

QoS-Based Routing Framework

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Goals

- Define QoS R terminology precisely (minor)
- Describe pertinent QoS R issues
- Develop QoS R requirements
- Develop consensus on QoS R capabilities
- Facilitate the development of a high-level architecture that encourages innovative solutions

Updates to the Previous Version

- Further emphasis on the separation of intra and interdomain routing
- Further description of the interdomain routing model
- Expansion of the “issues” section
- Re-organization of the draft

Basic QoS Assumptions

- IP flows (unicast and multicast) with QoS requirements
- Signaling mechanism to indicate flow QoS to routers (explicit or implicit)
- QoS management capabilities in routers

Broad QoS Issues

- Routing information generation and propagation
- Path metrics
- Path computation (unicast and multicast)
- Path establishment and maintenance (unicast and multicast)
- Flow granularity and aggregation
- Higher level admission control
- Administrative control

QoS R Possibilities

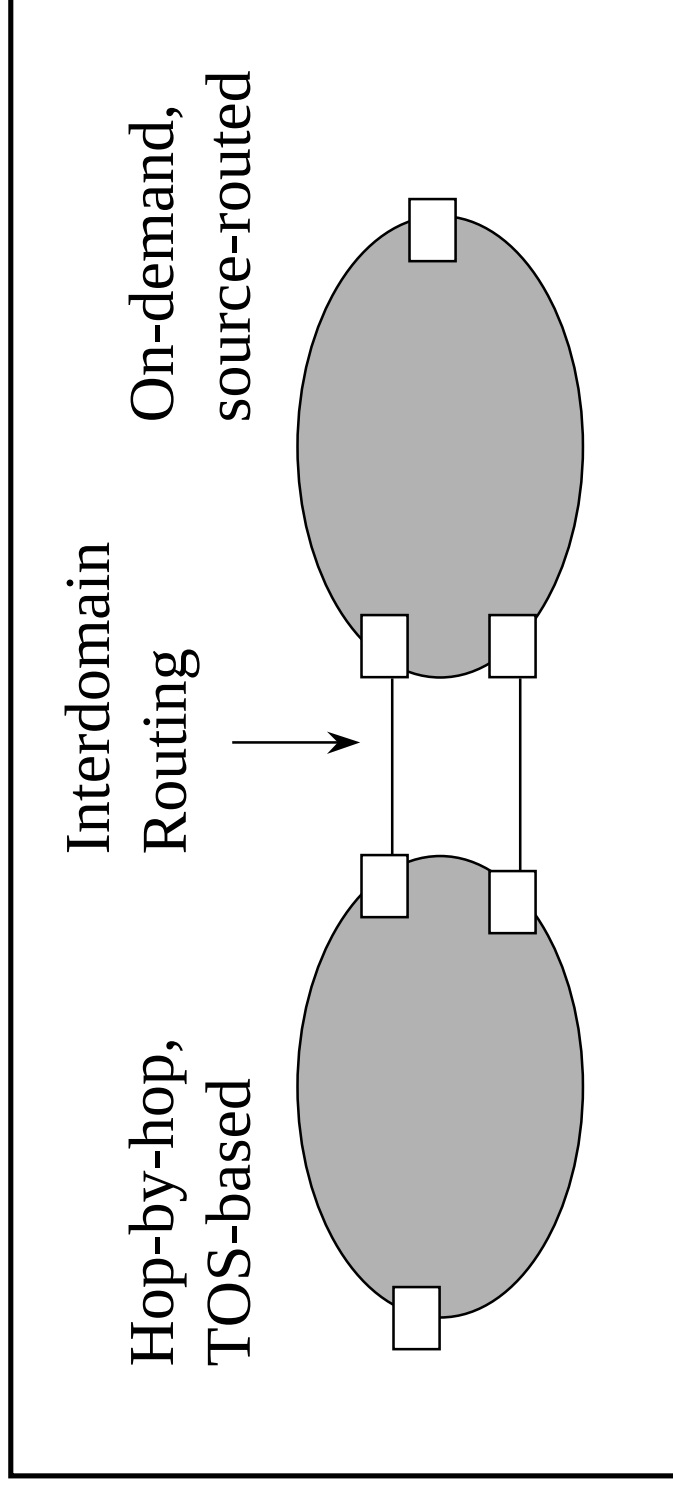
- On-Demand source routing
- Hop-by-hop QoS-based routing
- TOS-based routing
- Etc.

