WP2: Experimentation

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measurement and architecture for a middleboxed internet

measurement architecture experimentation

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Objectives

- Middlebox classification and modeling
  - based on analysis of data collected in WP1
  - simulation of middlebox behavior based on this model
- Validation and experimentation
  - Experimentation with low latency support via MCP
  - fd.io based passive measurement of encrypted protocols

Who Does What?

Partner	MM	Task 2.1 Middlebox Classification	Task 2.2 Middlebox Modeling	Task 2.3 NFV-based Experimentation	Task 2.4 Validation of Approach
ETH	6			√	√
ULg	20	√	√		
UoA	6	√			√
TID	10		√	√	
SRL	5	√			√

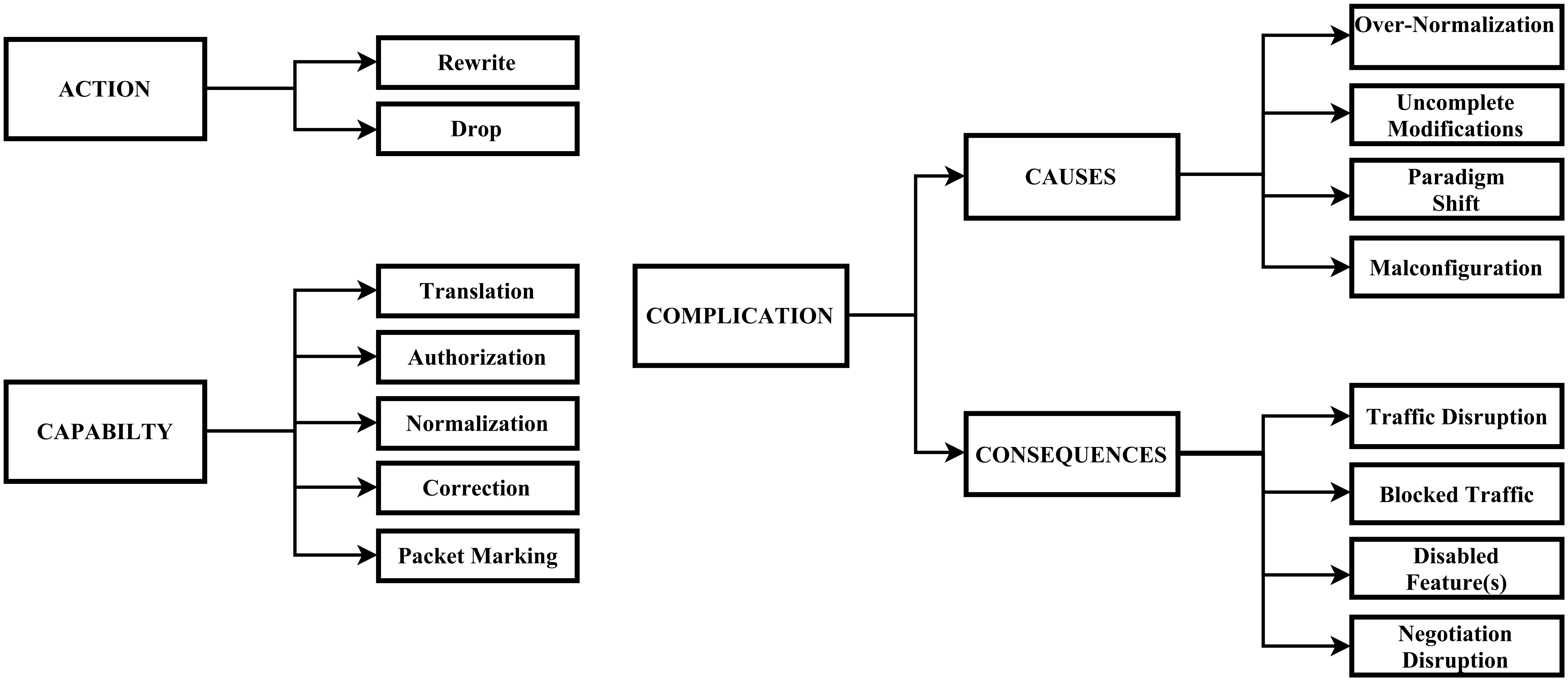
WP2 Classification and Experimentation

- Middlebox Taxonomy based on measurements (see WP1)
- MCP experimentation
  - Initial LoLa support
  - Upcoming: throughput guidance
  - Upcoming: passive measurability using fd.io-based monitors

