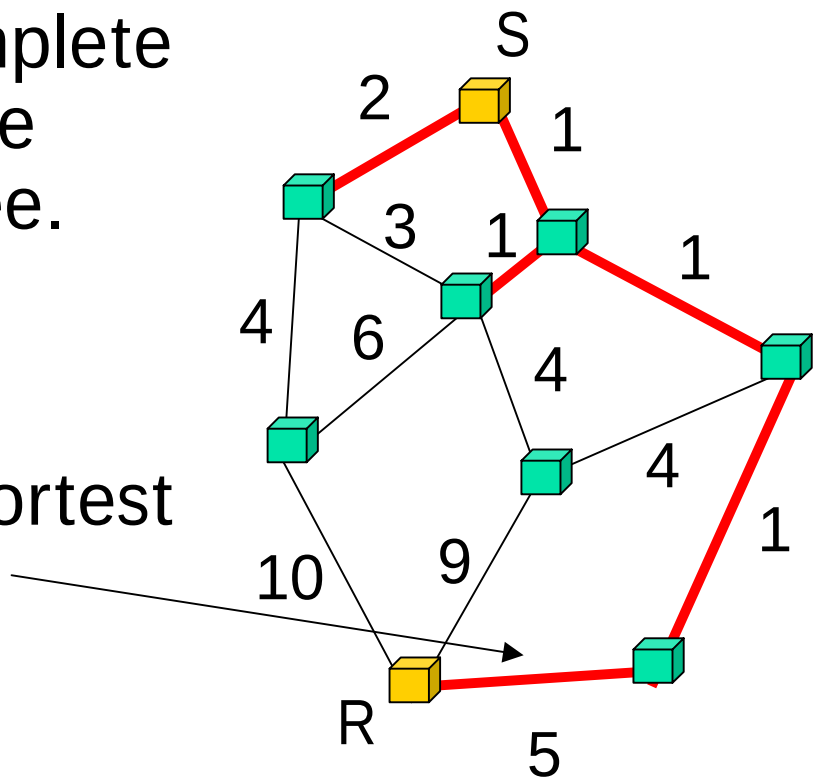
- There looks no path that can assure 5Mbps bandwidth.

ATM Forum's P-NNI v.1

Approach 2

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

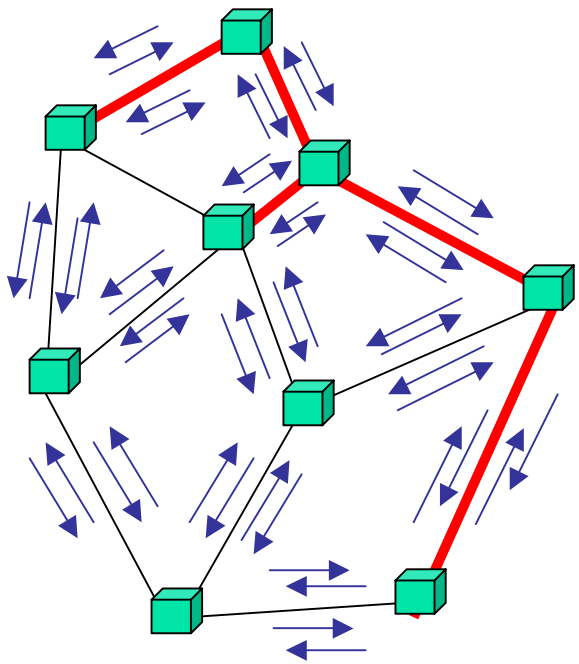
- R can choose the shortest path to the tree
  - Efficient utilization of bandwidth



QOSPF (Internet Draft)

