Resource Reservation and Routing: Requirements, Interactions, Interfaces

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- Lots of input from other rsvp, int-serv folks

Introduction

- Routing and Reservation protocols interact
  - Routing distributes Reservation requests to appropriate routers
  - Reservation protocol feedback should influence route selection
- Should be Independent protocols
  - Heterogeneous Context
    - Routing needs to support non-reservation traffic also
    - Reservation protocol must run over heterogeneous routing protocols
  - Operate at different granularities
    - Quality Of Route (QOR) is coarse relative to flow/reservation QOS
- Goal: Define service interface between the two and requirements for routing mechanism development

Who does what

- Reservation Setup
  - Setup reservation state
  - Maintain reservation state
  - Reestablish reservation state after failure
- Routing
  - Provide route(s); including alternates
  - Notify reservation setup of failure/change

Functional Requirements for Routing

- Provide unicast or multicast routes that meet receiver's service requirements
- Quick, efficient transition from inoperative path (e.g., failed link) to repaired path
- Prompt notification of failure to reservation protocol
- Routing changes should not disrupt service, unless link/node failure; support smooth transitioning between functioning routes if desired
- Request of any receiver should not disrupt service delivered to other receivers in the absence of link/node failure.

Routing Assumptions

- Unicast routing generates forwarding information base (FIB).
- FIB maps destination and COARSE grain QOR to next hop/source routes.
- QOR examples:
  - Reservation capable
  - Low latency
  - Target bandwidth
  - Usage sensitive charges
  - Policy
  - ...
- Multicast trees built out of unicast paths
- Reservation and Multicast routing control messages forwarded using Dest+QOR unicast routing.

Overview of Mechanistic Interaction

- 1. Rcvr joins mcast group G along Default route
  - "Default route" is that used by unicast routing to send packets to Dst with a certain QOR
- 2. Mcast routing control message sent upstream to extend delivery tree; control message routed according to S,G,QOR
- 3. Rcvr sends reservation request; RSVP notifies Rcvr re. reject.
  - Optimization: Reservation request may be sent along with tree join.
- 4. If reservation rejected or resulting QoS inadequate, Rcvr may request alternate route.
- 5. Alternate path routing mechanism used to join multicast tree on alternate branch, Return to step 3.

Interesting Issues

- Default route changes
  - Route pinning
  - Smooth transition
- Establishing alternate branches on multicast delivery tree
  - Selecting alternate routes
  - Maintaining distribution tree integrity
  - Dealing with higher reservation requests
- Open Design Questions: heterogeneity, gathering path information, etc.

Change in Default Route

- If routing immediately switches to new default route, reservation may be rejected and delivered service may be disrupted.
- Maintain previous reservation on previous route to avoid any service disruption (route pinning)
  - Optionally inform user of new default, OR
  - Optionally provide user with "advertisements" of delivered service along new default route
- Attempt to smoothly transition reservation to new default route
  - Verify reservation acceptability and delivered QoS before switching

Route Pinning: Implied Routing Capabilities

- Optionally route multicast join and reservation messages according to previously-used route; instead of new default route.
- Optionally deliver path advertisement messages (See Shenker talk yet to come) down path not used by data.

Smooth Transition: Implied Routing Capabilities

- Duplicate packets can occur where new route intersects old tree
- Activate new branch and prune old (timing determines black hole vs. duplicate tradeoff)

Establishing Alternate branches

- When default route cannot accept reservation or provide desired service, try alternate route.
- Select alternate based on QOR and reject information
- Assume reservation and multicast join messages processed together hop by hop
- At each hop, routing action depends on feedback from RSVP:
  - RSVP says merge: stop forwarding join
  - RSVP says continue (higher reservation level): forward reservation upstream
  - RSVP says fail: pass back failure to trigger alternate path

Selecting alternate routes

- Routing keeps ordered set of precomputed and on-demand computed alternate paths.
- Ordered based on length, QOR, etc.
- Routing uses feedback from reservation protocol to filter paths
- Dynamic information may be used (e.g., hop count limited flood of utilization, path explorer)
- Individual adaptation and unilateral selection of alternate routes by different receivers may lead to suboptimal trees. (we dont do optimal flow placement)

Grafting onto distribution tree via Alternate routes: issues

- Maintaining tree integrity
- Accommodating higher reservation requests

Tree Integrity Problem

- Disconnected subgraphs can occur when receivers independently try different alternate paths.
- For example: two receivers' joins merge with each others partially established paths
- Solution: flag state status/type and avoid merging alternate path and unconfirmed state

Maintaining Tree Integrity

- State flagged:
  - Status:
    - Confirmed if connected to source
    - Unconfirmed if not yet part of tree.
  - Type:
    - Default path: state established along current default unicast path to destination with indicated QOR
    - Alternate path: route determined by Alternate path routing function.
- General rule: Alternate path join must not cross or merge with Unconfirmed state, therefore:
  - If Join hits unconfirmed state in tree: Backoff unless existing state and current join are both using same Default route

Reservation Requests that exceed existing distribution tree capacity

- Receiver's alternate route for higher reservation overlaps existing tree downstream of bottleneck
  - Reject higher level request (alternate branch must graft above bottleneck), OR
  - Reroute upstream tree if new tree is acceptable to preexisting receivers.
- Attempted rerouting of upstream tree according to reservation request may disrupt service to current receivers
- If rerouting OK, only process one reroute action on the tree at a time: At any time, at a given node, there is not more than one current path and one alternate-being-attempted path

Some Open Design Questions

- Whether and How to accommodate heterogeneity within distribution tree:
  - receivers joining with different QORs
  - reservation requests that exceed capacity of existing tree
- Gathering path information before use:
  - Constructing alternate routes with desired QOR in response to reject
    - Should reject provide full path information to allow grafting above bottleneck?
  - Probing admission control along path to discover resource availability
  - Obtaining advertisements along candidate routes to discover currently deliverable QOS.

Things I "did not have time" to talk about

- Unicast case (more or less subset of multicast mechanisms)
- Mobility (more or less subset of adaptation mechanisms)

What is next

- RSVP and "Routing folks" work on defining interface
- Routing folks work on developing supporting mechanisms

Service Interface Options

- Reroute or Notify upon route failure
- Pinning flavors (dont, do, notify, advertise QoS of new route)
- Rearrange upstream tree to accommodate higher level requests
  (dont, do, notify, advertise QoS of new route)
- ...