1999-12-15

BU/NSF Workshop on Internet Measurement, Instrumentation and Characterization

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http://hdl.handle.net/2144/3751

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Network Support for Adaptive Multimedia Applications

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BU/NSF Workshop on Internet Measurement, Instrumentation and Characterization
August 30, 1999

Joint work with Ellen Hahne, Ping Pan and Xin Wang
Overview

- scalable resource reservation: YESSIR and aggregation
- monetary feedback for adaptation: RNAP
- measurement and feedback
“Classic” Service Classification

- best effort
- guaranteed (delay)
- controlled load (≈ 0 loss)
- differentiated service: “where all the flows are above average”
Service Classification

bw

reserved
FSA-DTT

TCP data transfer
"TCP-friendly"

multimedia

transaction

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Adaptive Interactive Multimedia

• “TCP-friendly” is not good enough
• MM need limited bandwidth-changes: “fading”
• audio only allows step-wise adjustment
• reservation: trade blocking ↔ loss probability
• need incentive to adapt
• non-interactive multimedia: TCP with buffering?
YESSIR: RSVP Problems

Complexity:
- receiver-initiated
- error handling

Scaling:
- state management per router
- CPU overhead for refresh messages

Reservation restrictions:
- always rejects request fail-and-retry churn

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YESSIR

- RTCP sender reports marked with router-alert option
- set up reservations for associated data (RTP) flow
- no additional reservation protocols needed
- router marks if reservation failure
- receiver report reports back failure(s)
- still support sender flow-merging
- without flow spec: byte count$\_i$ – byte count$\_{i-1}$
- measurement-based admission?
Partial Reservations

- stop reserving at first failure vs. reserve what one can get
- at refresh time, pick up new links
- possibly more efficient than try-and-cancel?
- resource fragmentation under high-load
Reservation Aggregation

- reservation aggregation for sink and source trees
- additive aggregation, not flow merging
- hysteresis for merged flows
RNAP: Resource Negotiation and Pricing

- even diff-serv needs admission control
- RNAP: either separate protocol for diff-serv or RSVP+
- just dropping packets doesn’t work well for multimedia
- users need economic incentive to throttle
- constant reservation over bounded immediate or future intervals
RNAP Operation

Query: services, prices for interval
Quotation: time-limited offer
Commit: network admits service
Close: negotiation session

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Notes on Pricing

- \( p(\text{guaranteed}) > p(\text{CL}) > p(\text{BE}) \)
- price = holding + usage + congestion
- price = \( f(\text{predictability interval}) \)
- holding = opportunity cost; can only resell as lower grade
- usage = \( f(\text{type, burstiness, \ldots}) \)
- price capping reject calls
- temporary price inequalities
- demand \( D \), supply \( S \): \( p_c(n) = p_c(n - 1) + k(D, S) \times (D - S)/S \)
RNAP Pricing Example

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RNAP: Centralized

Access Network

--- RNAP messages

<> Intra-domain Messages

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RNAP: Distributed

--- => RNAP messages
Utility Function Learning

- utility function is personal & task-dependent
- learning mechanism: user adjusts quality with price feedback
- value of call decreases with duration of session?
Open Router Architecture

installable code

public
private

protocol
router alert
port

OIF = f(addr)

router alert
route

packet classifier
## Monitoring

<table>
<thead>
<tr>
<th></th>
<th>granularity</th>
<th>access</th>
</tr>
</thead>
<tbody>
<tr>
<td>SNMP</td>
<td>pull interface</td>
<td>limited</td>
</tr>
<tr>
<td>mrouted</td>
<td>push mcast group</td>
<td>mcast only</td>
</tr>
<tr>
<td>RTCP</td>
<td>push mcast group</td>
<td>RTP only</td>
</tr>
</tbody>
</table>

- 3rd party RTCP: forced to receive media + feedback
- no selectivity
Threshold-Based Monitoring

- motivation: lots of small *unicast applications (Internet telephony)*
- need *third-party monitor*
- “this conversation may be monitored for quality assurance”
- geographic correlation
- use *RTCP feedback with scaling & reconsideration, but …*
Threshold-Based Monitoring

fault correlation
monitor

Bob - Alice: 10%

multicast

threshold: 5%, 1000 complainers

RTP

Alice

Bob

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Conclusion and Speculation

• need multiple reservation, routing, measurement, … protocols

• price predictability vs. fairness (INDEX, …)

• currently, hard to add functionality

• efforts like P.1520 or active networks too brittle

• installable code (API) + standard in-band control + standard IP

• need new finger(pointing) protocol: “who’s dropping/delaying my packets?”