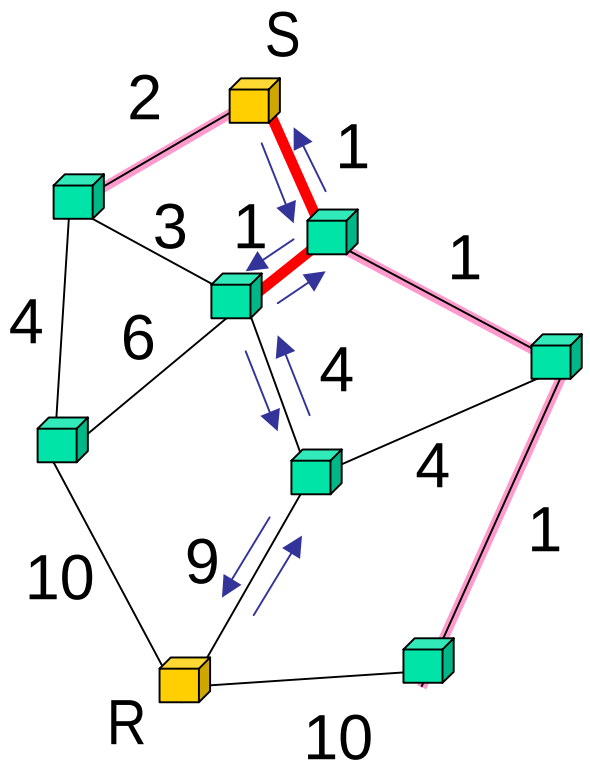
Week Point in Approach 2

- 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



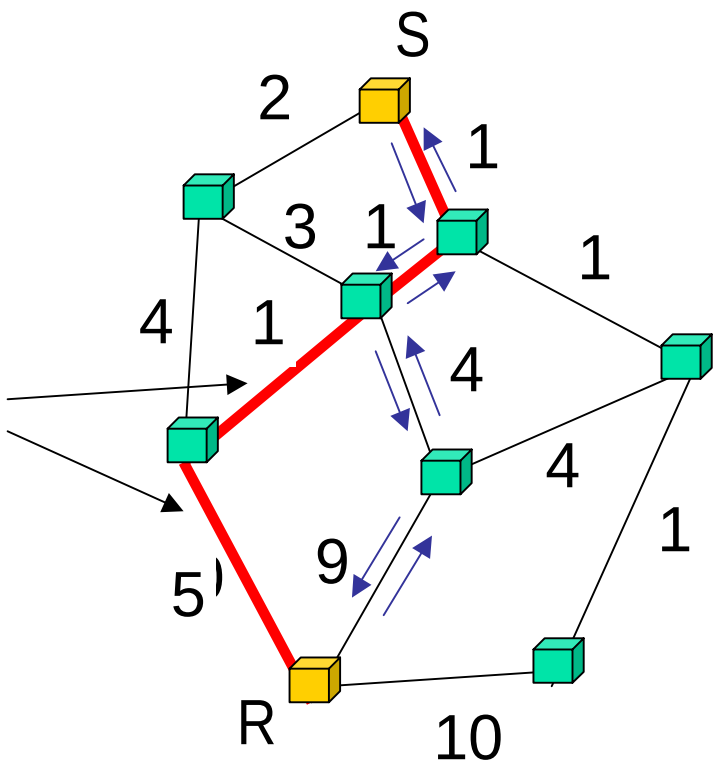
PQ (PathQoS) [Goto, Inet97]

- Receiver R collects flow-specific information partially about the multicast tree, when it is needed.
  - Query is done along the best-effort route.



PQ (PathQoS)

