A test-bed investigation of QoS mechanisms for supporting SLAs in IPv6

Vasilios A. Siris and Georgios Fotiadis

University of Crete and FORTH
Heraklion, Crete, Greece

vsiris@ics.forth.gr

Funded in part by GRNET, through subcontract in 6NET (IST-2001-32603)
Objectives and motivation

- Investigate operation and interaction of QoS mechanisms in IPv6 networks
  - Policing, shaping, queuing
- These mechanisms will be used in customer-provider interface
- Tuning is important for supporting Service Level Agreements (SLAs)
  - Tuning each in isolation not sufficient
- Do they have different performance in IPv6 compared to IPv4?
User-network interface

User/customer

shaping, class-based queuing

traffic flow

Provider

policing

class-based queuing
QoS mechanisms investigated

- Cisco Traffic Policing
  - Committed Access Rate – CAR not supported in IPv6
- Cisco Generic Traffic Shaping - GTS
- Linux Traffic Policing
- Linux Traffic Shaping
  - Token Bucket Filter – TBF
- Linux Class Based Queuing - CBQ
**Token bucket algorithm**

- True token bucket \((r,b)\)
- Shaping includes a buffer

### Diagram

- **Arriving packet:** length \(L\)
- **Token rate** \(r\)
- **Token bucket depth:** \(b\)
- **Yes, \(x=x-L\)**
- **No, packet is nonconforming**

### Implementation differs
- Mean rate or Committed Information Rate (CIR)
- Committed Burst Size (Bc)
- Time interval \((=Bc/CIR)\)
IPv6 test-bed

- Linux-based router or Cisco 7100/7200
- 100 Mbps
- RedHat Linux 9.0

- shaping, class-based queueing
- policing
- class-based queueing

- TCP traffic generated with Iperf 1.7.0 for Linux
- RTT < 4 ms
Policing tests topology

Linux-based router or Cisco 7100/7200

- For fixed policing rate, measure aggregate throughput for different burst sizes
Variable policing rates (1/3)

Only Policing (Router),
Variable Policing Rate,
1 Connection - 3 Flows

Burst size, $B_c$ (Mbits)

Aggregate Throughput (Mbps)

- 10 Mbps
- 20 Mbps
- 30 Mbps
- 40 Mbps
- 50 Mbps
- 70 Mbps
Variable policing rates (2/3)

- Aggregate throughput increases with burst size, but is always < policing rate
- For higher rates throughput is proportionally smaller
  - Rate = 10 Mbps -> Throughput = 9.7
  - Rate = 70 Mbps -> Throughput = 46
- Experiments for both Cisco & Linux routers gave identical results
Variable policing rates (3/3)

- Throughput versus burst size exhibits a “knee” at $Bc^*$, which is approximately:
  - If Rate $< 40$Mbps,
    $$Bc^* = 0.6 \text{ Mbit} + 0.03\text{sec}*\text{Rate}$$
  - If Rate $> 40$Mbps,
    $$Bc^* = 1.5 \text{ Mbit} + 0.01\text{sec}*\text{Rate}$$
- Burst Size $> \text{RTT}*\text{Rate}$ not sufficient!
Variable number of flows (1/2)

Only Policing (Router), Variable Number of Flows, Policing Rate = 50Mbps

Aggregate Throughput (Mbps)

Burst size, Bc (Mbits)
Variable number of flows (2/2)

- Optimum burst size ("knee" value) is independent of the number of flows
- Aggregate throughput increases with number of flows (multiplexing)
- Similar results for Cisco & Linux routers
Interaction of policing & shaping

For fixed rate & burst size of policer and rate of shaper, measure aggregate throughput for different burst sizes of shaper.
Throughput vs. burst size (1/4)

Interaction of Policing and Shaping, Variable Number of Flows,
Shaping (Router1): Rate = 50Mbps, Buffer Limit = 1000pkts,
Policing (Router2): Rate = 50Mbps, Bc = 2Mbits.

Shaping at Linux
Policing at Cisco
Appropriate shaper burst size can lead to significant **throughput increase**
- Throughput is always higher with shaping
- Setting burst size of shaper = burst size of policer not always optimal

**Low throughput for very small burst sizes**
- Due to overflow at shaper’s queue

**But also, very large burst size gives low throughput**
- Very large burst sizes allow large bursts which lead to multiple drops at the policer
Throughput vs. burst size (3/4)

- For larger # of flows there is larger range of burst sizes that achieve maximum throughput
No qualitative difference when using two Linux or Linux & Cisco routers
Interaction of Policing and Shaping, Variable Number of Flows,
Shaping (Router1): Bc = 2Mbits, Buffer Limit = 1000pkts,
Policing (Router2): Rate = 50Mbps, Bc = 2Mbits.

Throughput vs. shaping rate (1/2)

Shaping at Linux
Policing at Cisco

Policing rate

Throughput vs. shaping rate (1/2)
Throughput vs. shaping rate (2/2)

- Throughput maximum for shaping rate a little higher than policing rate
- Very high shaping rates leads to throughput degradation, due to bursts that are allowed by the shaper
Delay jitter tests (1/3)

- Policing/Shaping tests showed there is a range of shaper burst sizes for which throughput is maximized.
- Which burst size is best?
- Answer: consider delay
Interaction of Policing and Shaping,
Shaping (Router1): Rate = 50Mbps, Buffer Limit = 1000pkts,
Policing (Router2): Rate = 50Mbps, Bc = 2Mbits.
Jitter decreases when burst size increases

Optimal burst size is one for which delay jitter is smallest, but is in the range of values that maximize throughput
Interaction of Policing and Class Base Queuing

For fixed rate & burst size of policer and rate of CBQ, measure aggregate throughput for different maxburst values.
Variable *maxburst* at CBQ (1/2)

Interaction of CBQ and Policing,
CBQ (Router1): Rate = 50Mbps
Policing (Router2): Rate = 50Mbps, Bc = 2Mbits,

CBQ at Linux
Policing at Cisco
Variable *maxburst* at CBQ (2/2)

- Maximum throughput achieved with appropriate *maxburst* value
- Low throughput for small *maxburst*
- Large *maxburst* values do not result in throughput degradation
  - *maxburst* has different effect than burst size in shaping
  - CBQ performs traffic smoothing
Conclusions and outlook

- **Interaction** of QoS mechanisms is important for **effectively supporting SLAs**
- In the presence of **policing**, **shaping** can **increase aggregate throughput**
  - Must appropriately set shaping parameters
- Tuning of parameters should consider **throughput & delay**
- Similar behavior with Cisco/Linux, IPv6/IPv4
- Further research directions:
  - Experiments in wide area (larger RTT)
  - Experiments in wireless networks
A test-bed investigation of QoS mechanisms for supporting SLAs in IPv6

Vasilios A. Siris and Georgios Fotiadis

University of Crete and FORTH
Heraklion, Crete, Greece

vsiris@ics.forth.gr

Funded in part by GRNET, through subcontract in 6NET (IST-2001-32603)