Classification of IP networks for audio and video parameters

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Agenda

- What QOS is and isn’t
- Classification Example
- QOS Architectural Considerations
- Customer Example / Tests
- Modern FEC Performance
- Summary

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What QOS is

- Packet classification

  Define separate queues within routing nodes for priority treatment during resource contention (congestion)

- IP Networks should be engineered to avoid congestion
- When congested, QOS set’s forwarding priorities from the configured queues

  ..chooses who’s packets to drop. ;)

- The best QOS policy is to have no queues

  Does not eliminate resource management

- QOS is a safety net

What QOS isn't

- Doesn't create bandwidth
- Doesn't improve packet forwarding performance
  - Modern routers forward at line-rate already
  - Can improve (decrease) latency
- Doesn't guarantee resources
- Isn't a bulk resalable service
  - Not for all customers, data, and flows

Abilene Network Experience

"Today our Abilene network does not give preferential treatment to anyone's bits, but our users routinely experiment with streaming HDTV, hold thousands of high quality two-way video conferences simultaneously, and transfer huge files of scientific data around the globe without loss of packets"

Testimony of Gary R. Bachula, Vice President, Internet2 Before the United States Senate Committee on Commerce, Science and Transportation Hearing on Net Neutrality February 7, 2006

http://commerce.senate.gov/pdf/bachula-020706.pdf

Abilene Network Experience

"We would argue that rather than introduce additional complexity into the network fabric, and additional costs to implement these prioritizing techniques, the telecom providers should focus on providing Americans with an abundance of bandwidth – and the quality problems will take care of themselves."

Testimony of Gary R. Bachula, Vice President, Internet2 Before the United States Senate Committee on Commerce, Science and Transportation Hearing on Net Neutrality February 7, 2006

http://commerce.senate.gov/pdf/bachula-020706.pdf

Reality check..

- Infinite free bandwidth would be nice
  - Investment money ready for any viable solution - see me after. ;)
- The Abilene network was subsidized
  - Limited business model relevance
- BUT it is an ALL IP Network unicast/multicast IPv4/v6
  - COMPLETELY technically relevant
- Proof-case that un-congested IP is ready for high-quality audio and video today
- But happens when there is congestion?
  - Or, what should the safety net look like?

When congestion strikes..

- Synchronization events

  Mothers' day - telco legend

  Unforeseen world events - news, disaster, entertainment

- Network failure events

  Rerouting traffic where bandwidth is limited

- DDOS attacks

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Classification Example
ITU Y.1541

QoS Class	Applications (Examples)	Node Mechanisms	Network Techniques
0	Real-Time, Jitter Sensitive, High Interaction (VoIP, VTC)	Separate Queue with Preferential Servicing, Traffic Grooming	Constrained Routing/Distance
1	Real-Time, Jitter Sensitive, Interactive (VoIP, VTC)		Less Constrained Routing/ Distance
2	Transaction Data, Highly Interactive (Signalling)	Separate Queue, Drop Priority	Constrained Routing/Distance
3	Transaction Data, Interactive		Less Constrained Routing/ Distance
4	Low Loss Only (Short Transactions, Bulk Data, Video Streaming)	Long Queue, Drop Priority	Any Route/Path
5	Traditional Applications of Default IP Networks	Separate Queue (Lowest Priority)	Any Route/Path

Classification Example ITU Y.1541

- 6 classes, 4 queues
- Close match to current IP deployments
    - More later…
- No mention of multicast
- Video may be unicast, multicast, or both
- Signaling protocol specification under development
    - draft-ietf-nsis-y1541-qosm
- Support QoS mapping among diverse networks
    - Questionably enforceable between administrative domains
    - (my personal view)

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QOS Architectural Considerations

- Not all routers are created equal

  Configuration parameters, number of queues, ingress vs egress, performance, etc..

- Modern core routers use distributed forwarding

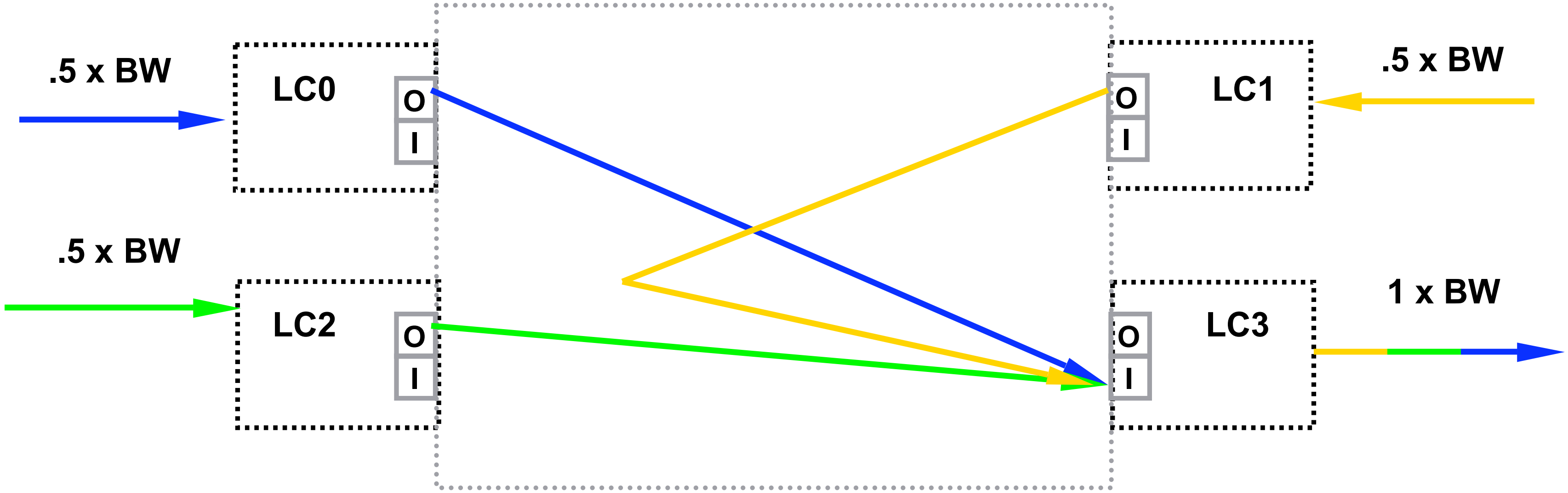
  Centralized forwarding allowed for single-point forward (drop) decision - no more.

- Congestion is an egress event, but packets should be dropped in ingress for optimal efficiency

- Not all architectures allow for mixing of unicast and multicast queues and priorities

  Multicast replication in routers can create QOS challenges (as well as others..)

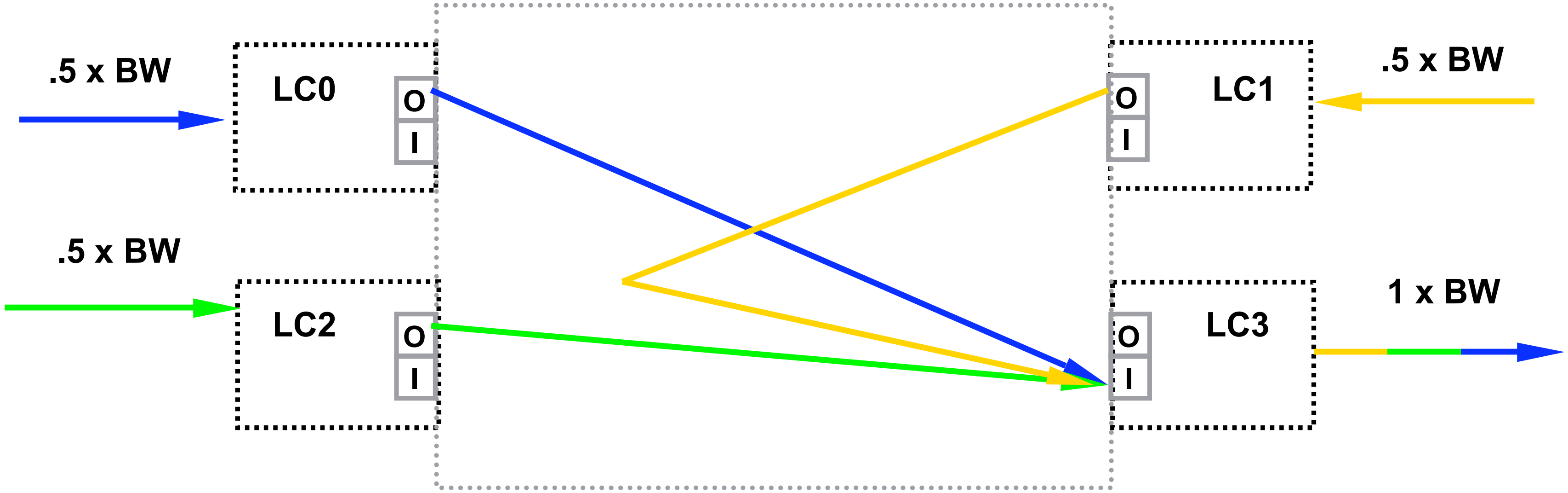
Distributed forwarding
a very simple example