- 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

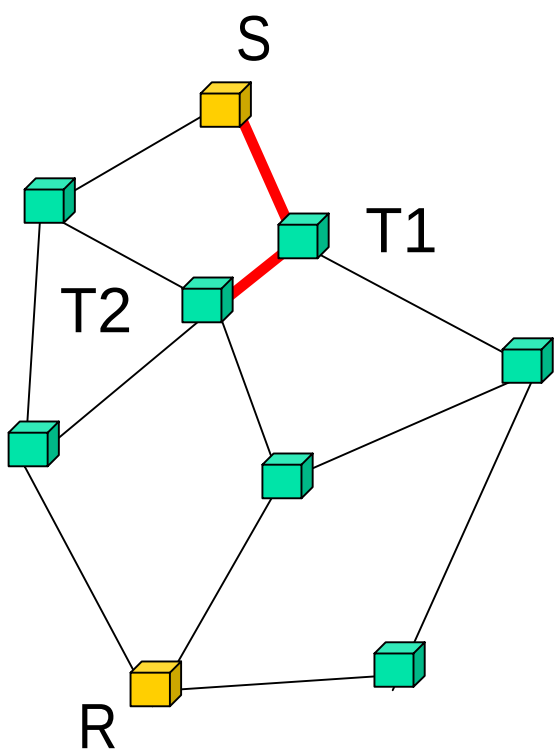


Our Framework for QoS Multicast Routing

- 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

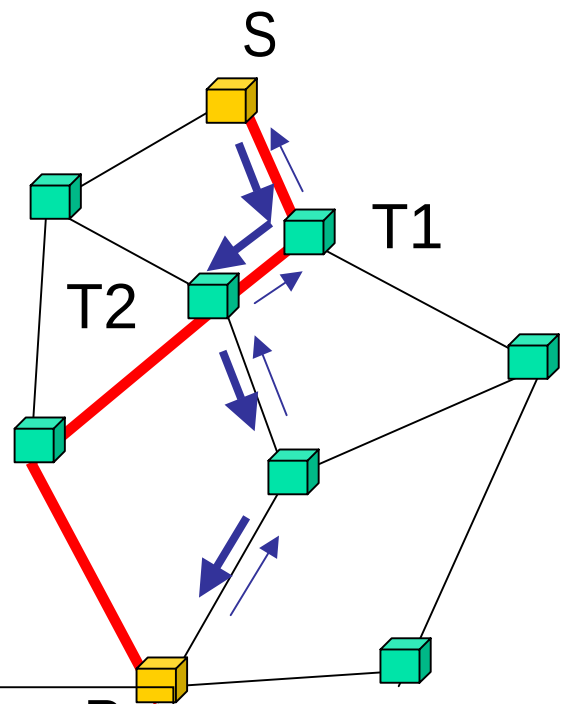
- PQ (Path QoS)
  - Flow-specific precise QoS information on links along a path
- PQ Collection
  - Each router sends a signaling Path message with adding PQ
  - Receiver calculates a QoS route using QoS route information, originally by HQLIP and modified via PQ.



PQ Collection

Path message

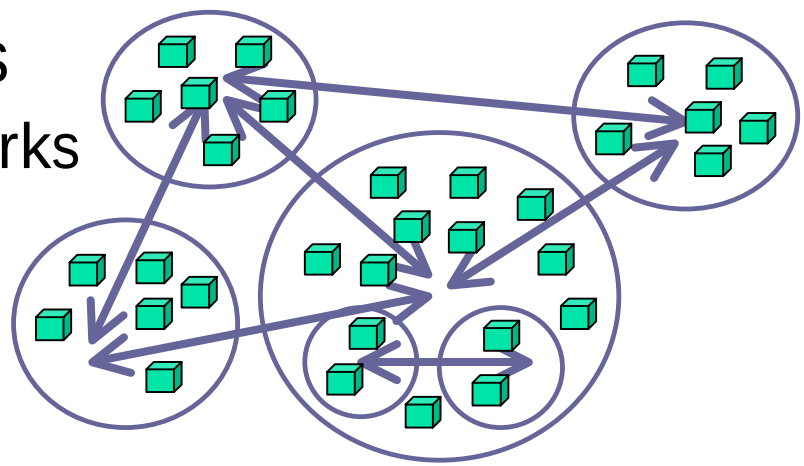
	PQ(T1←S)	
	PQ(T1←S)	PQ(T2←T1)
	PQ(T1←S)	PQ(T2←T1)
	PQ(T1←S)	PQ(T2←T1)



