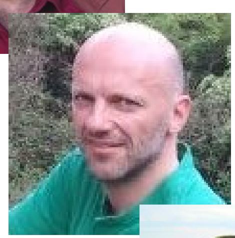
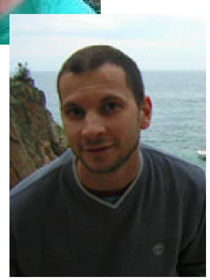
Low Latency, Low Loss, Scalable Throughput (L4S)

Problem Statement

draft-briscoe-tsvwg-aqm-tcpm-rmcat-l4s-problem





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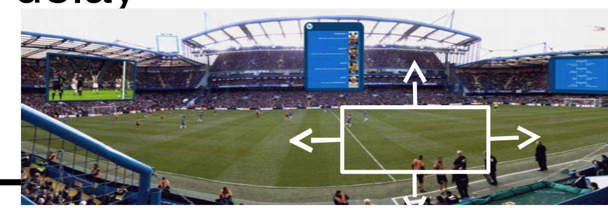
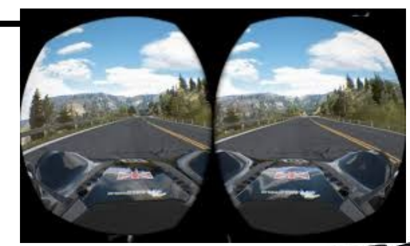
The application performance problem

- increasingly *all* of a user's apps at one time require low delay

  - online gaming
  - voice
  - conversational video, interactive video



  - virtual reality, augmented reality



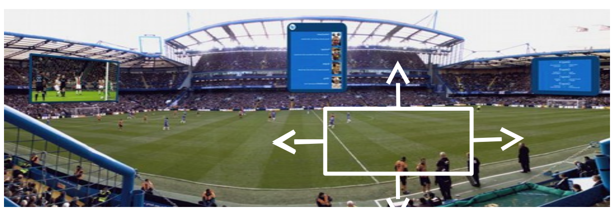
  - instant messaging
  - interactive Web, Web services
  - remote desktop, cloud-based apps

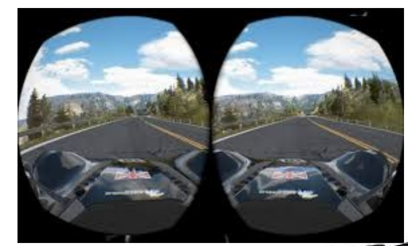
- Need a new service for *all* Internet traffic to transition to

- caches have cut base (propagation) delay, where they can
- queuing remains a major component of delay, albeit intermittent
  - under load, delay roughly doubles,
    even with state-of-the-art queue management tuned for your current base RTT

The deployment incentive problem

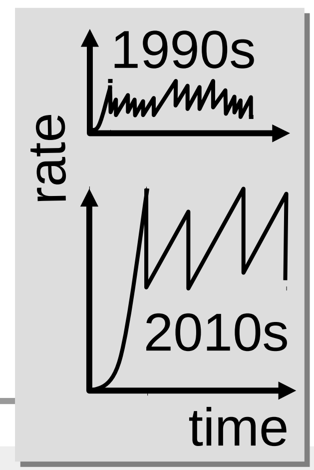
- Significantly better – not just incremental
  - worth the deployment hassle
  - enable valuable new products and services



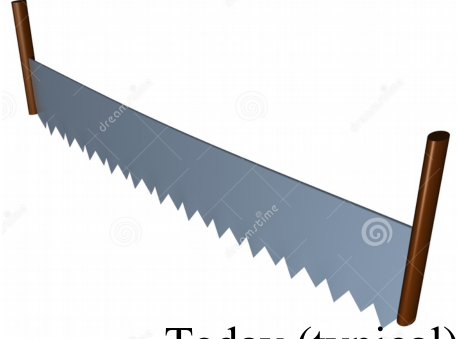


The technology problem

- More access bandwidth?
  - does not address queuing delay
- Differentiated services (Diffserv)?
  - only cuts delay for some packets at the expense of others
- Per-flow queuing?
  - isolates one flow from the delay of another, but not from its own
  - requires L4 header inspection and significant processing expense
- Active Queue Management (AQM)?
  with Explicit Congestion Notification (ECN)?
  - on the right track, but the root problem is beyond AQM control...
- …'Classic' TCP (not the network) determines queue delay
  - to go faster, its saw-teeth get bigger (unscalable)



New word: Classic TCP =
Reno congestion control [RFC5681] & friends: Cubic, SCTP, QUIC, etc.