Ingress LineCards(LC) are undersubscribed

The sum of all traffic to LC3 oversubscribes the LC capacity

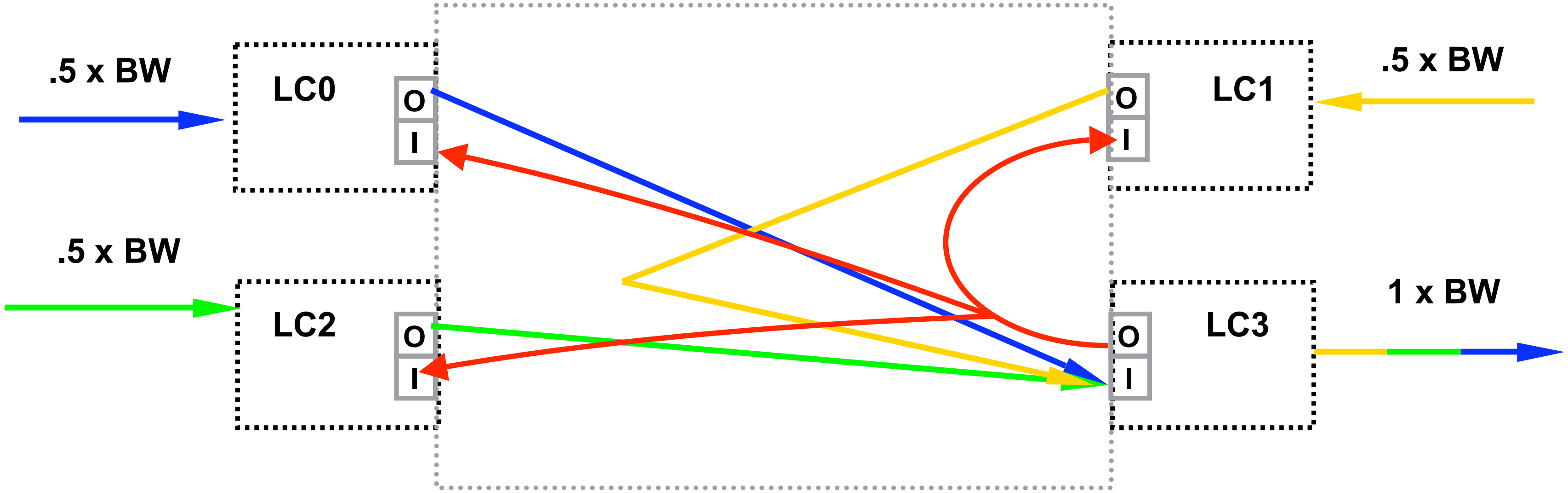
Distributed forwarding
a very simple example



Egress QOS policy can only apply IF:

- the fabric bandwidth TO each LC is equal to the total bandwidth capacity of the entire chassis, or multic-chassis system
- The from-fabric buffers are large enough for all queues on all interfaces of the linecard
- physically impossible on large-scale systems (Tbps systems)

Distributed forwarding
a very simple example



Solution:

Provide back-pressure signaling from egress to ingress

Allow egress QOS policy to be applied at ingress in real-time

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IPMcast Customer QOS Requirements

- Network congestion is not a significant impairment contributor
  - ..normally..
- BUT it is a necessary safety-net
- On-network multicast (video) traffic is well known
  - Flows, rates, sources..
- Access can sycronize/spike
  - "Mother's day" events
- Real-time (VoIP) traffic should not suffer from other traffic events

Triple-Play
QOS Customer test assumptions

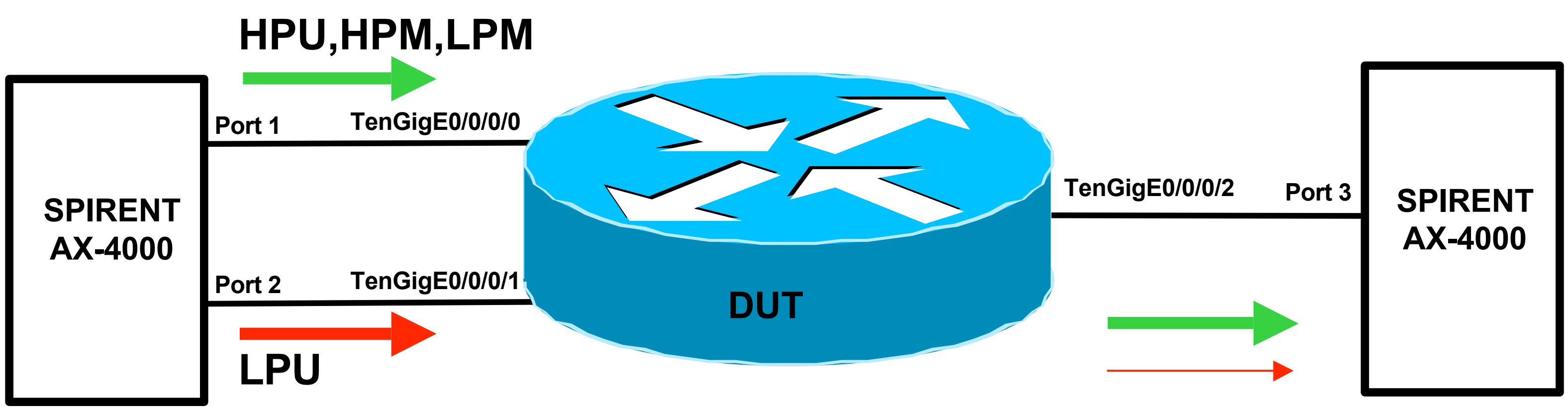
- Support 4 classes of service with a strict priority relationship between these classes as follows:

  Unicast High > Multicast High > Multicast Low > Unicast Low

  ie: Voip > Premium Vid > Broadcast Vid > Access

- Full line rate performance is expected for all traffic transmitted in each class when uncongested.
- No effects observed on higher class performance due to traffic transmission on a lower class.
- No effect on unicast traffic, nor should the unicast traffic effect the multicast traffic.
- Congested interface should not affect same multicast flow(s) destined to adjacent uncongested interfaces.