Taxonomy Global Overview

- A path-impairment oriented middlebox policy taxonomy
  - **capabilities**
    - what the policy expect to achieve
    - its purpose
  - **action**
    - how the policy tries to achieve its goal(s)
  - **complication**
    - the possible resulting path connectivity deterioration

Detailed Vision

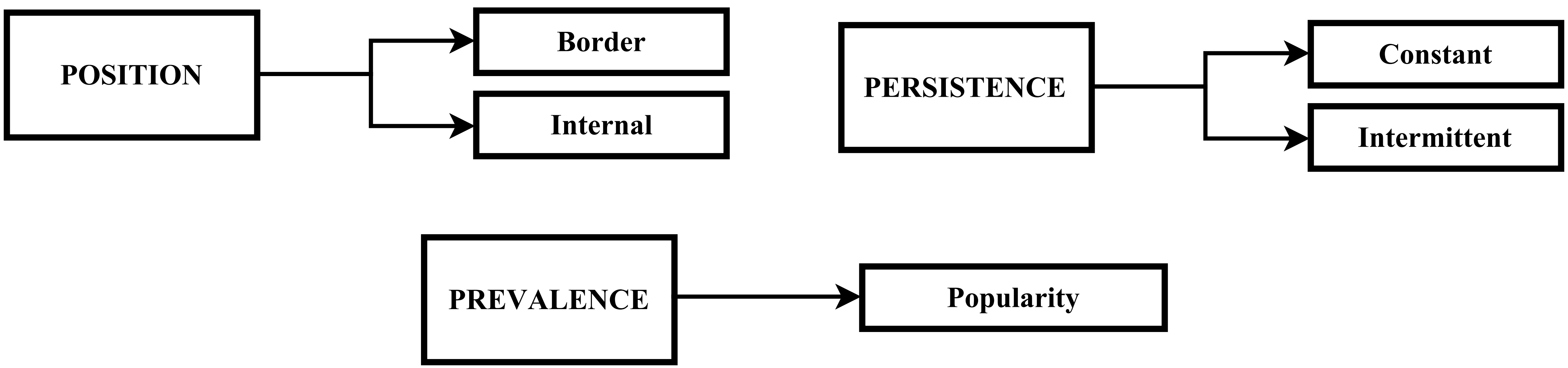


Middleboxes vs. Taxonomy

	ACTION			CAPABILTY							COMPLICATION				
	Rewrite	Drop	Translation	Authorization	Normalization	Correction	Packet Marking	Over-Normalization	Uncomplete Modifications	Paradigm Shift	Malconfiguration	Traffic Disruption	Blocked Traffic	Disabled Feature(s)	Negotiation Disruption
Strip unknown TCP option	X				X			X			X			X	
TCP ISN shuffling	X					X			X			X			
Drops MPTCP		X			X			X					X		
SNAT	X		X						X			X	X		
8-bits DSCP (ToS)	X						X				X	X		X	