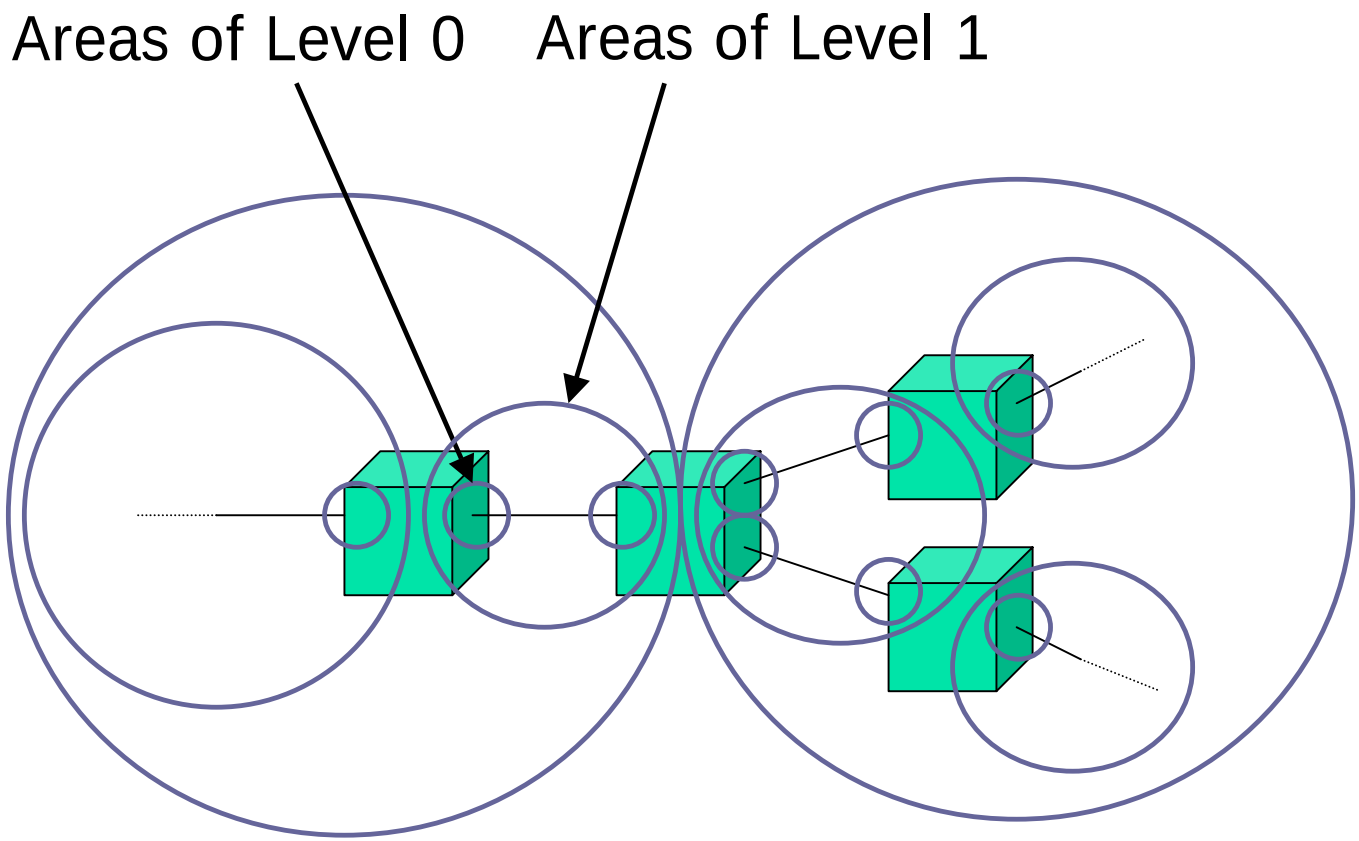
R requests S Path message for a multicast flow