QOS Test Configuration 1

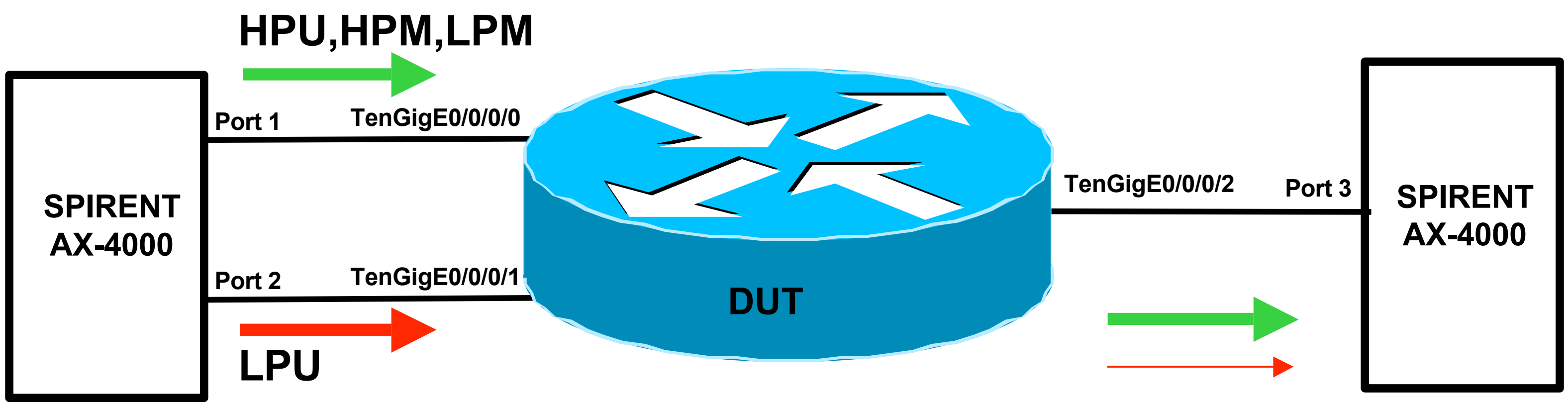


HPU + HPM + LPM + LPU > 100%

HPU + HPM + LPM + LPU = 100%

Strict Priority order for dropping
HPU > HPM > LPM > LPU

QOS Test Configuration 1



HPU + HPM + LPM + LPU > 100%

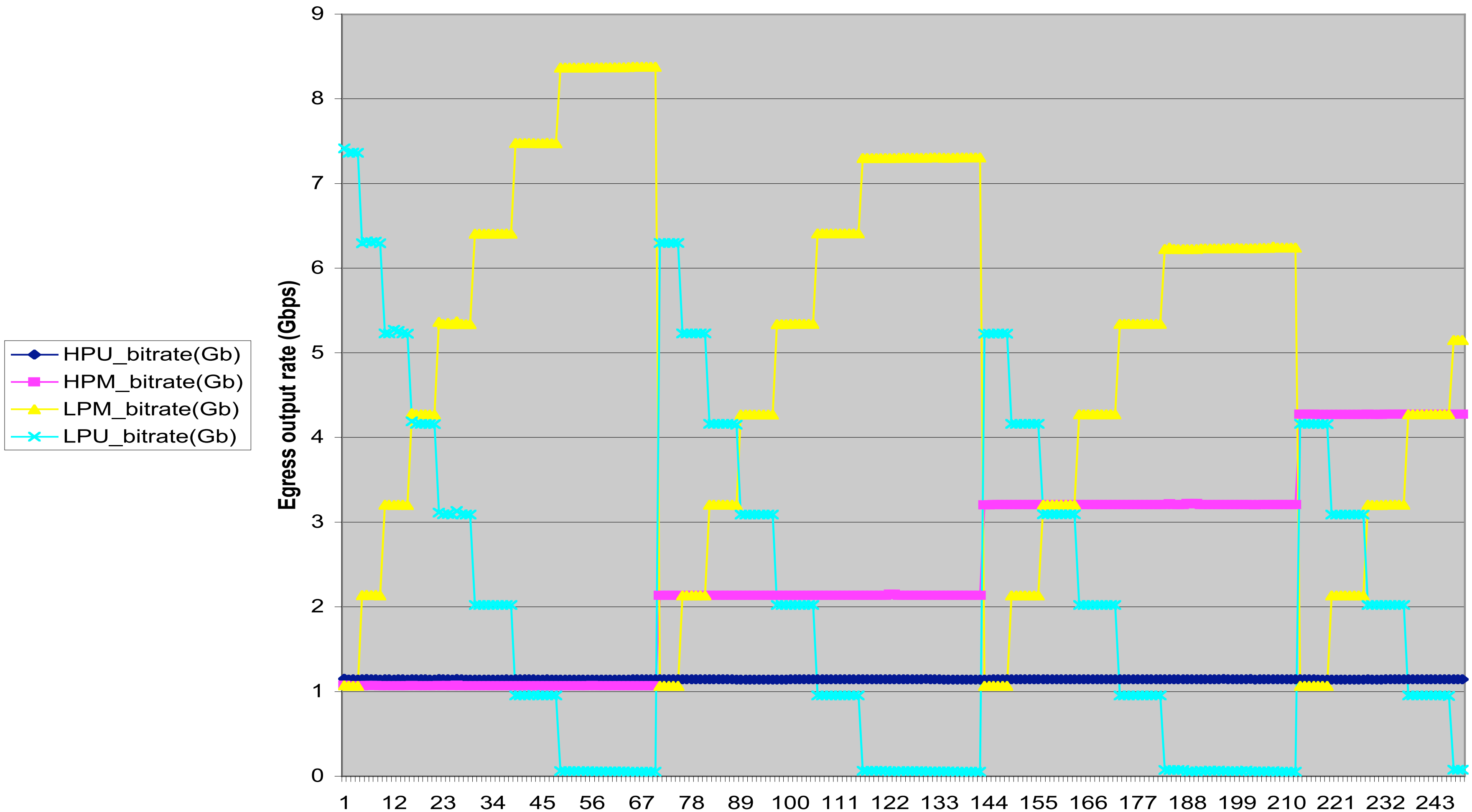
HPU + HPM + LPM + LPU = 100%

<u>Test parameters:</u>

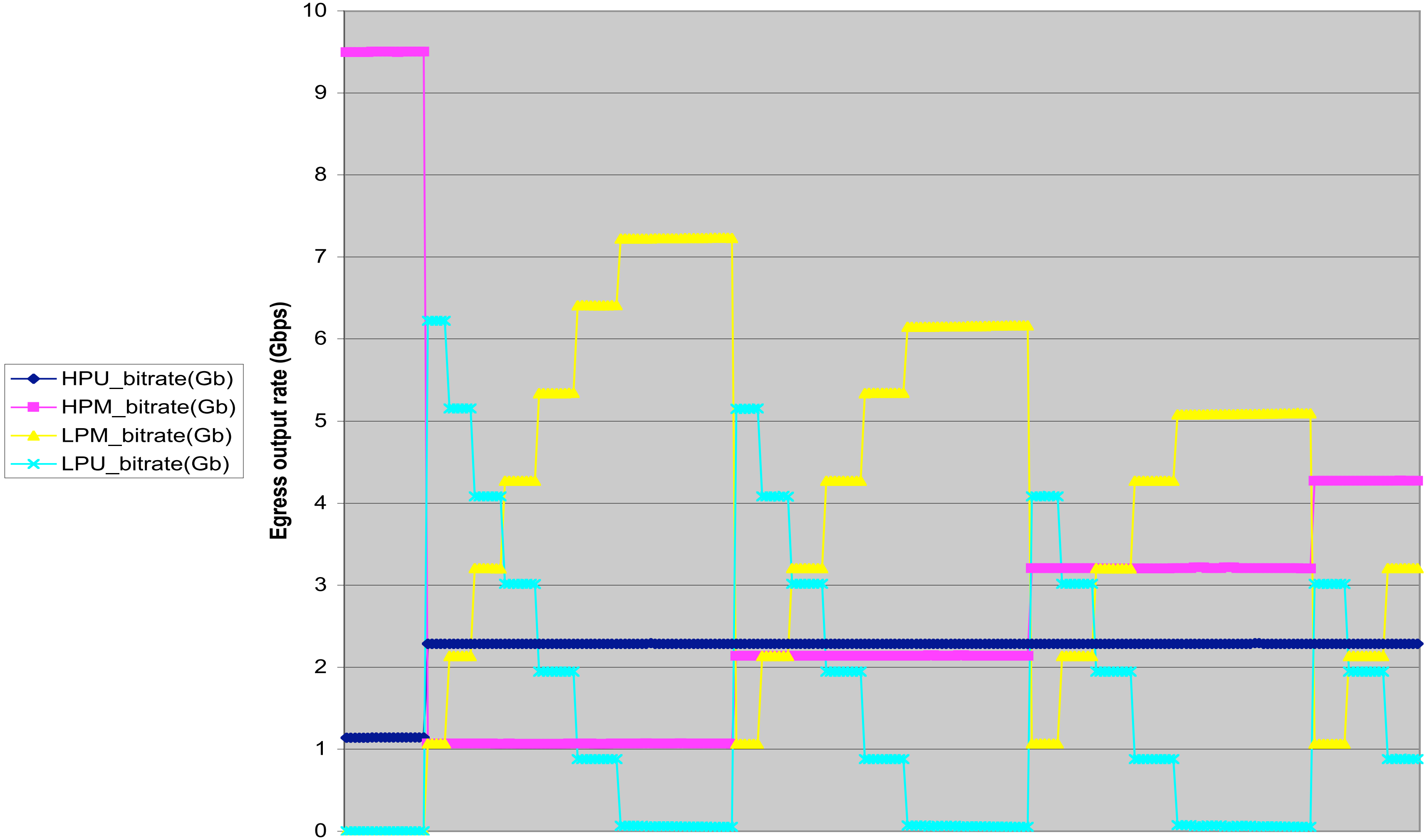
Rate: Data traffic is changed in steps of 10% for four different classes from 10% to 90% for port1 and port2.