Taxonomy Extension

- We add operational characteristics to the taxonomy



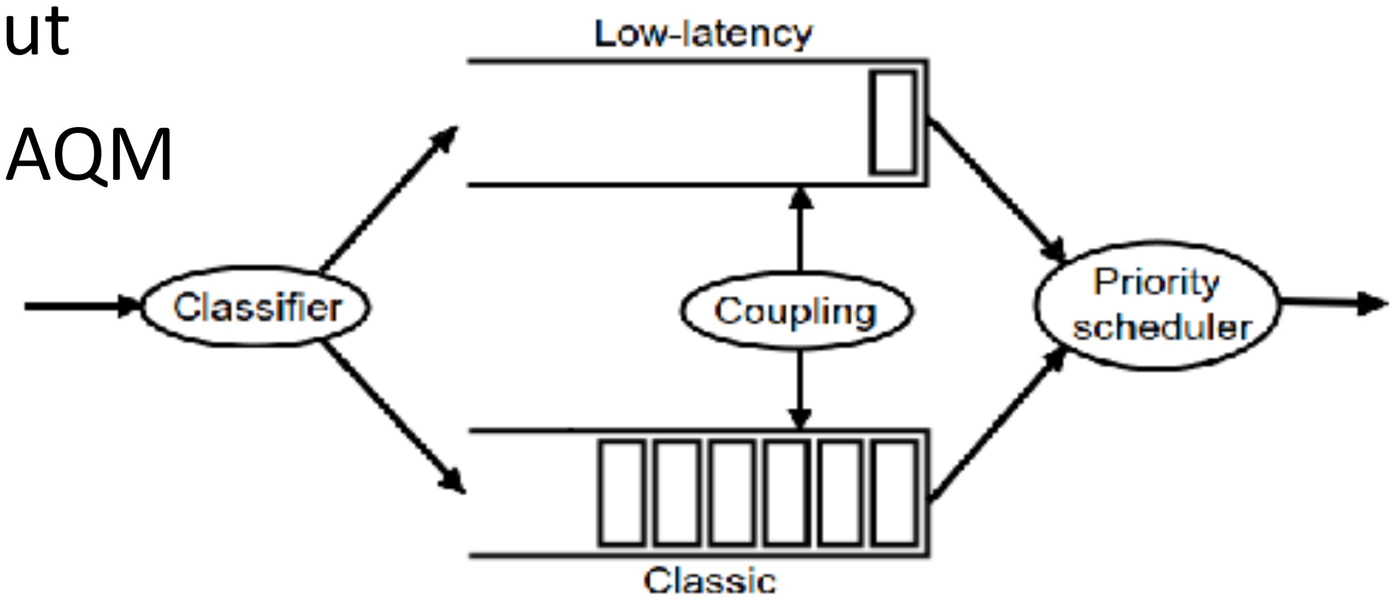
Taxonomy

Capability	
Translation	1.3 %
Normalization	41.0 %
Correction	54.8 %
Packet Marking	2.4 %
Authorization	NA
Unknown	0.5 %

Complication Causes	
Malconfiguration	2.9 %
Incomplete Modification	56.1 %
Over-Normalization	41.0 %
Complication Consequences	
Traffic Disruption	57.2 %
Blocked Traffic	1.3 %
Disabled Features	41.0 %
Unknown	0.5 %

Loss/Latency tradeoff (LoLa)

- A simple, net-neutral, sender to path signal (L bit in PLUS)
  - Traffic separation into 2 classes
  - Trade-off between low latency and high throughput
  - L4S: Dual Coupled AQM



- Application to mobile networks
  - Goal: Efficient use of (scarce) radio resources taking into account the latency budgets of different flows
    - Supporting low latency flows
    - (Possibly) Informing handover strategies

MCP LoLa Analysis

- Simulation
  - NS-3, LTE module
- Emulation
  - Linux, queueing disciplines (qdisc)