Suggested Approach

- Intra and Interdomain routing (extension of the present model)
- Independent intradomain routing solutions:
 - Extensions to OSPF, etc.
 - New solutions
- Scalable interdomain QoSR architecture with simple, consistent and stable interactions between domains.

What This Means

- Minimal requirements on intradomain routing
- Flexibility for developing intradomain solutions
- Focus on interdomain routing



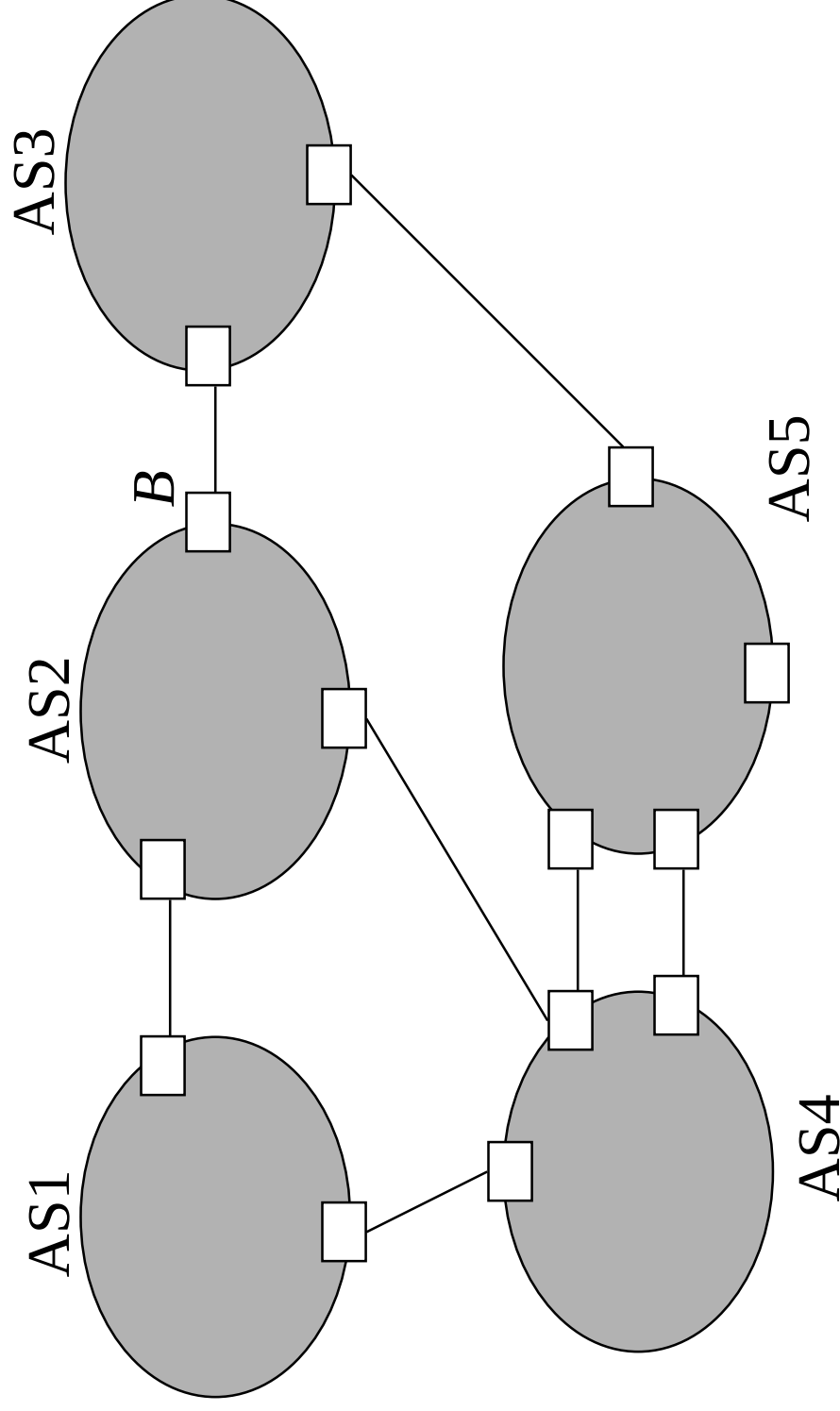
Intradomain Routing Requirements

- Flow routing along a QoS-accommodating path
- Indication when QoS cannot be satisfied
- Indication of disruptions to the flow path
- No signaling requirements for best-effort flows
- Optional support for QoS-based multicast with heterogeneous receivers and shared reservation
- Recommended capabilities:
 - Optimization of resource usage
 - Higher-level admission control
- Etc.

Interdomain Routing