Packet size: 220 bytes for HPU, 1496 for HPM, LPM and LPU

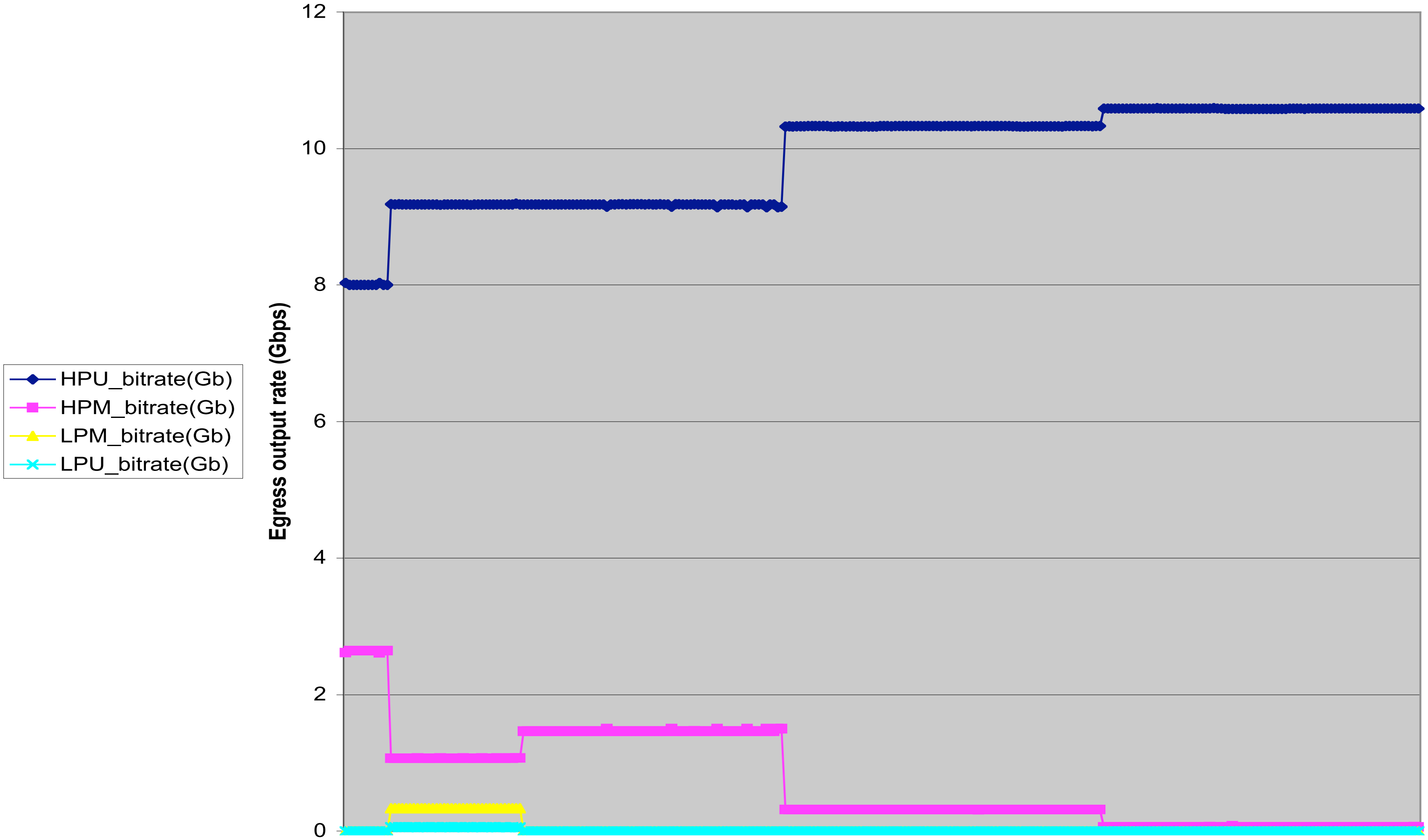
CRS QOS Test 1… (1of3)



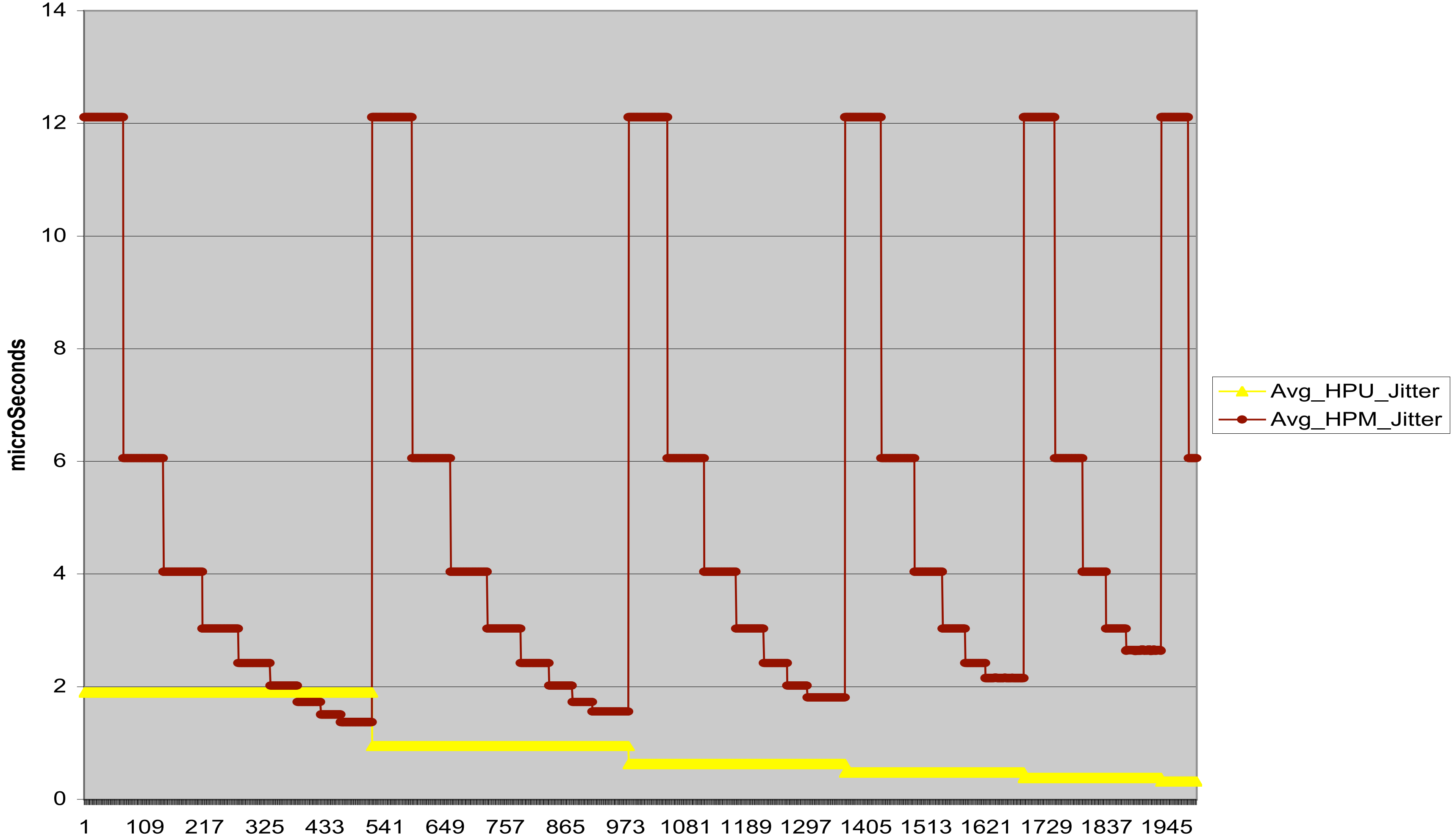
CRS QOS Test 1… (2of3)



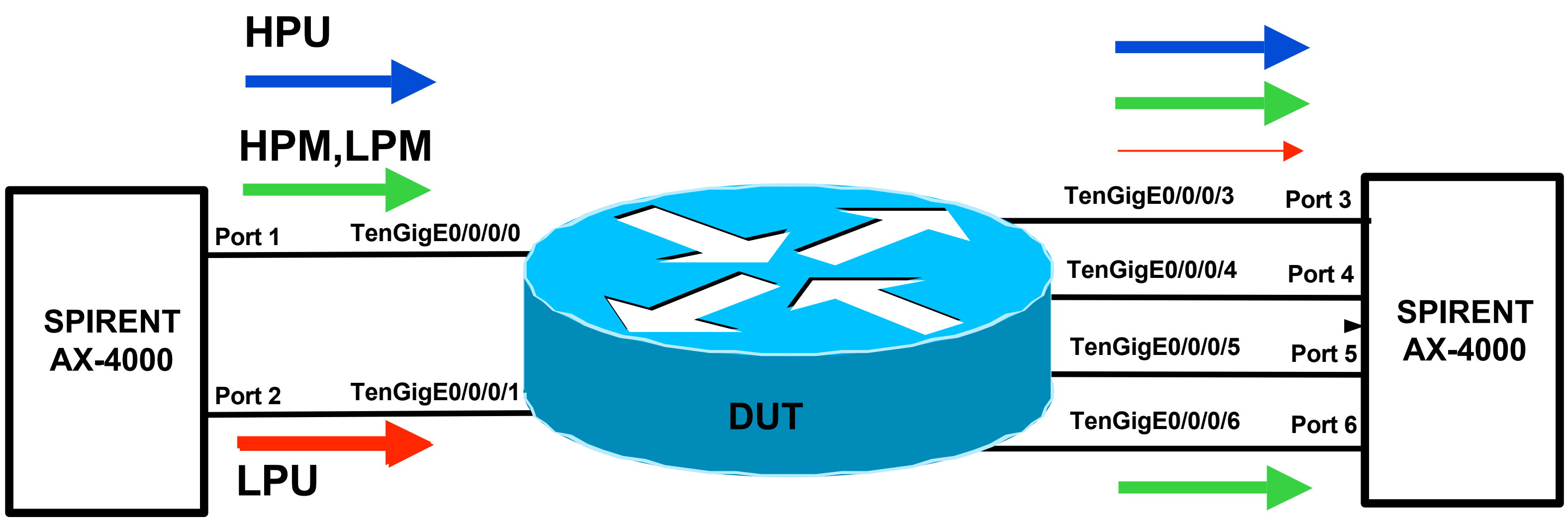
CRS QOS Test 1… (3of3)



QOS Test 1 - Jitter (subset)