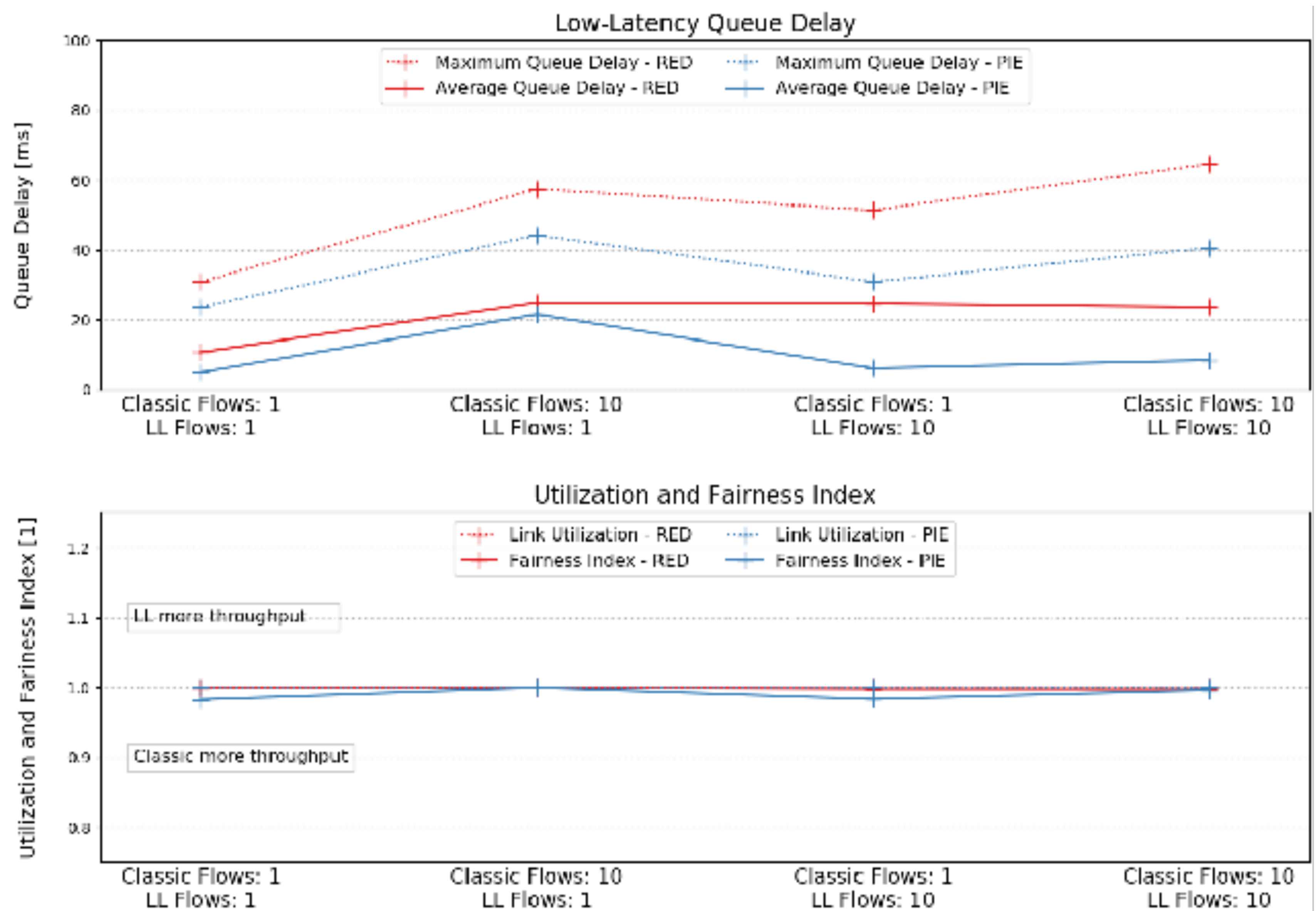
- Expected Benefits in mobile networks
  - High aggregate cell throughput
  - Treat latency sensitive flows as first class scheduling citizens

Evaluation of Low-latency Traffic Separation in ns-3

Scenario (uncoupled)

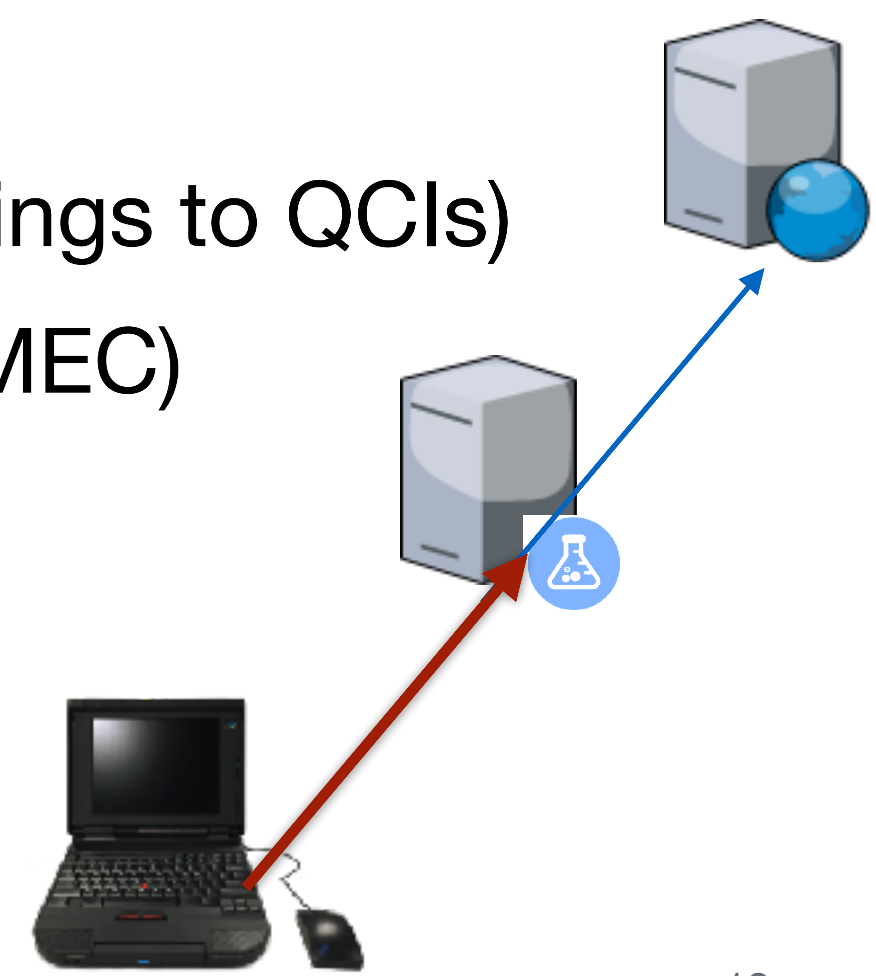
- Fixed link
- AQM with low latency target for Low-Latency Class
- Large buffer for classic flows