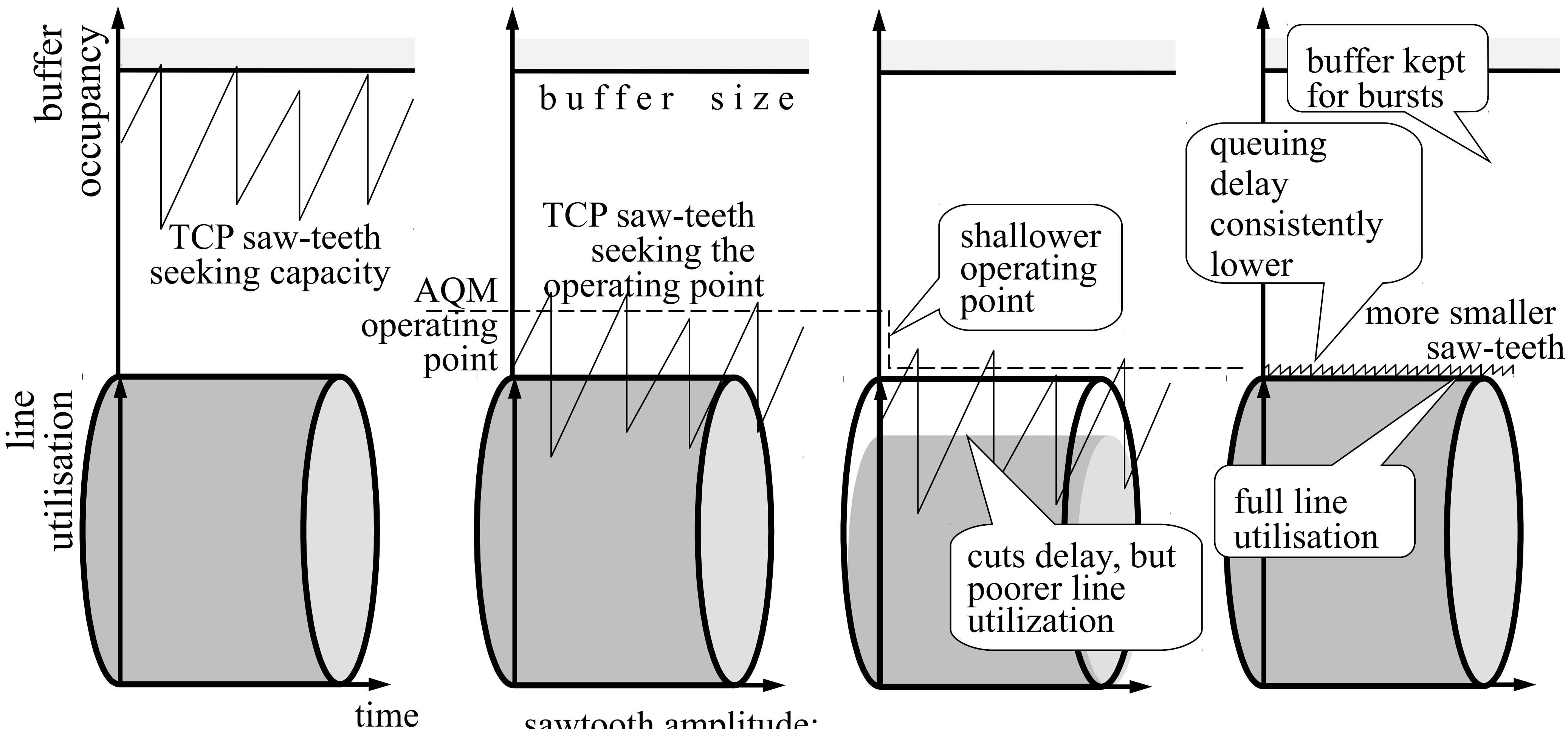
The Classic TCP dilemma: delay vs. utilization