- Goal:
 - Simple and stable interactions between domains
 - Routing complexity delegated to intradomain routing
 - “Sufficient” information exchanged between domains to support defined capabilities

Interdomain Routing Model



Some Interdomain Routing Issues

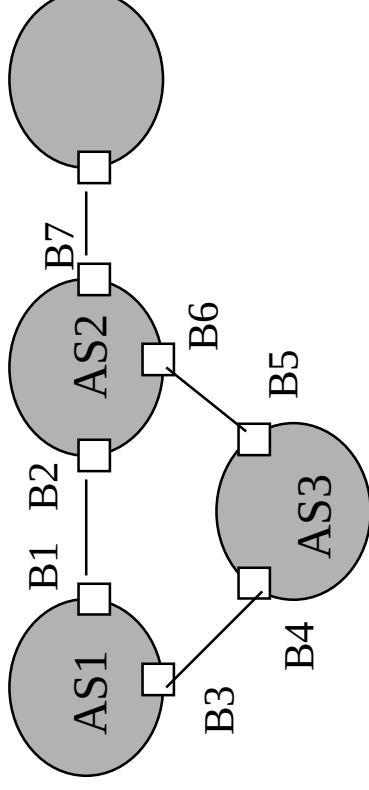
- Interdomain routing capabilities
- Nature of interdomain routing information
- Routing metrics
- Interdomain path computation
- Policy controls
- Flow aggregation
- Multicast routing

Interdomain Routing Capabilities

- Determination of reachability
- Loop-free flow routes
- Routing information aggregation
- Determination of path QoS. QoS advertised by a given domain should be stable. Flow aggregation when needed
- Optionally, determination of multiple paths based on QoS
- Expression of routing policies, including cost, as a function of flow parameters and administrative factors
- Etc.