➡ Traffic separation can achieve low latency while maintaining high throughput



MCP LoLa Mobile Deployment Scenario

- At the border of the mobile core:
  - In the Packet Gateway (PGW), or
  - As a separate box in the SGi LAN
- Directly in the RAN:
  - In the scheduler (mapping LoLa markings to QCIs)
  - As a Multi-access Edge Computing (MEC) function at the antenna



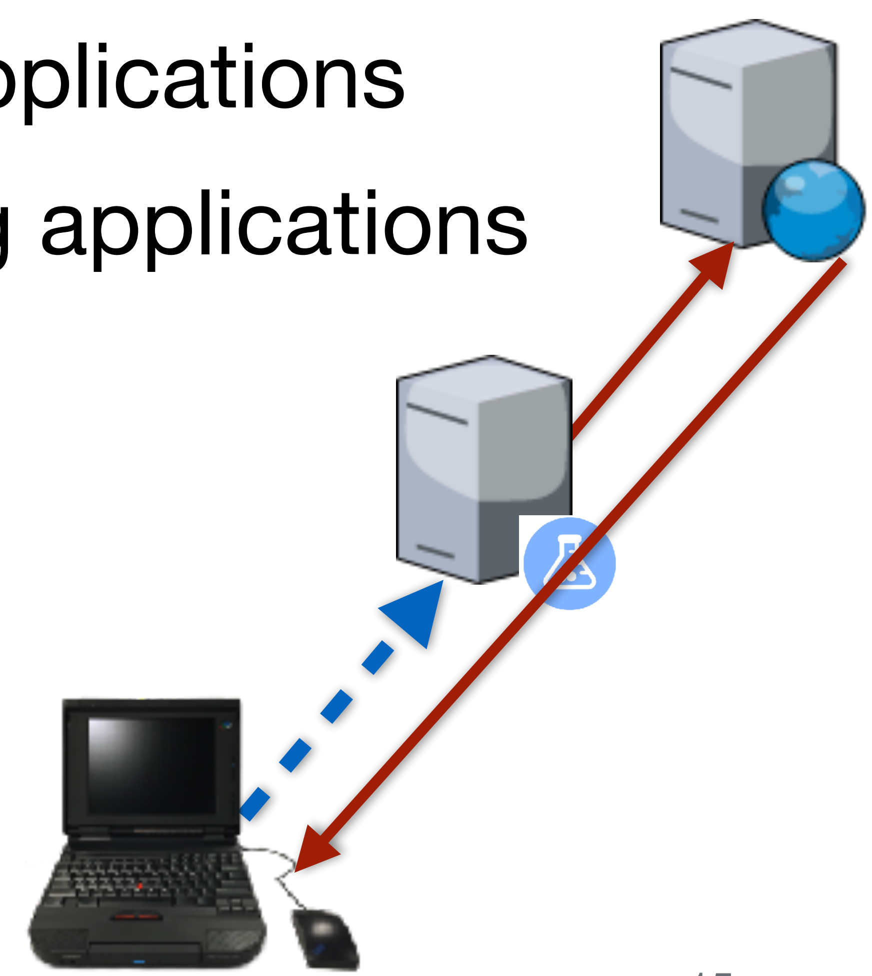
MCP LoLa Current Status

- First round of measurements using emulation and simulation conducted by ETH Zurich and Nokia
- Currently refining the experimental setup and measurement framework (open source)
- Driving activity within GSMA aiming at disseminating the experimental setup and measurement framework within the mobile network operators and equipment vendors community

