Network-Scale Virtual Output Queues

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Agenda

- IVN QoS
- Causes of Latency and Packet Loss
- Queues and Networks
- Intro to VOQs
- VOQ Behavior Analysis
- Shaping Algorithms
- Conclusions
In-Vehicle Network QoS Objectives

• Bounded latency
• Minimal packet loss
What causes latency?
What Causes Packet Loss?

- Bit errors
  - $10^{-12}$ BER—1/12,000,000 lost packets
- Buffer overruns
  - 10:1 rate disparity—9/10 lost packets
Congestion is the Real Problem

• Increases queue occupancy
• Increases risk of packet loss
A Network of Queues

- servo commands
- display information
- distributed processing
Rate Limits Prevent Congestion

- servo commands
- display information
- distributed processing
Sources of Traffic
Head-of-Line Blocking
Virtual Output Queues
More About Chassis Fabrics

• Non-blocking
  • Clos topology

• Single priority
  • priorities handled by ingress VOQs

• Shallow buffers
  • well-behaved ingress
Applying Chassis Concepts to IVNs

• Commonalities
  • mostly-static topology
  • small buffers in network & destination

• Differences
  • traffic patterns
  • non-blocking fabric
Network-Scale Virtual Output Queues

- Applied to network endpoints
  - equivalent to chassis ingress
- One output queue per connection
  - “connection” = “two communicating software processes”
- Shaped output queues
- Shapers tuned to connection requirements
Source Endpoint Characteristics

- Unbounded source buffer size
- Unlimited enqueue bandwidth
- Multiple packets per queue entry
Separate Transmit Ports
Shared Output Queue
Separate Output Queues
Comparison

shared output queue:

separate output queues:

- 1.8x latency
- 0.2x latency
Downstream Bridge

receive port → transmit port 0
receive port → transmit port 1

Ingress Endpoint Shared Output Queue:

Ingress Endpoint Separate Output Queues
Shaping Algorithms

- Asynchronous
  - ATS, CBS
    - doesn’t really matter
- Synchronous (TAS) adds unnecessary complexity
- Transmit rate $\leq$ configured rate
  - no queue depth growth
- Benefits greatly from network-wide bandwidth planning
VOQs and 802.1Q

- 8-queue limit
  - Tied to VLAN priority field
- VOQs operate at endpoints, not bridges
- 802.1Q does not apply
Conclusions

• Chassis and IVN share some characteristics
• Precision ingress rate controls prevent congestion
• VOQs solve head-of-line blocking
• VOQs reduce average latency
Questions?
Thank You