Today (typical)
TCP on end-systems
Drop-tail buffers

Today (at best)
TCP on end-systems
AQM at bottlenecks

delay-utilization
dilemma

A Scalable TCP
Resolves dilemma
Have to change TCP



sawtooth amplitude:
~1 'typical' base RTT
(round trip time)

Actually, it's a Hexlemma

- Three impairments:

- Three wider issues:

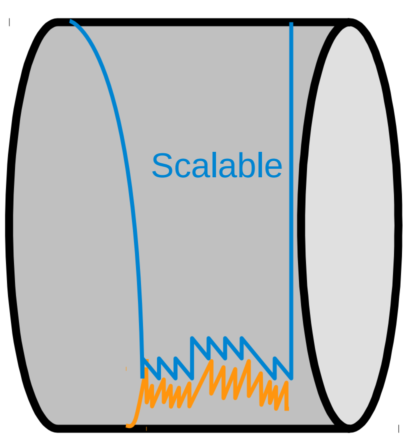
- If AQM reduces one, TCP increases the others

New word: hexlemma =
like a dilemma, but between six things

Fine saw-teeth
are only feasible...

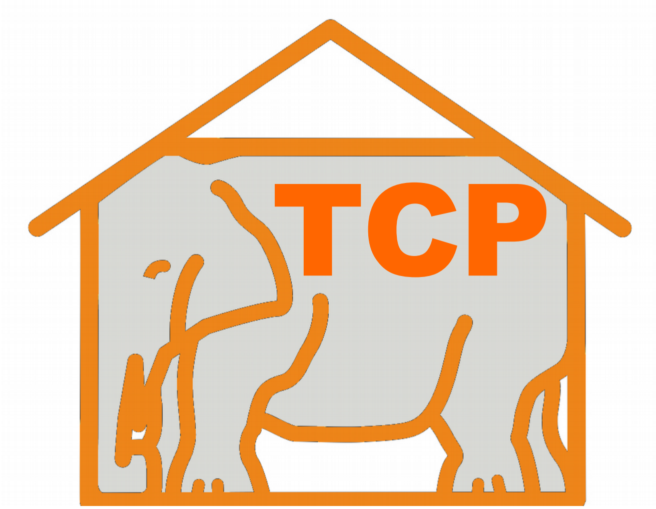
1) if drop is not used as the congestion signal
   - drop would be too frequent
   - need explicit congestion notification (ecn)
     - and not “the same as drop” [RFC3168], otherwise coarse saw-teeth

2) if the 'coexistence problem' is solved
   - one 'Scalable' flow with frequent sawteeth looks like many 'Classic' flows to a 'Classic' TCP flow
   - so the Classic flow starves itself



Problem: very high level summary

- Problem: Classic TCP is the elephant in the room
- Solution: build another room without the elephant



