Necessity of Network-Application Collaboration in Wireless Access Scenarios

(draft-meng-tsvwg-wireless-collaboration)

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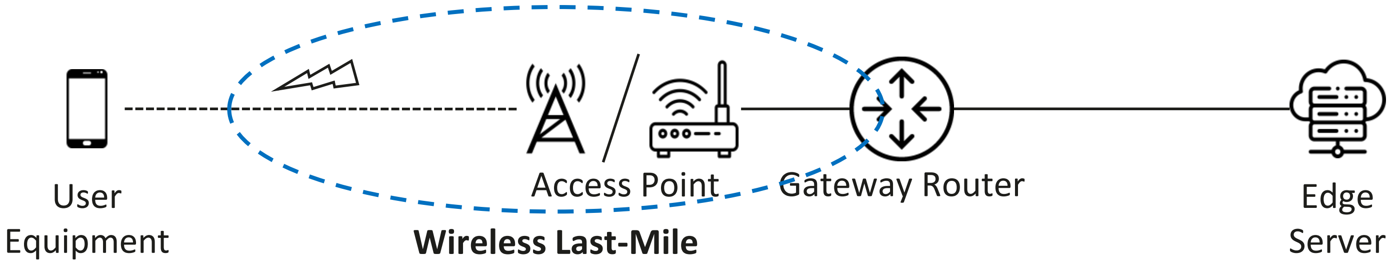
Many Drafts on How to Accomplish App-Net Collaboration

- RFC 9419 on Path Signals
  - Design Principles
- SADCDN
  - Append network-host signaling in-band with data packets
- CIDFI
  - Network-server signaling relayed by client
- FAST
  - IPv6 Hop-by-Hop option
- MED
  - UDP Option
- …

Scope

- **Scenario: Interactive and immersive (Metaverse) applications with wireless access links**