QOS Test Configuration 2

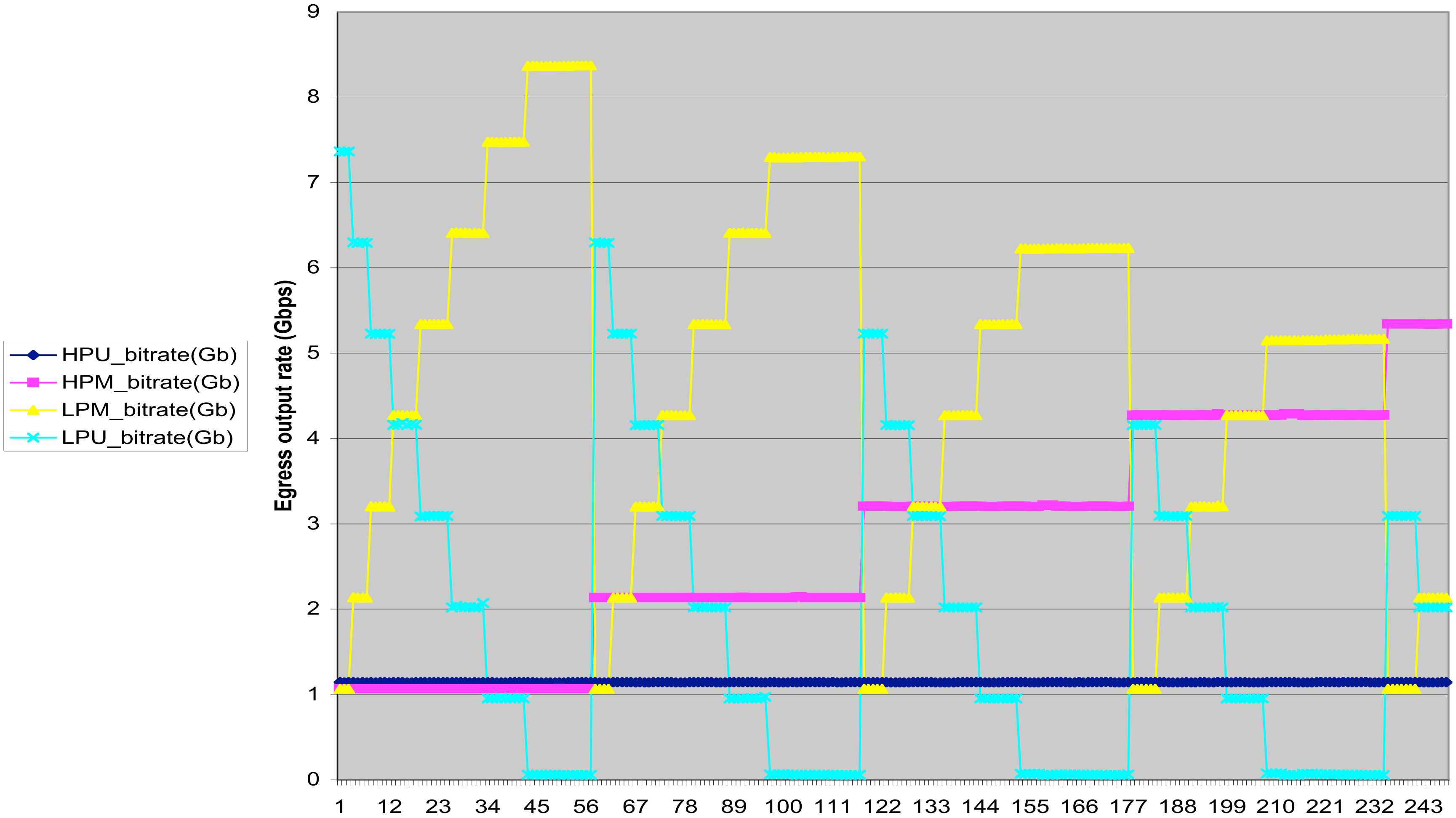


HPU + HPM + LPM + LPU > 100%

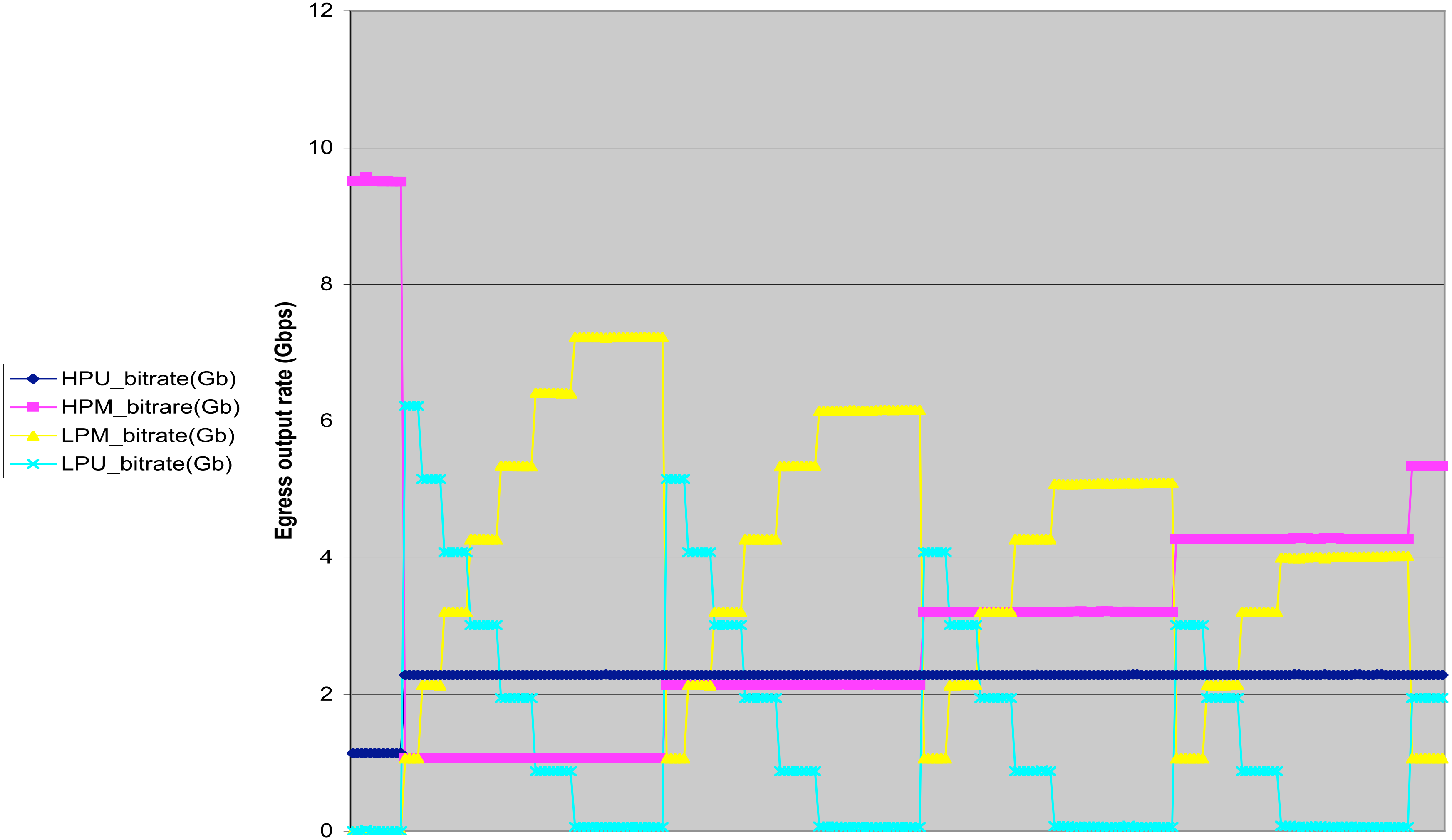
HPU + HPM + LPM + LPU = 100%

Strict Priority order for dropping
HPU > HPM > LPM > LPU

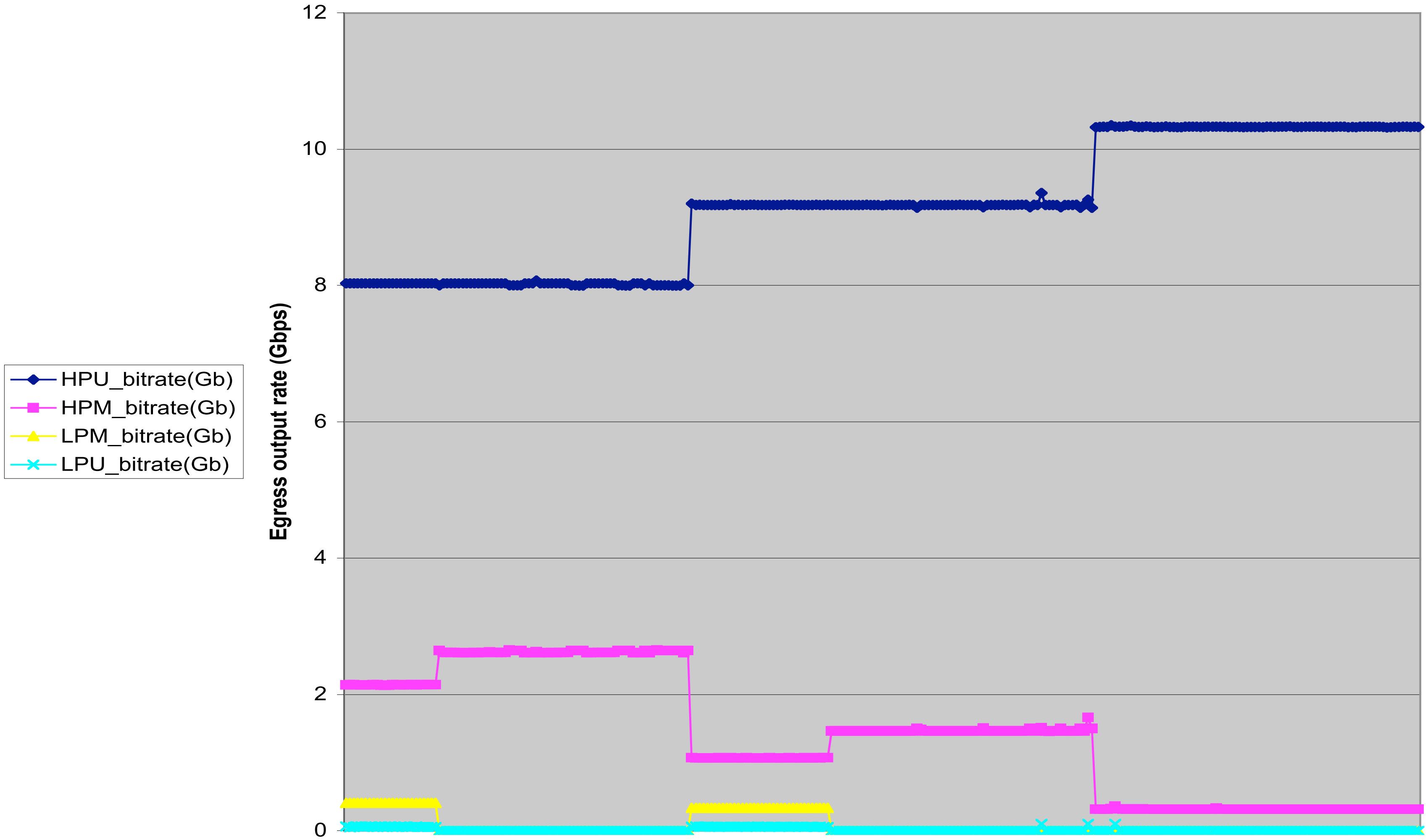