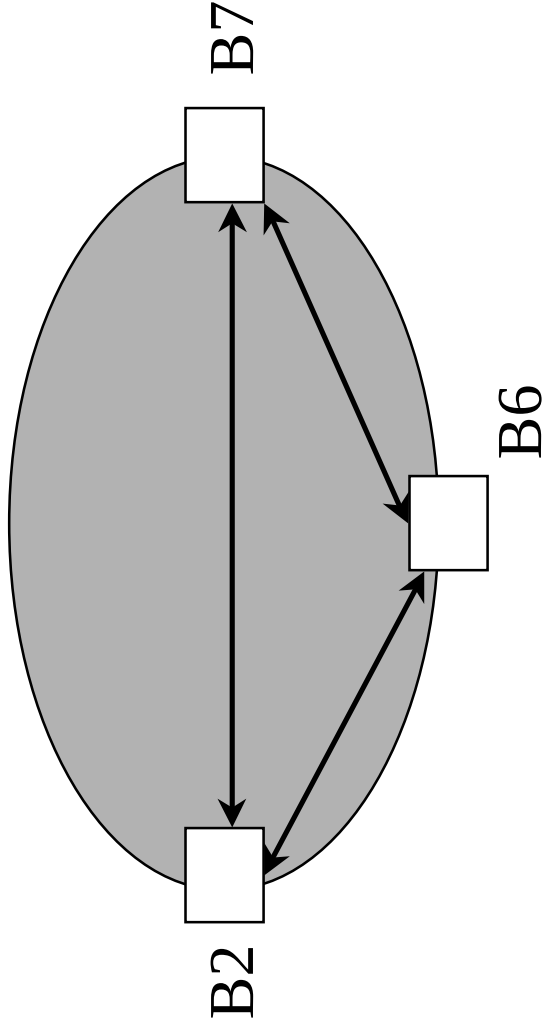
Path QoS

- Path metrics composed of “AS metrics”
- AS metrics should be relatively static; may be based on engineered QoS for transit flows
- E.g., B2 and B6 may utilize different AS metrics for paths advertised to B1 and B5, respectively



AS Path QoS

- Within AS2, engineered resources of the “virtual path” between border nodes may be used for computing advertised path QoS.



AS Metrics

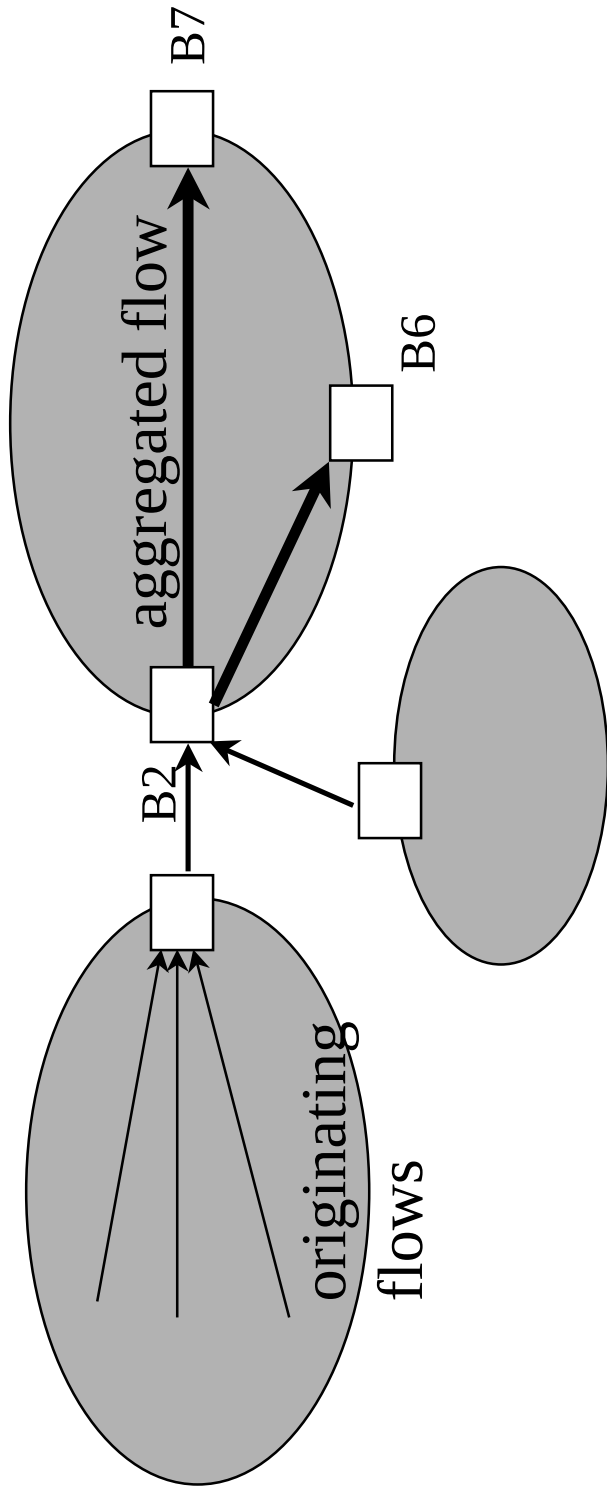
- Engineered bandwidth
- Expected delay
- Routing cost
- Etc.
- Metric composition rules may mean maintenance of multiple paths for each destination
- Metrics should change relatively infrequently
- Path computation may also be subject to policies

