Lightweight Flow Setup

Wirespeed Flow Reservation

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Resource Reservation in Internet?

- Bandwidth reservation can provide dramatically better performance for some applications.

Obstacles to resource reservation in Internet.
  » distaste for signaling protocols
  » perceived complexity of IntServ+RSVP
  » requires end-to-end deployment
  » little motivation for service providers

How to get resource reservation in Internet?
  » keep it simple
    • focus on top priorities - one-way unicast flows
    • avoid complex signaling - leverage hardware routing mechanisms
  » make it useful when only partially deployed
  » provide motivation for ISPs to deploy it
Basic LFS Operation

- One way, unicast setup with partial reservation.
  - complete reservations *locally* when bandwidth released
- Optional ack returned by far-end access router.
- Reservation may terminate explicitly or time out.
- May alter reserved bandwidth but no re-routing.
Soft Reservations

- Basic LFS provides **firm reservations**.
  - user guaranteed bandwidth until releases

- Can extend to provide **soft reservations** as well.
  - soft reservation can be adjusted by the *network* as traffic changes
  - can be intermixed with firm reservations to provide a firm minimum, plus more bandwidth as available

- Uses of soft reservation.
  - apps. that need guaranteed minimum and can sometimes use more, but can adjust use to what’s available
  - more rapidly responding congestion control for traditional best-effort traffic
Basic IP Option for LFS

- **Code** identifies LFS option.

- **Operations**
  - request firm reservation
  - request soft reservation
  - release state

- **Flags**
  - sender status request
  - sender network status request
  - public network status request
  - intra-domain status request

- **Rrate**: requested rate.
- **Arate**: allocated rate.

- **Trace** used by each domain to track usage.

<table>
<thead>
<tr>
<th>IP header (fixed part)</th>
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<tbody>
<tr>
<td>code</td>
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<td>Arate</td>
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- **Allocated rate** stored at “last hop” router for status generation

- **F.P. rates with 4 bit mantissa, 4 bit exponent.**
  - specify rates from 64 Kb/s to 4 Gb/s, 6%
  - “granularity”
Network providers need to monitor LFS usage for network management and accounting purposes.

- trace field used by ingress router of each domain to mark LFS packets with domain-specific identification
- egress router of each domain maintains record of each LFS flow, including copy of trace field
- end-to-end records created through off-line accounting resolution mechanisms
Status Reporting

- Basic LFS option supports sender status and trace field for accounting.
- Network providers likely to want more.
  - sender net status allows LFS service verification
  - public net status allows “end-to-end” status check
  - intra-domain status for verifying local status
  - each “extra” status report requires insertion of requestor’s IP address, increasing LFS option length
Partial Deployment

- Receivers need not be LFS-aware.
  - web site may use LFS to reserve bandwidth for streaming media - users benefit, even without LFS-aware hosts

- Issues with non-contiguous LFS domains.
  - route changes may create “orphan reservations”
  - no simple way to determine status reporter

- No support for non-contiguous LFS domains.
  - LFS router forwarding to a non-LFS router (or host) strips LFS option and implements status reporting
    - status report includes IP address of reporting router, letting sender know how far the reservation went

- Public IP carrier can accept LFS option from client networks (LAN) even if client net is not LFS-aware.

- Clients may use tunnel to access LFS service.
Regulating LFS Use - Net Access Svc

- Permitting unconstrained access to LFS creates big security vulnerability.
- Limit use to authorized users.
- Limit number of reservations and amount of reserved bandwidth by authorized users.
  - access router keeps record and enforces limits
  - complication - user may use LFS from multiple locations
    - maintain records in distributed set of servers - each server keeps records for some fraction of the users - use hashing to select
- Access router needs means to identify user.
  - host IP address insufficient (DHCP, NAT)
  - encryption-based authentication (IPSEC)
- Combine access control with usage accounting.
- What special issues arise with multiple domains?
Implementation - Router Input

- If flow table entry present, use stored next hop.
- If no flow table entry, lookup route & create entry
  » store selected next hop in flow table entry
  » may use datagram forwarding table or separate LFS forwarding table
  » LFS table may support list of next hop candidates
If flow table entry present, use it to find queue, otherwise create an entry & allocate queue.

If firm reservation specified, update entry.
- keep list of unsatisfied reservation requests to process as bandwidth becomes available

If soft reservation, update fair share, pacing rate.
“Special” Processing

- At first LFS router in path.
  » verify usage privileges, check restrictions

- At sender network’s gateway router.
  » optionally request sender network status

- At entry to public network.
  » maintain status information, optionally request public net status
  » verify usage privileges of client networks

- At last LFS router in path.
  » maintain status information
  » generate sender status and sender network status packets
  » strip LFS option

- At domain entry.
  » update trace field, optionally request intradomain status

- At domain exit.
  » maintain domain-specific status, send intradomain status
Routing Flow Reservations

- May use standard datagram routing for flows.
- QoS routing can produce better results.
- Shortest path routing with suitable cost metric.
  - for lightly loaded paths, cost equals sum of link lengths (not just hop count)
  - increase cost of busy links to reflect blocking potential
- Multiple-choice forwarding table.
  - standard forwarding table includes single next hop
  - when link to next hop is too busy to accept reservation, alternate choices can be useful
  - ordered list of next hops
    - select first one with sufficient bandwidth on connecting link
    - if none, select one with smallest backlog of unfulfilled reservations
  - routes reservations around links that become busy between routing updates
Summary

- LFS provides simple reservations for QoS.
  - no complex signaling, wire speed setup
  - limited deployment can be broadly beneficial
  - support for usage monitoring & accounting gives network providers a motivation to deploy service

- Network access service for regulating usage.
  - preliminary specification has been developed
  - uses IPSEC for host/user authentication

- Performance analysis, simulation study underway.

- Routing issues.
  - evaluate QoS routing with multiple-choice forwarding
  - link state distribution for inter-domain routing
  - inter-domain routing policies