QOS Test 2 - 1of3



QOS Test 2 - 2of3

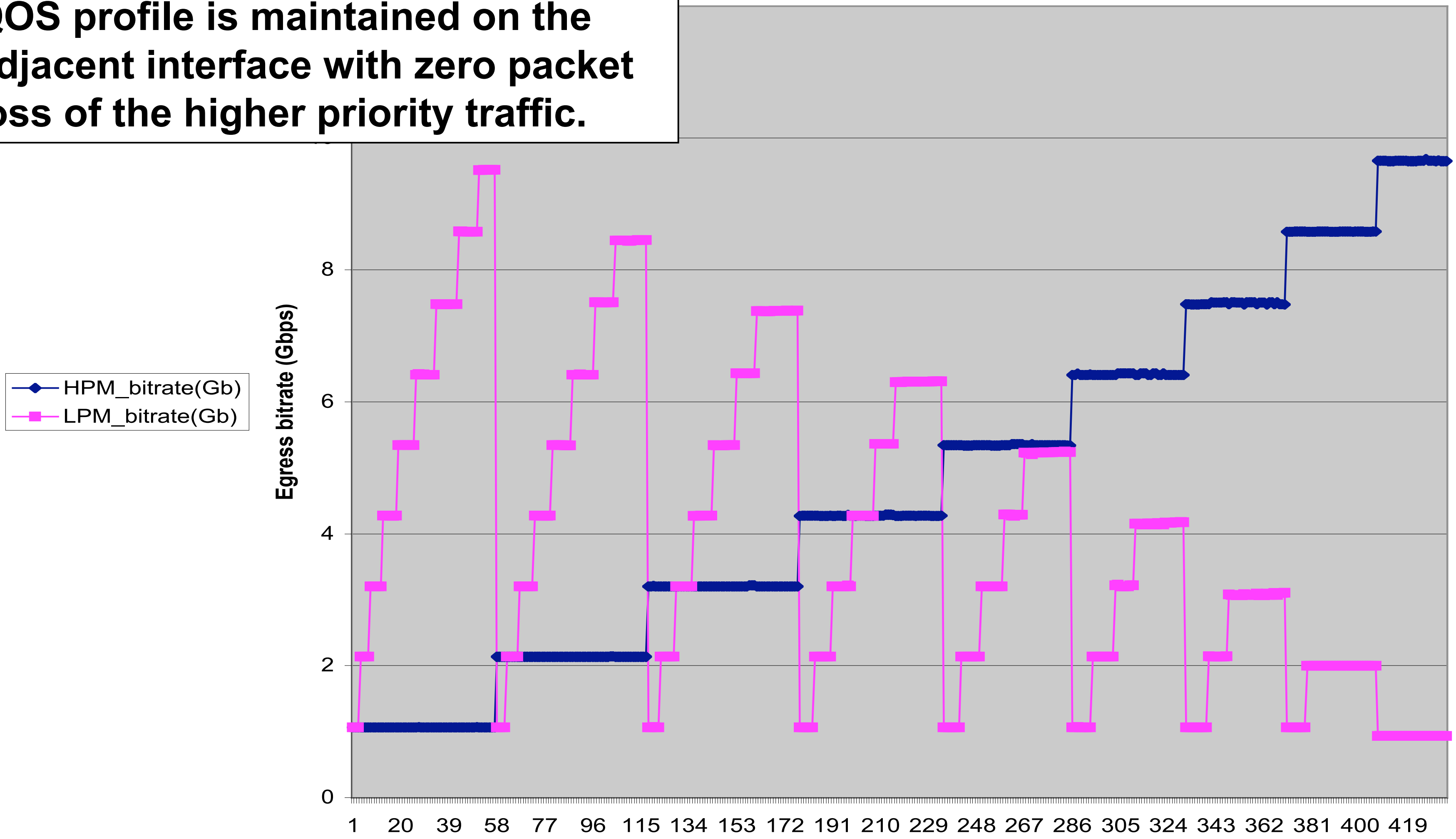


QOS Test 2 - 3of3

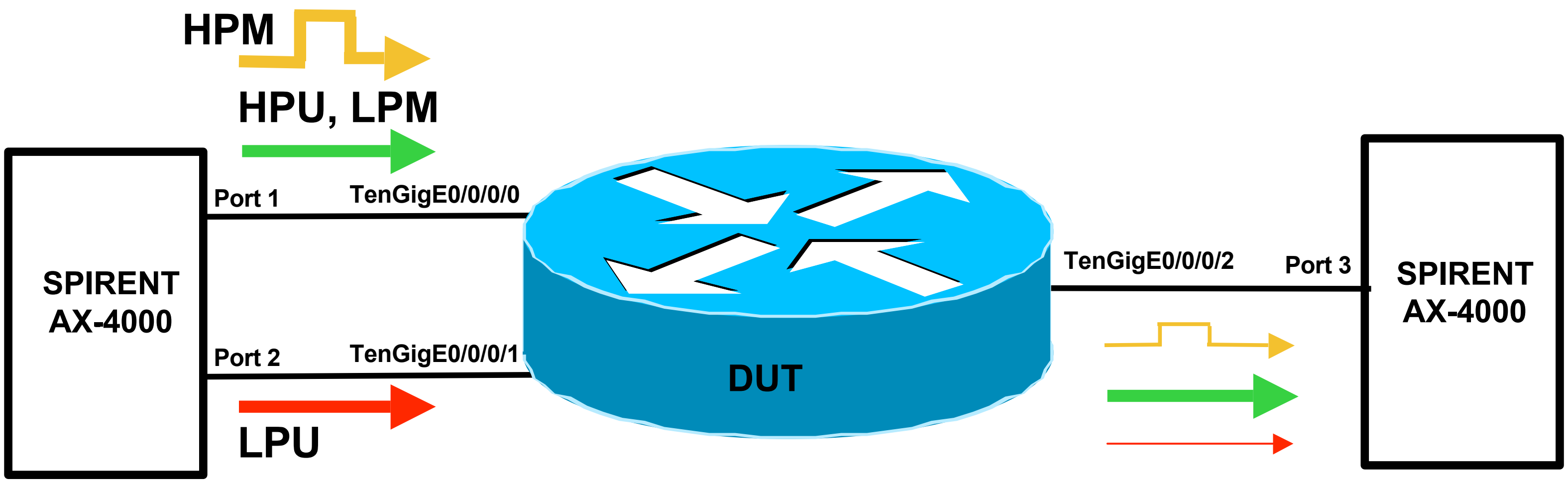


QOS Test 2 - Port 4

QOS profile is maintained on the adjacent interface with zero packet loss of the higher priority traffic.