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

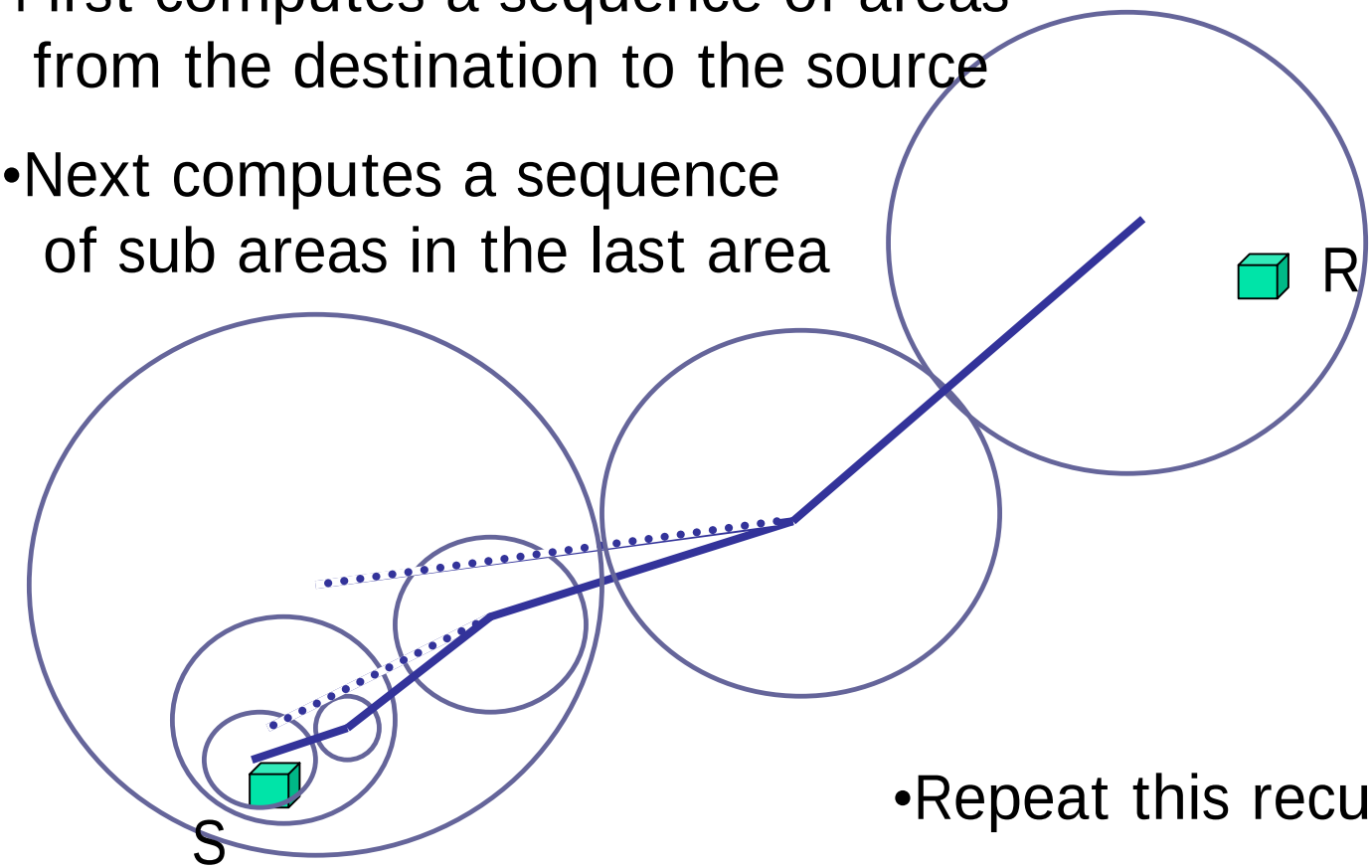


Hierarchy in HQLIP



Hierarchical Routing in HQLIP

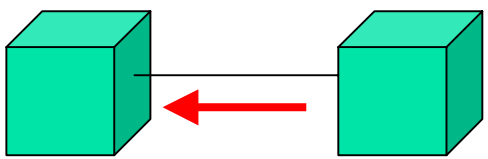
- First computes a sequence of areas from the destination to the source
- Next computes a sequence of sub areas in the last area