Link and AS Metrics

- Definition, representation and interpretation of metrics
 - Encoding of max, min, range and granularity
 - Definition of comparison and accumulation operations
 - Definition of triggers

Flow Aggregation

- Border routers may aggregate “individual” flows so that they are not visible inside a transit AS



Aggregation (Contd.)

- How?
- Is aggregation possible for all QoS types?
- Relationship to signaling?
- Implications on resource management inside an AS?

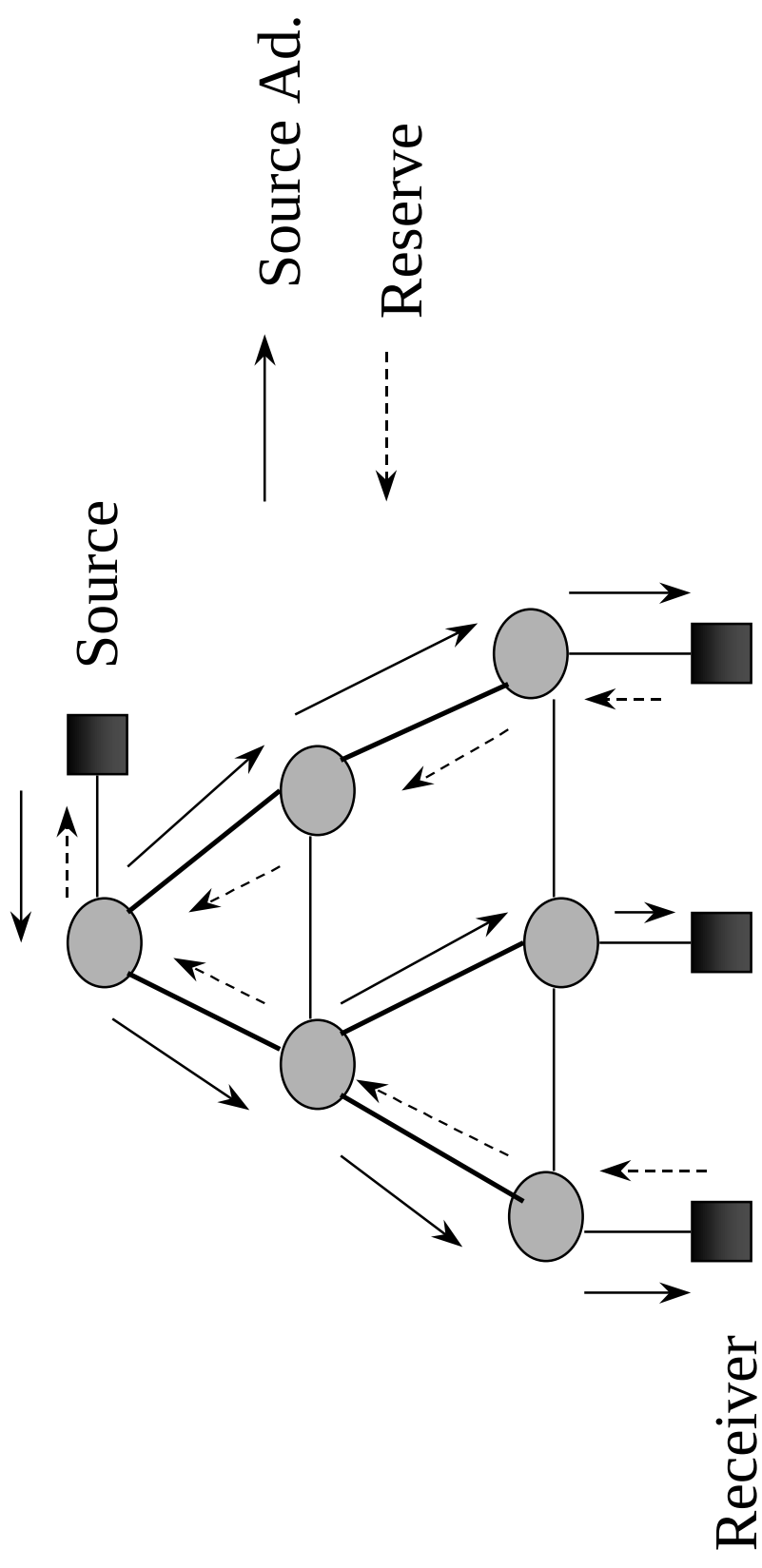