QOS Test Configuration 3

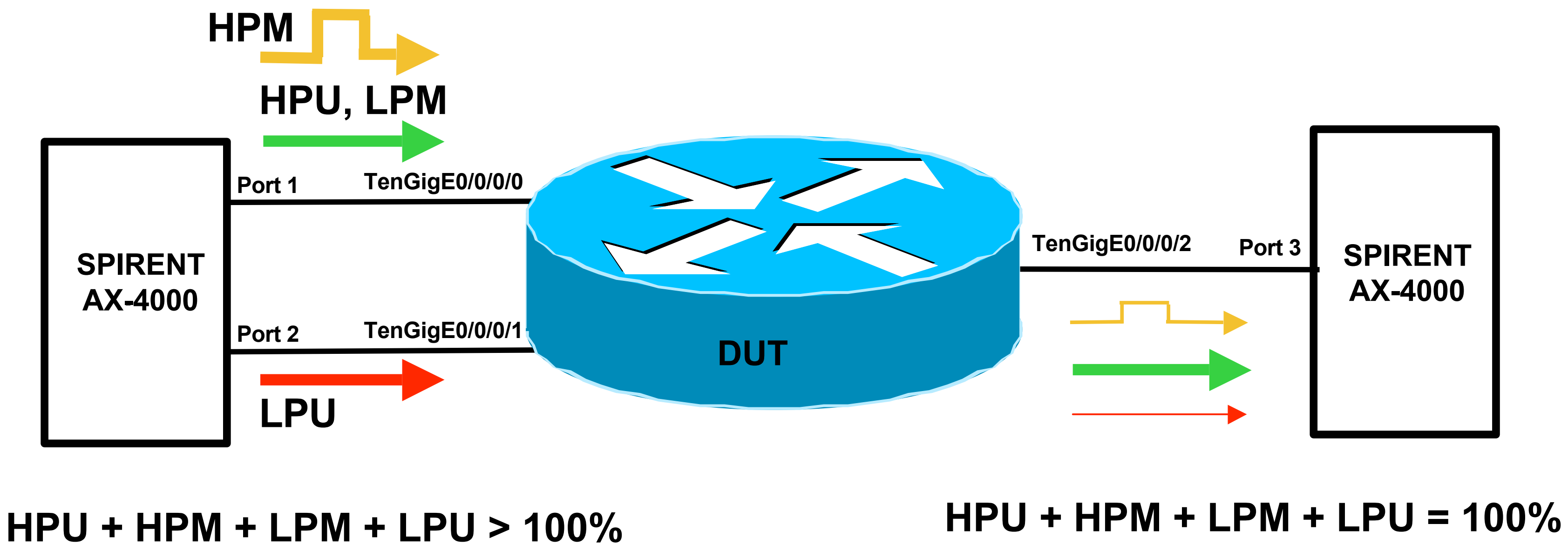


HPU + HPM + LPM + LPU > 100%

HPU + HPM + LPM + LPU = 100%

HPU = 55%, LPM = 30%, LPU= 5%
HPM step from 10% to 90%

QOS Test Configuration 3

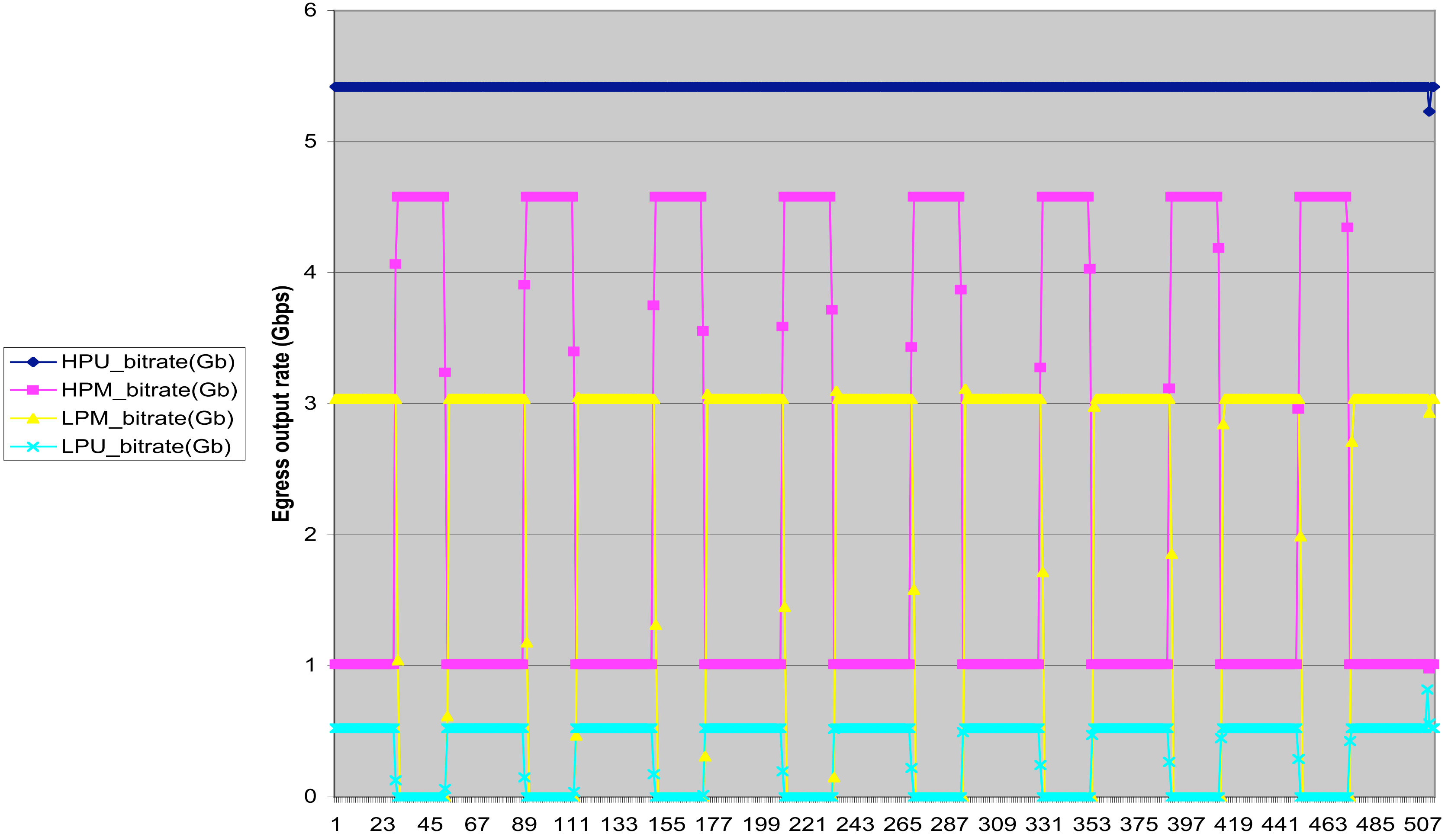


Test parameters:

Rate: Data traffic for HPU,LPM and LPU is fixed at 5.5Gb/s, 3.0Gb/s and 0.5Gb/s respectively.
HPM traffic follows square wave pattern from 1.0Gb/s for 30secs to 9Gb/s for 20secs to represent bursty HPM traffic

Packet size: 220 bytes for HPU, 1496 for HPM, LPM and LPU

QOS Test 3



HPU_bitrate(Gb)
HPM_bitrate(Gb)
LPM_bitrate(Gb)
LPU_bitrate(Gb)
Egress output rate (Gbps)
6
5
4
3
2
1
0
1 23 45 67 89 111 133 155 177 199 221 243 265 287 309 331 353 375 397 419 441 463 485 507

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End-to-end / node-to-node FEC