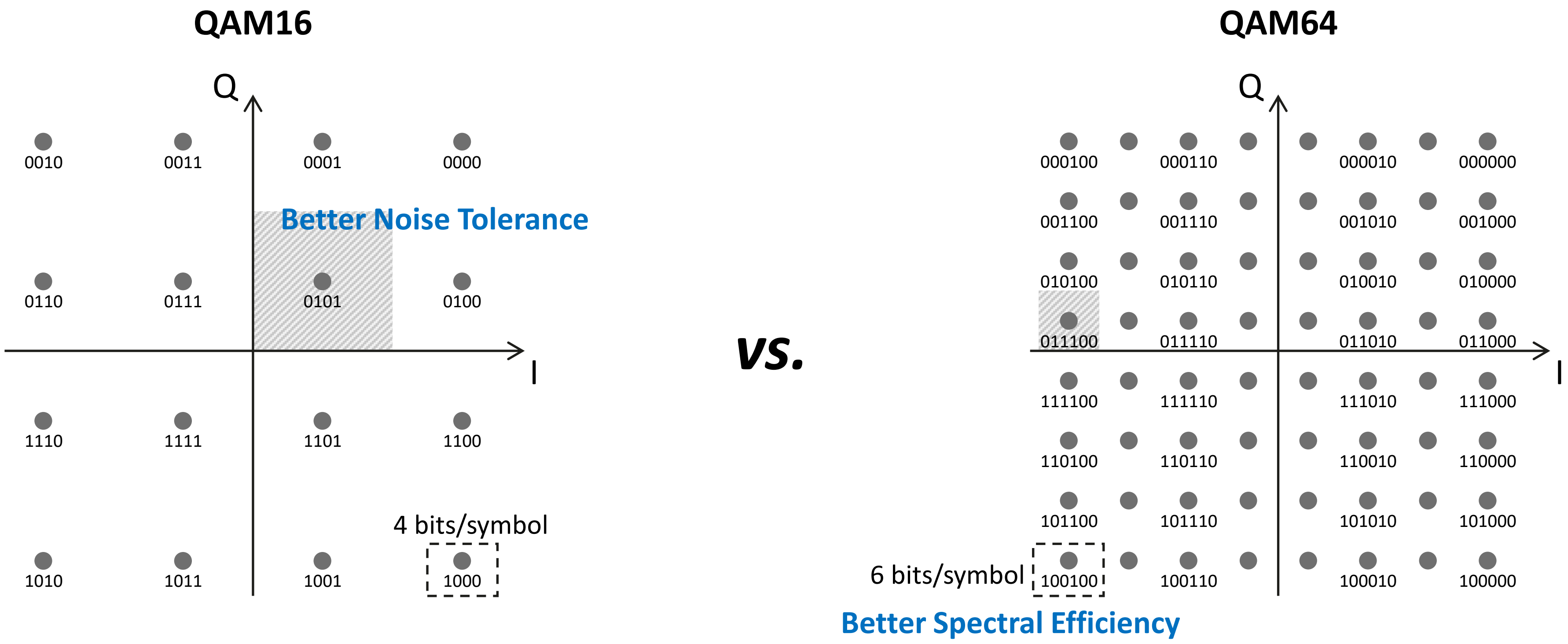


- **Immersive:** ultra-high bw
  - 30-100+ Mbps bitrate
- **Interactive:** ultra-low latency
  - 20-50 ms for transport

- What we discuss:
  - > Why application-network collaboration is necessary
- Out-of-scope:
  - > how to accomplish application-network (host-network) signaling

Tradeoffs to Mitigate/Compensate Inherently Unreliable Wireless Links

- Modulation and Coding Scheme (MCS)
  - > Higher-order modulation, less coding redundancy → Higher spectral efficiency, larger bw upper bound, but higher loss



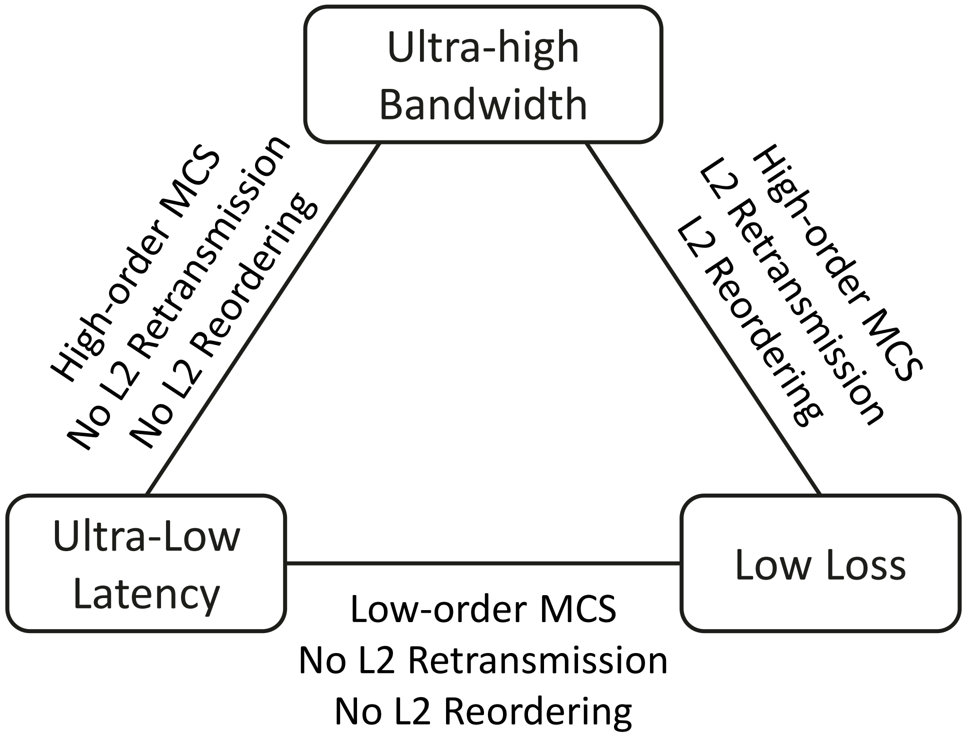
Tradeoffs to Mitigate/Compensate Inherently Unreliable Wireless Links