Path Cost Determination

- How to support accounting based on QoS requirements of a flow (or aggregated flows?)
 - Cost as a routing parameter
 - Consistent interpretation of cost across domains
- Correlation of cost with the QoS actually delivered

Multicast Routing

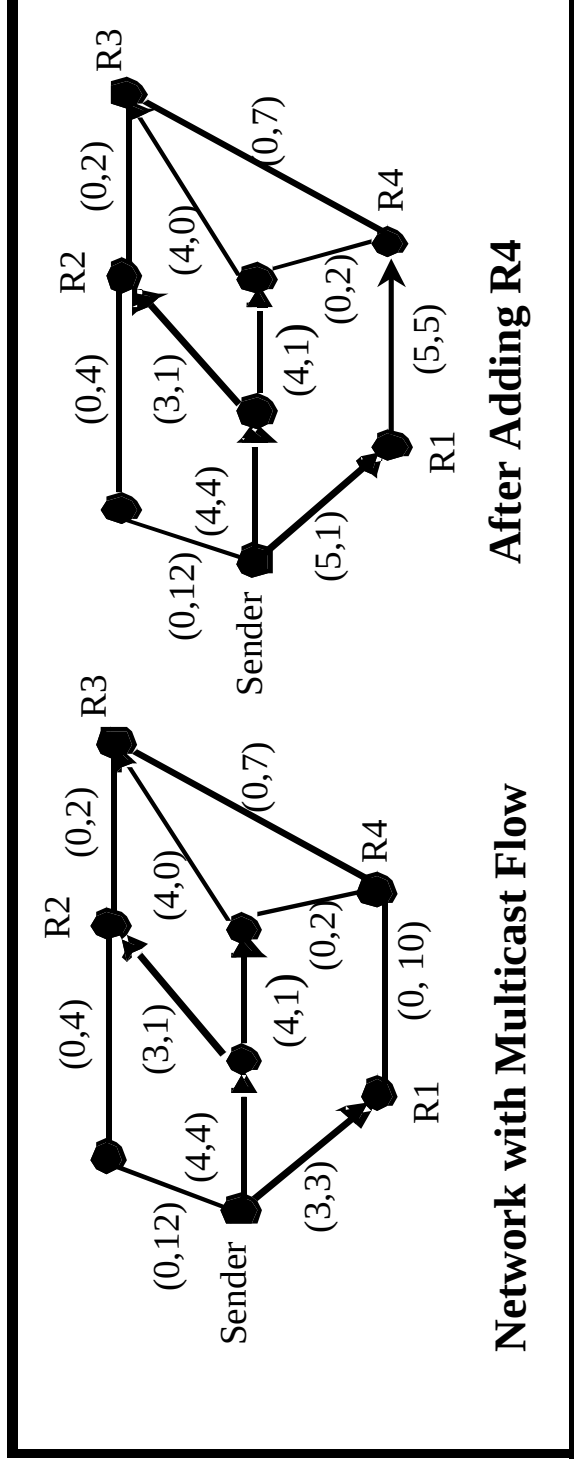
- Goals
 - Scalability to large groups with dynamic membership
 - Robustness
 - Support for receiver initiated, heterogeneous reservations
 - Support for shared reservation styles
 - Higher-level admission control