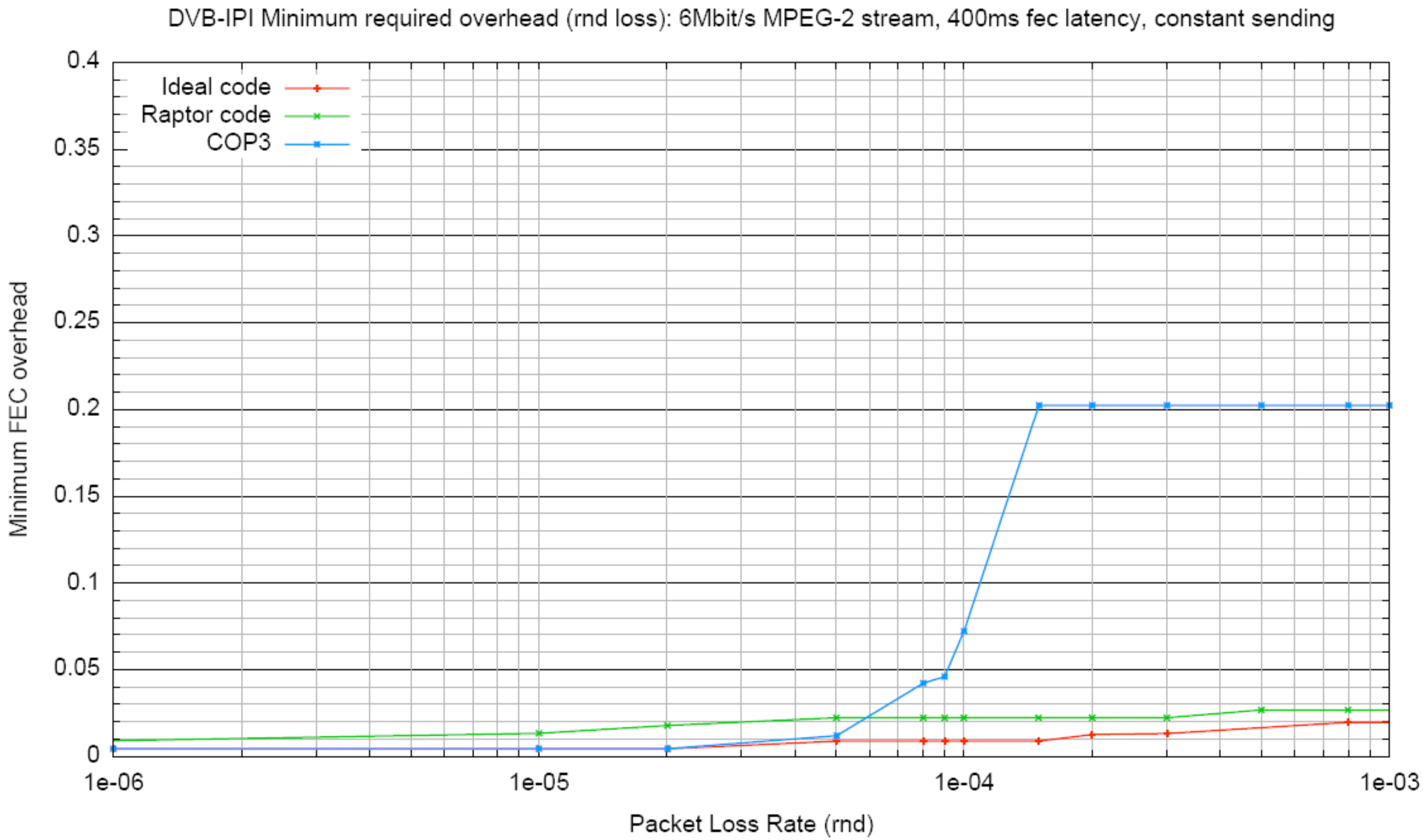
- QOS limits packet loss within the routing nodes
- QOS does nothing for transmission line loss
- Transmission line loss accounts for a statistically higher percentage of packet loss than all other elements combined

  "Video over IP" by WesSimpson (page 238) - 10^{-10} per trunk

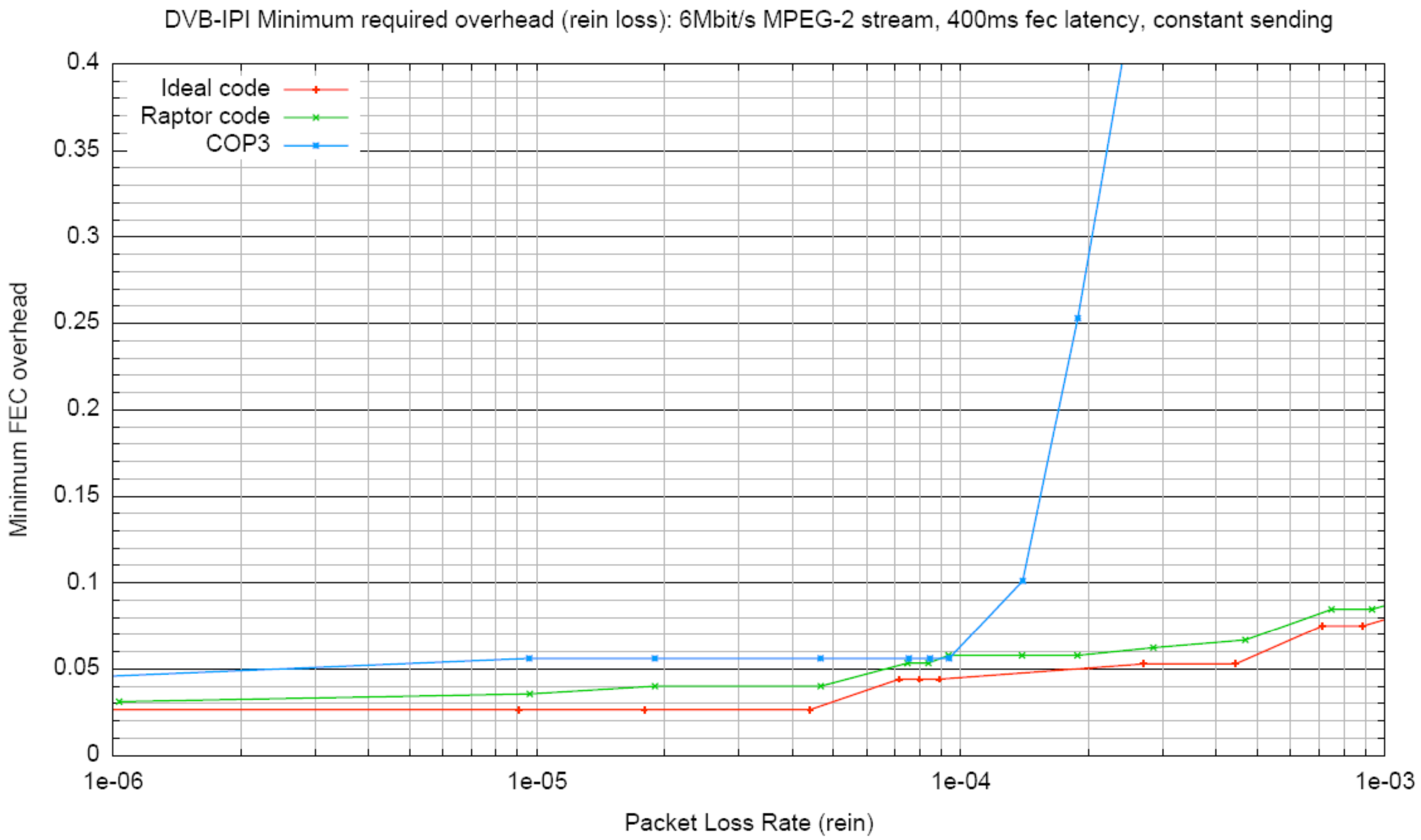
FEC Schemes

- Two dominant players in video today
  - Pro-MPEG COP3
  - Raptor - Digital Fountain
- Most "industry" comparisons look at random loss
- Even Correlated loss comparisons don't consider core network characteristics
  - REIN - Repetitive Electrical Impulse Noise
  - The REIN model results fixed length (8ms) burst losses which are randomly placed in order to achieve an overall loss rate within the 10^{-6} to 10^{-3} loss range of interest.
  - http://www.dvb.org/technology/bluebooks/a115.tm3783.AL-FEC_Evaluation.pdf

Pro-MPEG vs Raptor for Random Loss



Pro-MPEG vs Raptor for Correlated Loss



Comparison Conclusions

- There is a “loss rate threshold” in each case:

  Below this threshold, the Pro-MPEG overhead is very low and close to Raptor (sometimes higher, sometimes lower)

  Above this threshold, the Pro-MPEG overhead is significant (always much higher than Raptor overhead).

  The threshold is around 10-4 Packet Loss Rate (actually between 5-5 and 2-4), depending on the case

  < 8ms of correlated packet loss

Comparison Conclusions

- The results show the overhead required by the “best” configuration parameters for the Pro-MPEG COP3
- These were chosen by searching through the various possible configurations (including row packets only, column packets only, both row and column packets and different matrix sizes) and reporting only the lowest overhead which achieved the required quality.
- This means that the choice of code was based implicitly on complete knowledge of the loss rates and patterns in each case.
- No such restriction existed in configuring Raptor

Correlated Packet Loss

- 8ms is not representative of network-induced correlated packet loss
- Pro-MPEG does not appear capable of addressing any network-induced correlated packet loss
- Raptor can provide protection for larger correlated packet loss intervals

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Summary

- Modern IP routers/networks are well suited for high-quality audio and video transmission
- QOS can provide an appropriate safety-net to ensure high-quality transmission even under congestion
  - Modern router architectures vary in performance
- IP unicast and multicast are currently being used for IPTV, production, and broadcast quality video
- FECs offer an additional layer of protection for random and some correlated loss
  - FEC codes vary in performance