Solution: very high level summary

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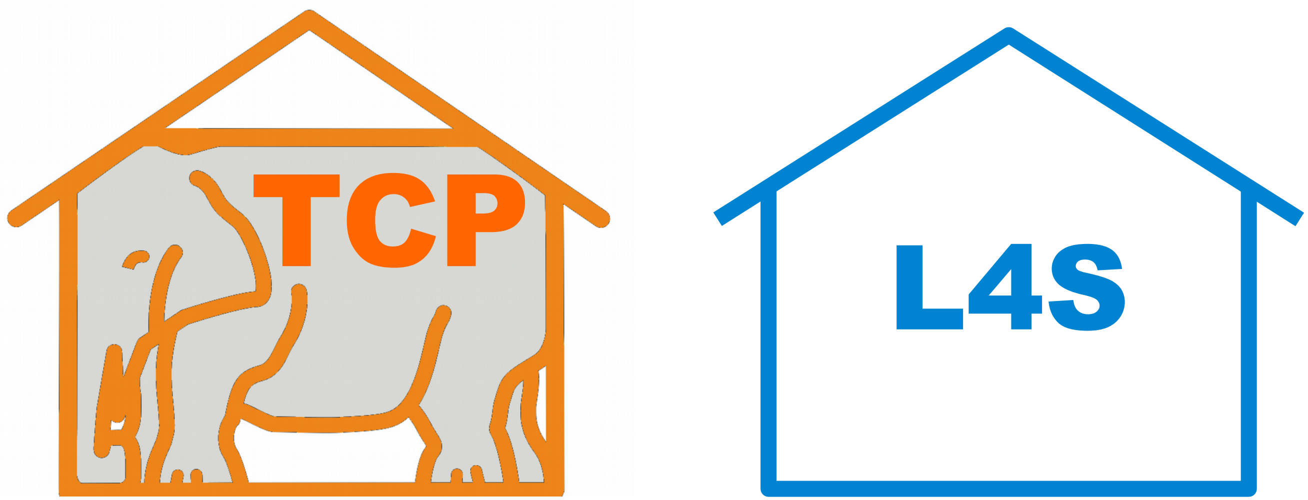
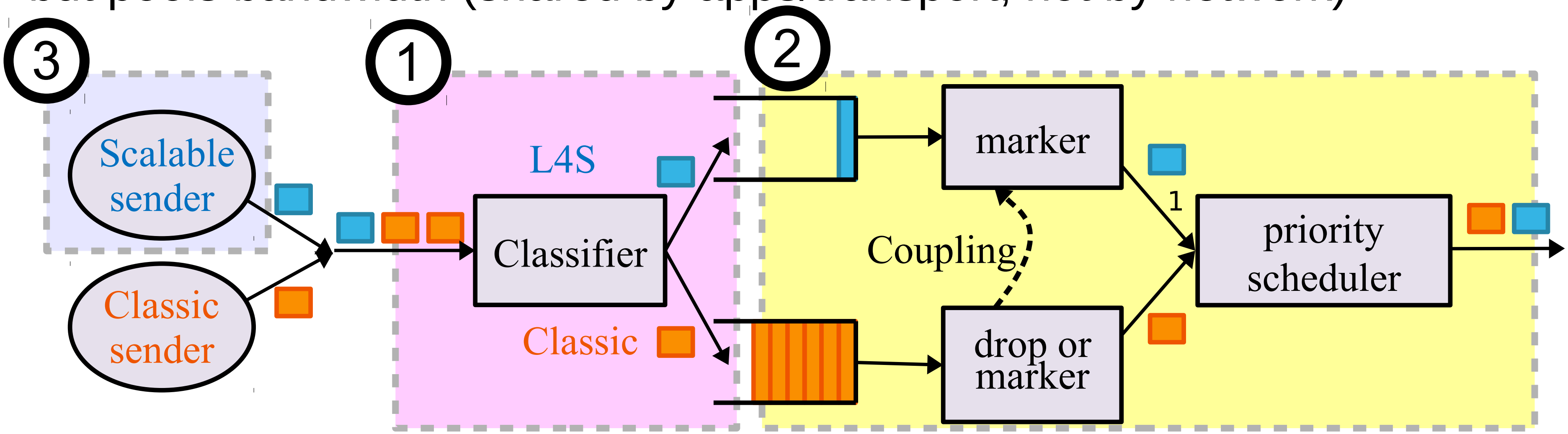
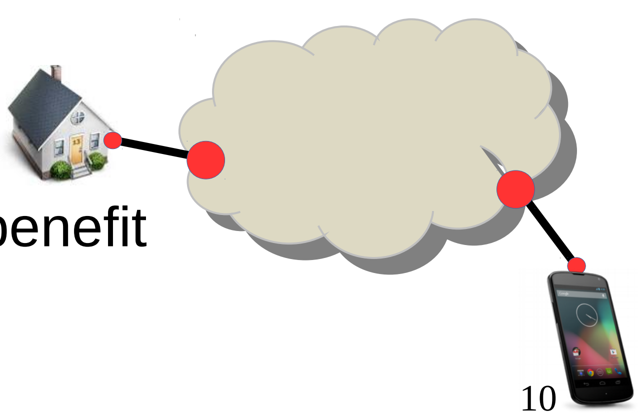


Coexistence: Solution Architecture

- DualQ Coupled AQMs: a 'semi-permeable membrane' that:
  - partitions latency (separate queues for L4S & Classic)
  - but pools bandwidth (shared by apps/transport, not by network)



- per 'site' (home, office, campus or mobile device)
  - typically one access bottleneck in each direction
  - deploying DualQ here should give nearly all the benefit