Multicast Flow Model



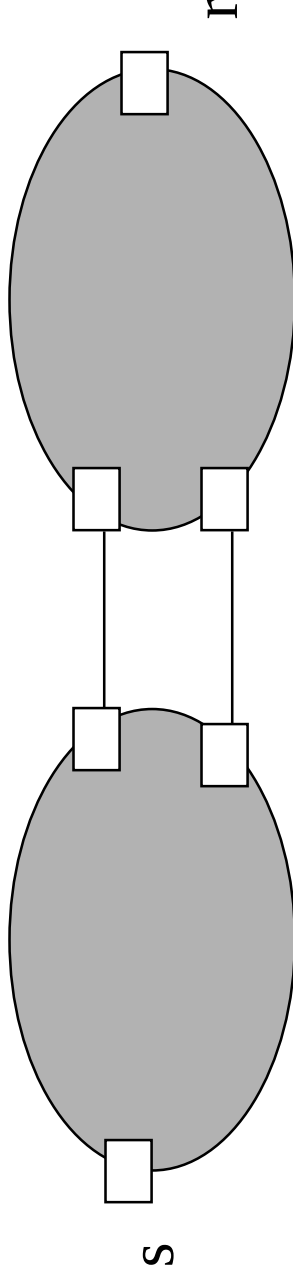
Scalability of Multicast Routing

- QoS-based multicast routing requires flow-specific knowledge to add new receivers