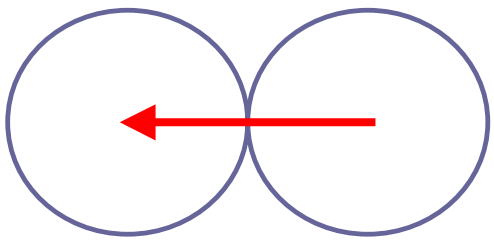
- Repeat this recursively

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



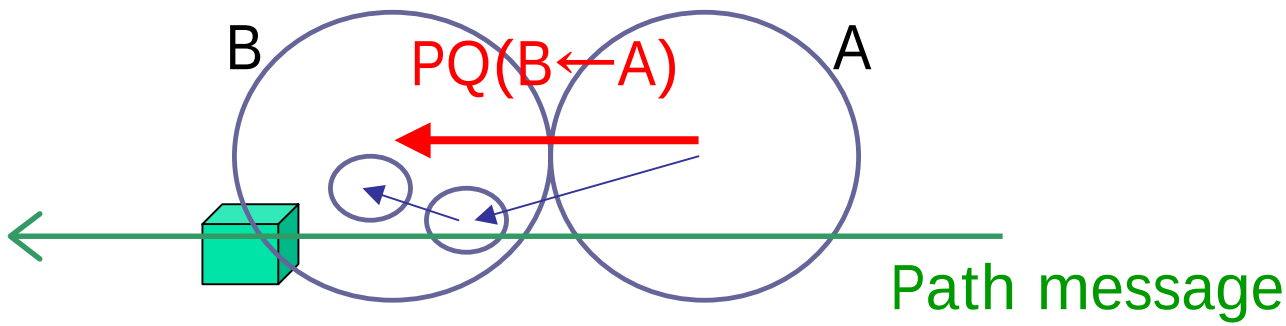
Original PQ



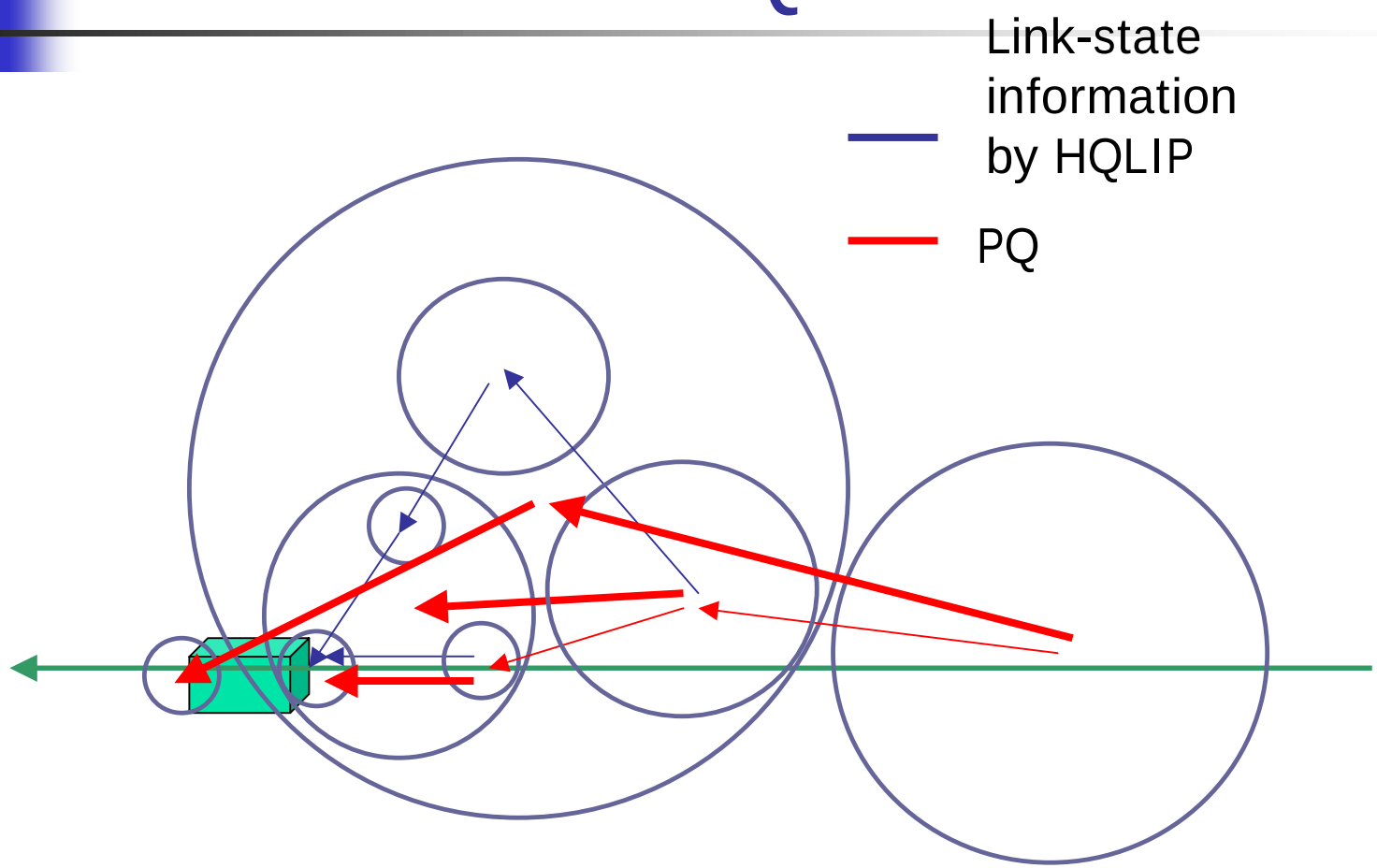
Hierarchical PQ

Hierarchical PQ

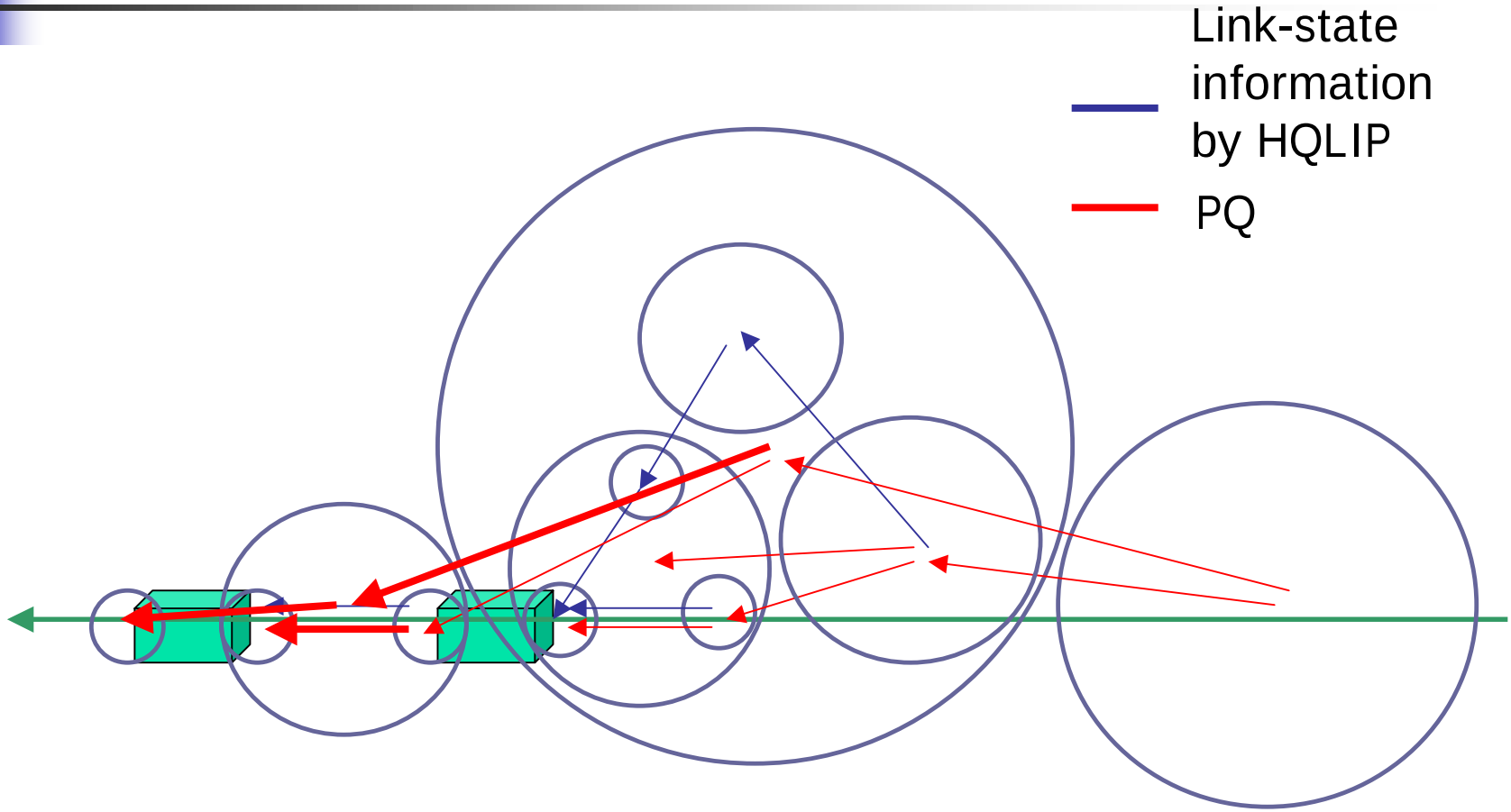