- Modulation and Coding Scheme (MCS)
  - Higher-order modulation, less coding redundancy → Higher spectral efficiency, larger bw upper bound, but higher loss
- L2 retransmission
  - Exposes lower loss rate to transport layer and above, but increases tail latency
  - Causes out-of-order delivery
- L2 reordering
  - Guarantees in-order delivery, but further increase tail latency
  - May cause throughput degradation to congestion control

Tradeoffs of Wireless QoS

- A single pervasive wireless QoS cannot efficiently guarantee high bandwidth, low latency, high reliability at the same time

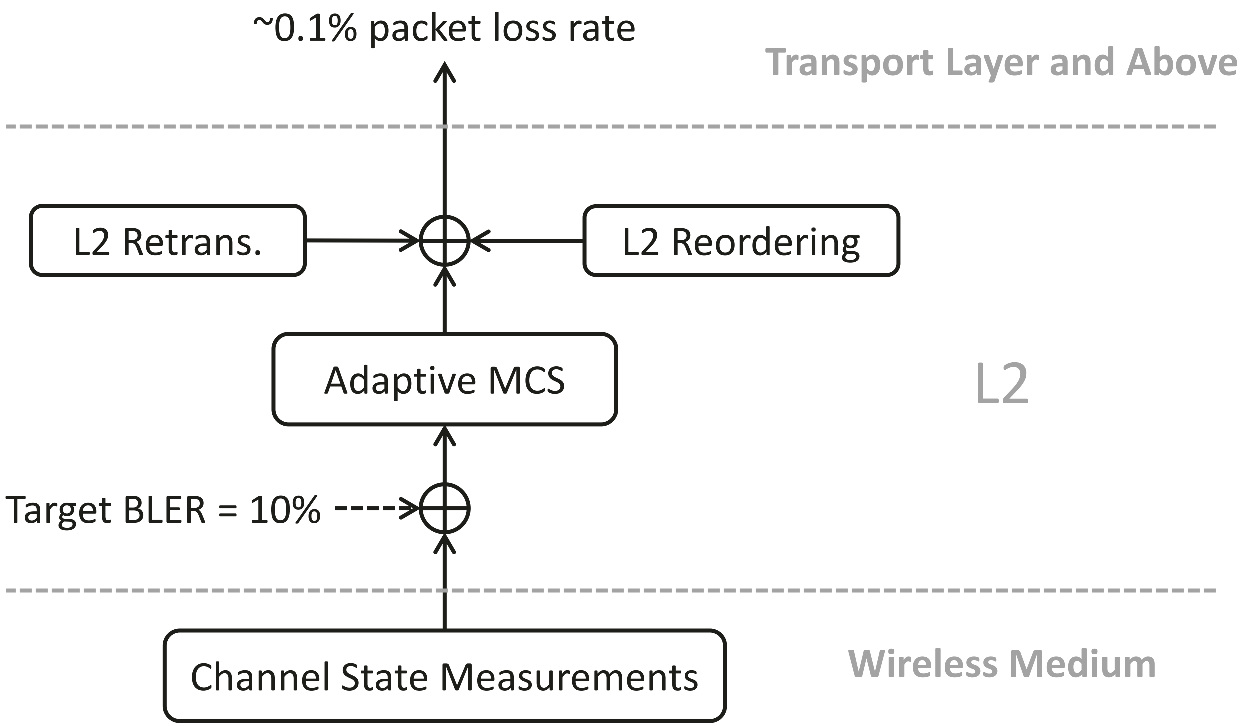
QoS Objective	Wireless Configurations
High spectral efficiency	• High-order MCS
Stable and low latency	• Disable L2 retransmission and reordering
Low loss	• Low-order MCS, OR • Enable L2 retransmission with reordering



AS-IS: Default Cellular Wireless Configuration

MCS adaptively set to satisfy a 10% low-layer transport block error rate

MAC retransmission with reordering



Pros:

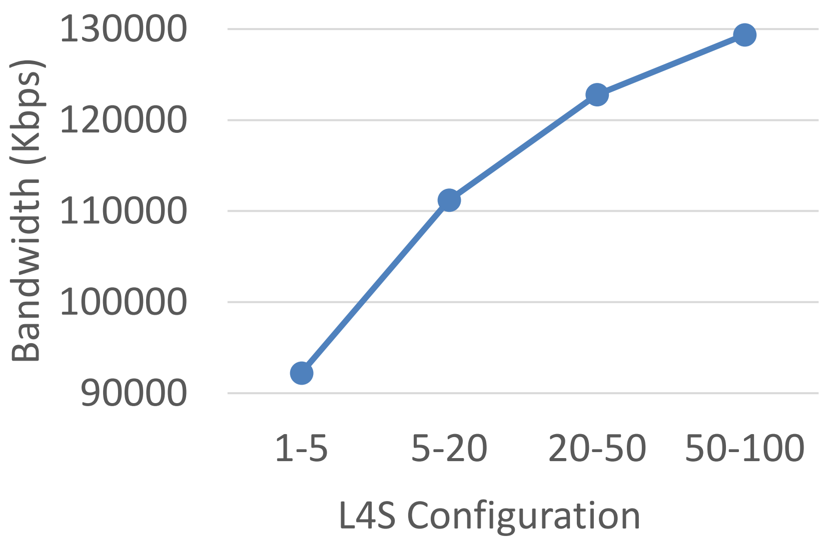
- Almost no random transport-layer packet losses in most cases
- Traditional TCP runs well

Cons:

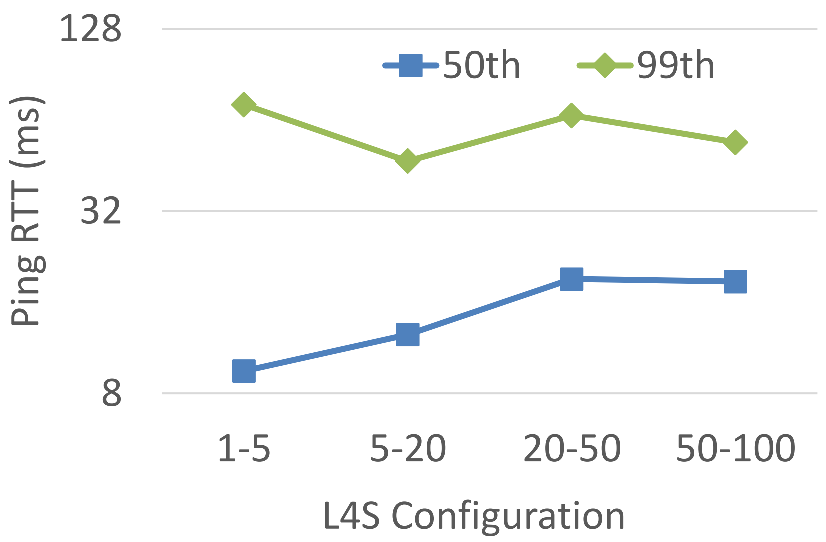
- Tail latency above 100ms even for 5G
- Application-layer mechanisms (e.g., WebRTC jitter buffer) do no help

L4S Atop Default 5G QoS Cannot Efficiently Guarantee Ultra Low Wireless Latency

- RED-style ECN marking at 5G gNB (low CE marking threshold – high CE marking threshold)
- IPerf using BBRv2 for bandwidth, concurrent ping for RTT
- LOS path near gNB, no neighbor cell interference, no background traffic