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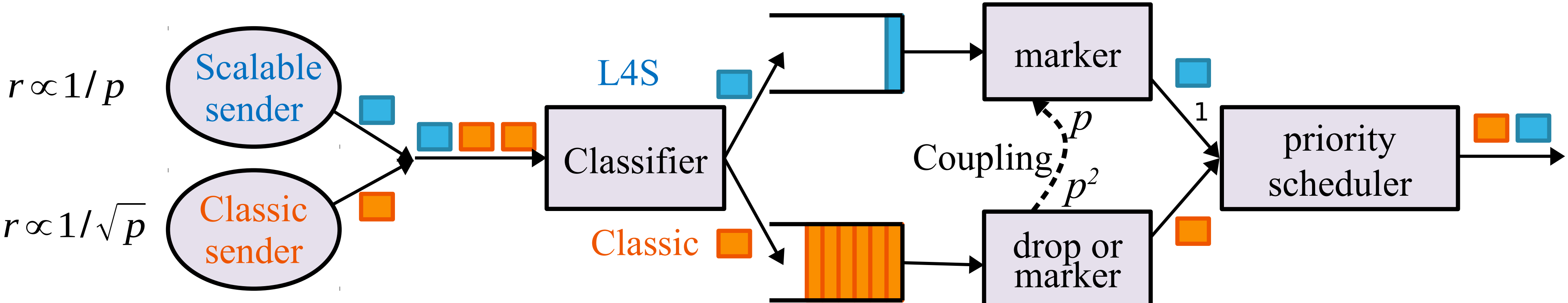
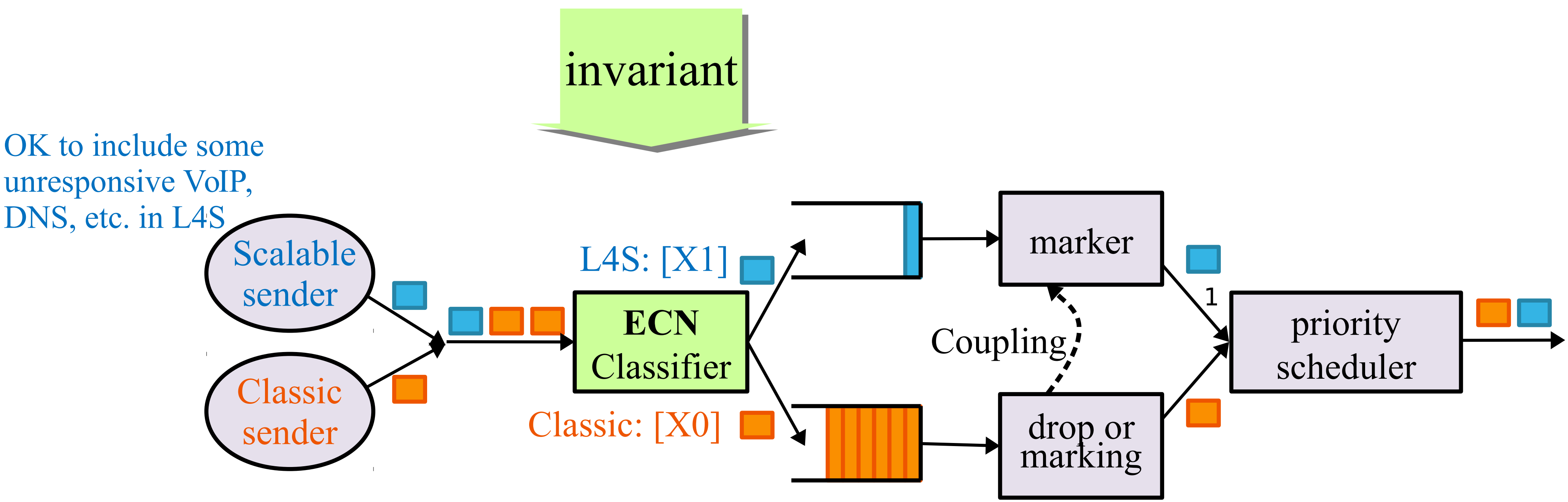


r: packet rate
p: drop/mark probability

Framework for Diverse Solutions

- The DualQ Coupled AQM draft is structured as a framework
  - pseudocode of concrete examples in the appendices



many scalable algorithms already:

DCTCP, Relentless, S-SCREAM, etc. (not yet with safety features–see later)

Classify

at IP layer or lower

2 different classic AQMs already implemented:

Curvy RED & PIE

2 different schedulers already implemented:

strict priority & MEDF

very high level summary

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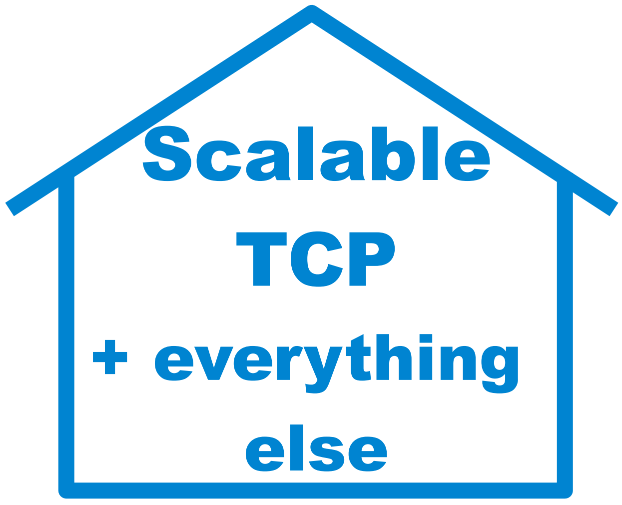
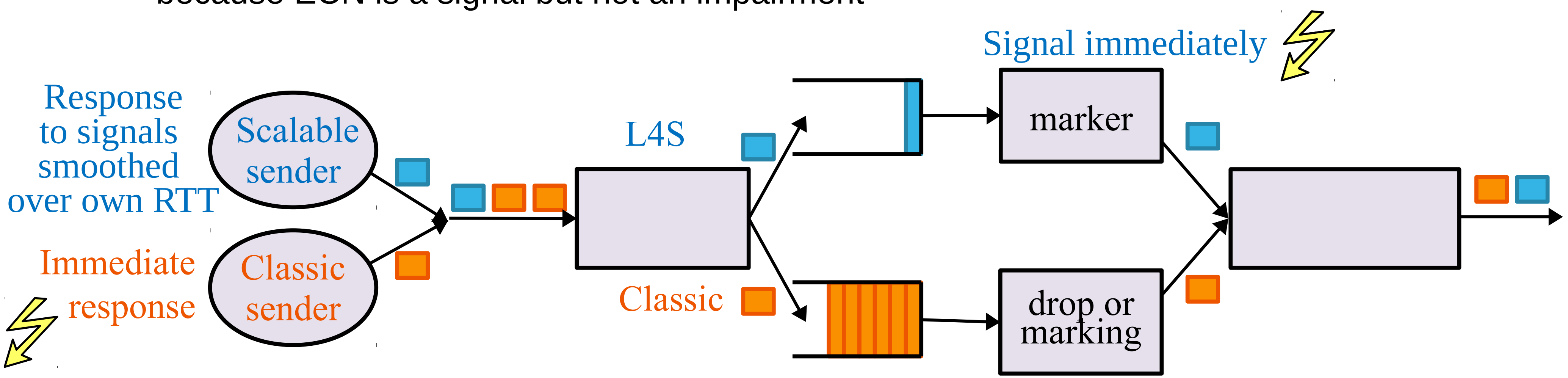


Q&A

large saw teeth can ruin the quality of your experience

Why is performance so much better?
Immediate signalling

- Today's AQMs defer drop for ~100ms
  1) to allow time for a worst-case RTT response
     because: the network doesn't know each packet's RTT
  2) to avoid drop unless the queue proves persistent
     because: drop is an impairment as well as a signal
- Using ECN for L4S makes it feasible to signal immediately
  - because ECN is a signal but not an impairment



Problem with the Classic approach:
a flow with RTT=5ms
gets no signal for 20 round-trips

related problems L4S also addresses

- incremental deployment of low delay DCTCP
  - within & between data centres with no unified control
- near-zero congestion loss
  - for short flows, loss translates to timeout and retransmit delay
- incremental deployment of scalable congestion controls
  - 'Scalable' = invariant recovery time
  - TCP Reno [RFC5681]: unscalable
  - TCP Cubic: less unscalable