- When a Path message is going out of area B, the border router of B generates PQ(B←A), where A is the previous-hop area of B



Example of Generating Hierarchical PQ



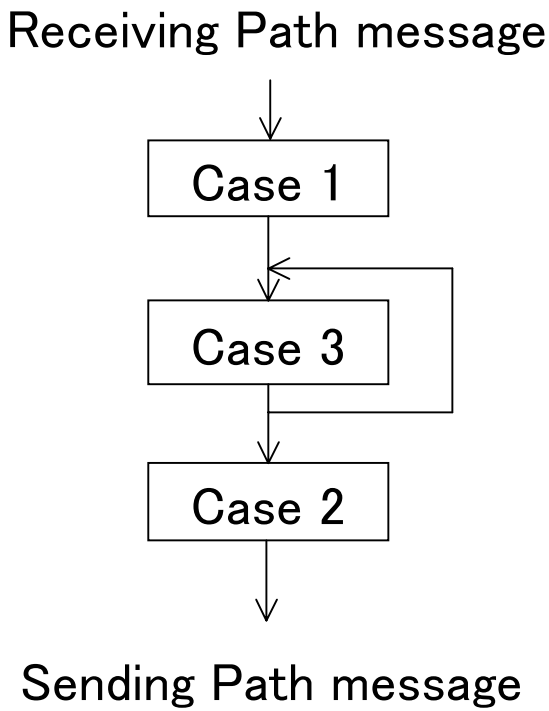
Example of Generating Hierarchical PQ (cont.)