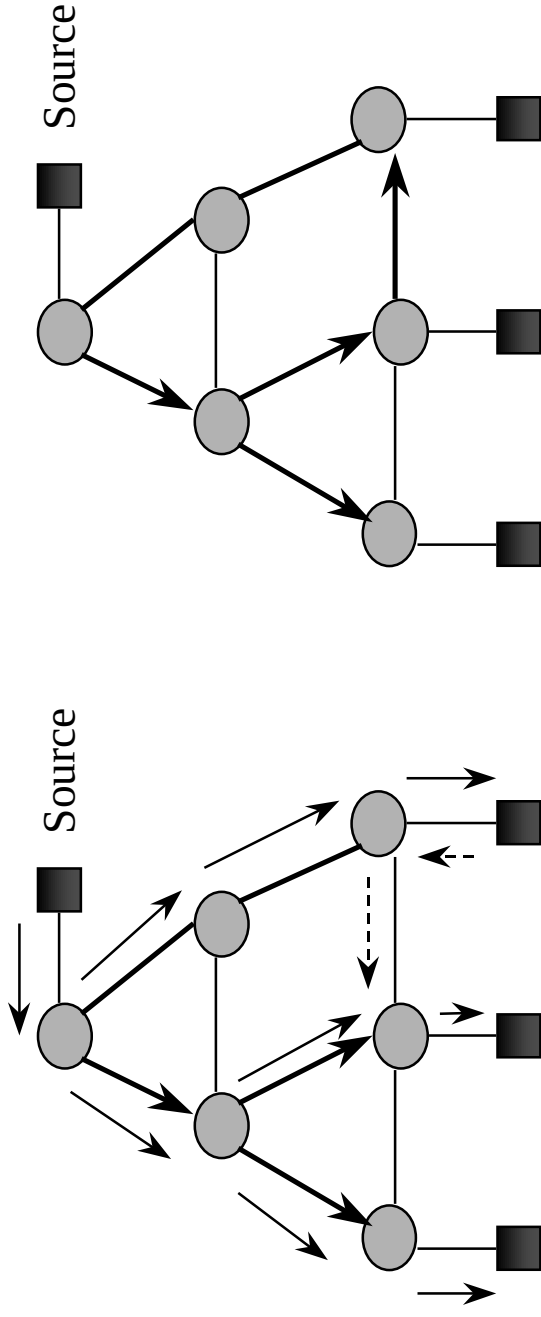
Multicast Source Routing

- Source switch determines flow path based on source and receiver locations
- Reserve messages flow in the reverse path. Actual resource allocation adjusted based on reservations
- Requires link state routing with flow-specific information.
- Compatible with RSVP, but not clear how this works in the interdomain case



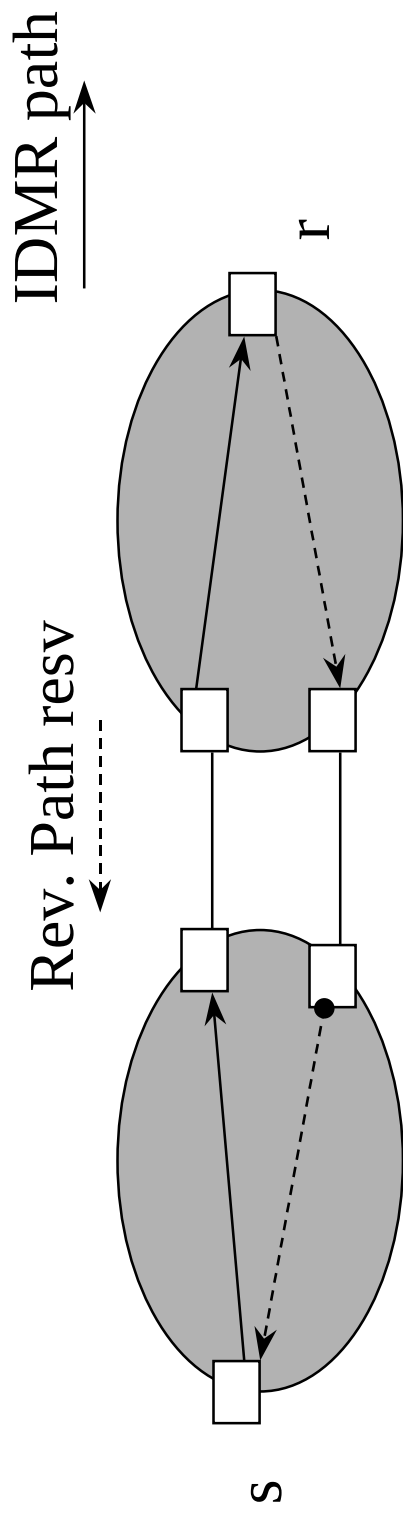
Receiver-Oriented Multicast Routing

- Source advertisements over best effort path →
- Independent reverse path computation by receivers ←-----
- Local merging



Receiver-Oriented Multicast Routing

- Multicast path computation broken up into several unicast reverse path computations
- Scalable, does not require flow-specific info.
- Natural extension to interdomain routing



Routing and Signaling

- Routing - Signaling interface:
 - Flow identification
 - Routing requests
 - Failure indications
- Signaling cannot be designed independent of routing
- Signaling can be explicit (e.g., RSVP) or implicit (e.g., bits in the data packet)

Summary and Conclusions

- There are many QoS issues
- A two-pronged approach, with a simple and stable interdomain routing, and more dynamic and “loosely” regulated intradomain routing suggested
- Receiver-oriented multicast routing has the advantages of scalability and straightforward interdomain operation, but RSVP unfriendly
- Definition of link and path metrics requires considerable thought.
- Cost as a routing parameter should be considered