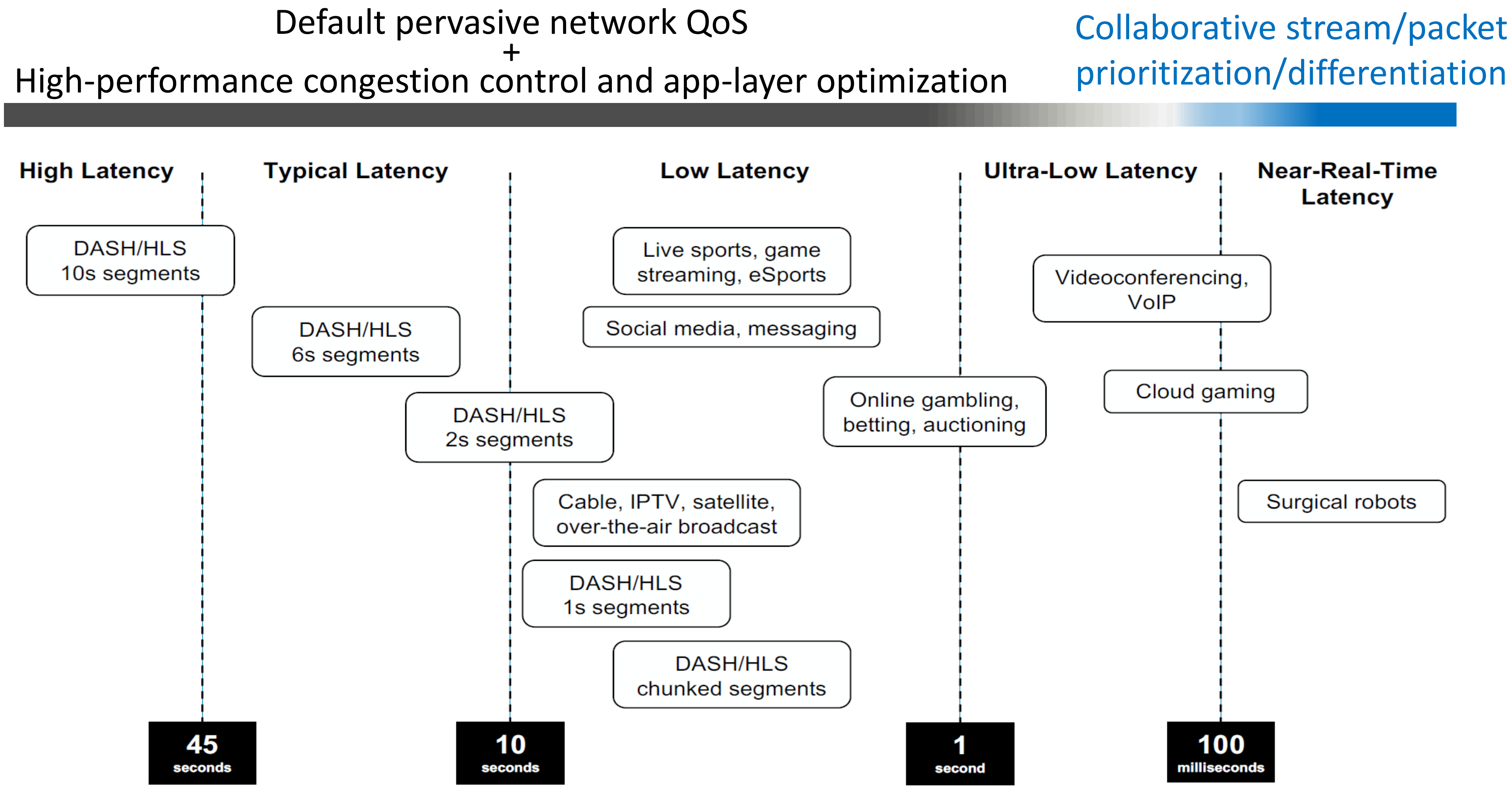
Ultra latency sensitivity comes with 30% lower utilization



Tail latency limited by L2 retransmission/reordering

Cannot efficiently satisfy high-bandwidth low-latency requirements of interactive immersive Metaverse applications

App-Net Collaboration Needed



Abdelhak Bentaleb, et al. *Toward One-Second Latency: Evolution of Live Media Streaming*

Thank You