Cases in PQ Generation Process

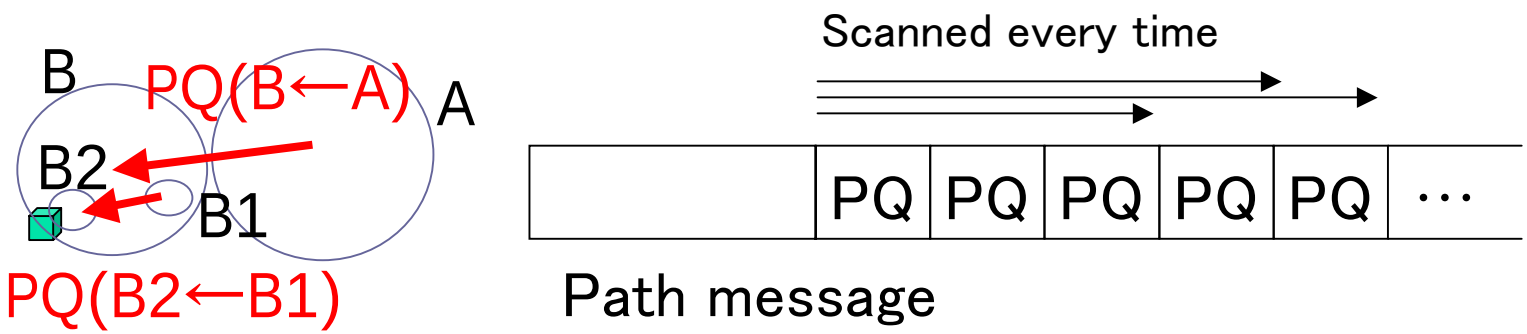
PQ from area A to B

- **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



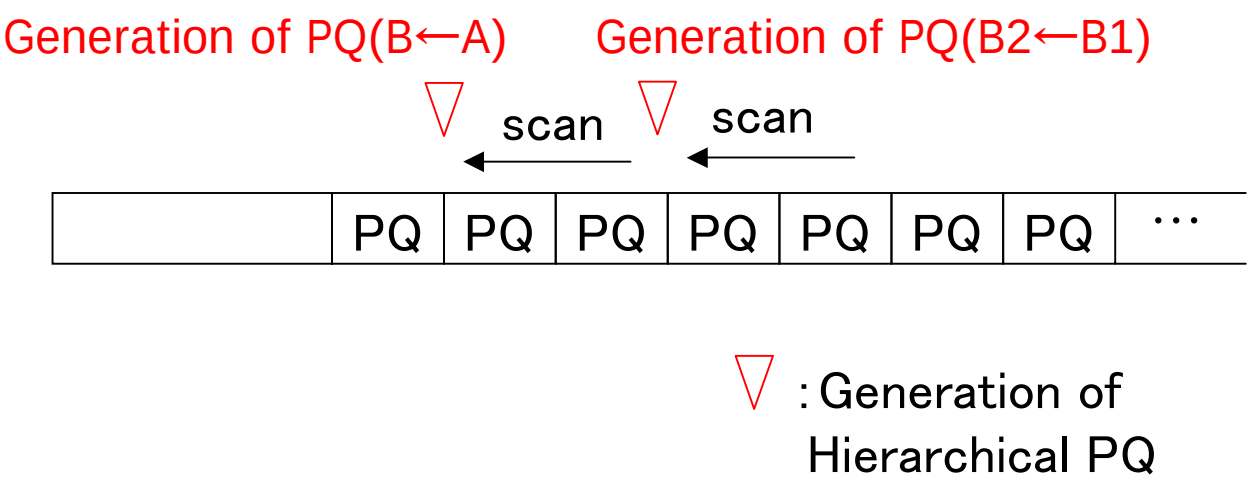
Details of the algorithm

- 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 .



Improvement

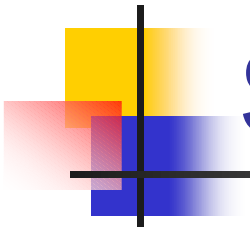
- Each router can find all previous-hop areas by scanning the Path message only once, from tail to head.



Implementation

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

```
sekiguch@kifune$ telnet localhost 7096
Trying 127.0.0.1...
Connected to localhost.
Escape character is '^]'.
…
RICD> show pathqos
…
PQ:
 0:10.0.0.1      ->  0:10.0.0.2  7100    1000
 0:10.0.0.10     ->  2:10.0.0.0  4000    0
 0:10.0.0.10     ->  0:10.0.0.9  7100    1000
 1:10.0.0.8      ->  2:10.0.0.0  4000    0
…
```



Summary

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