MCP Throughput/Capacity Guidance

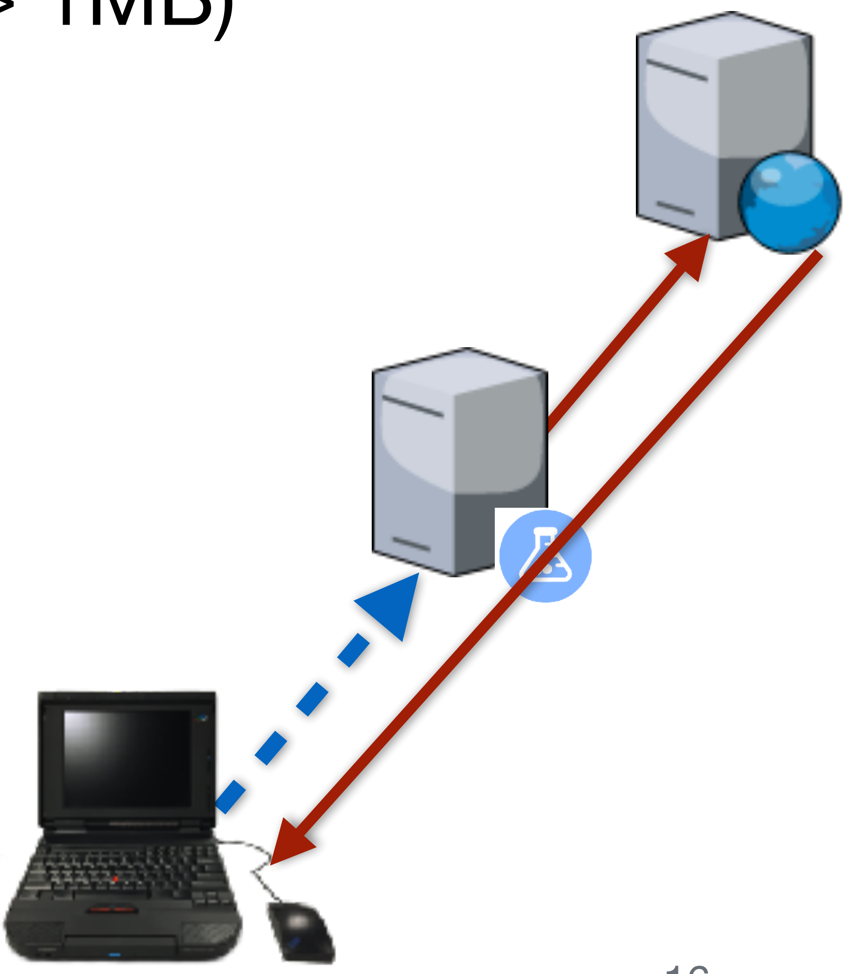
- A MCP router (Path) to receiver signal
  - Enables highly-effective congestion control

- Expected benefits
  - High performance for Low-latency applications
  - High throughput for capacity-seeking applications



MCP Throughput/Capacity Guidance

- Sender enables MCP signalling scratch area
- MCP routers signal about their flows/links
  - Signal link bandwidth/capacity
  - Signal number of active *large* flows (e.g. > 1MB)
- Signal passed to remote endpoint
  - Returned to the sender
- Sender able to adapt TCP parameters
  - cwnd and ssthresh



MCP Guidance Simulation Model

- Model MCP router in NS—3
  - Built within ns-3 Traffic Control (TC) Module
  - Also supports AQM/ECN such as RED, Codel, FqCodel, Mq, Fast Priority FIFO, PIE
  - ns-3 Traffic Control (TC) Module complete
- Model MCP aware TCP endpoints
  - Receiver feedback of received MCP signals back to the sender
  - Sender works with ns-3 TCP CC variants
  - Also can feedback info to applications
- Validation of platform
  - Explore very basic to advanced networking scenarios to make sure platform and models operate as expected; this includes operation of MCP, TCP, SACK, ECN etc

MCP Guidance Status

- Study *deployment* questions
  - When to signal
  - How to handle MCP-aware and/or -unaware bottlenecks
  - Most efficient/useful PCF representation for MTG
- Study *performance* questions:
  - Adjust transport parameters in response (i.e. sending rate)
  - Potential: novel congestion control and flow start mechanisms

- Goal: feed back to MCP design, academic publication

fd.io for passive measurement of encrypted traffic

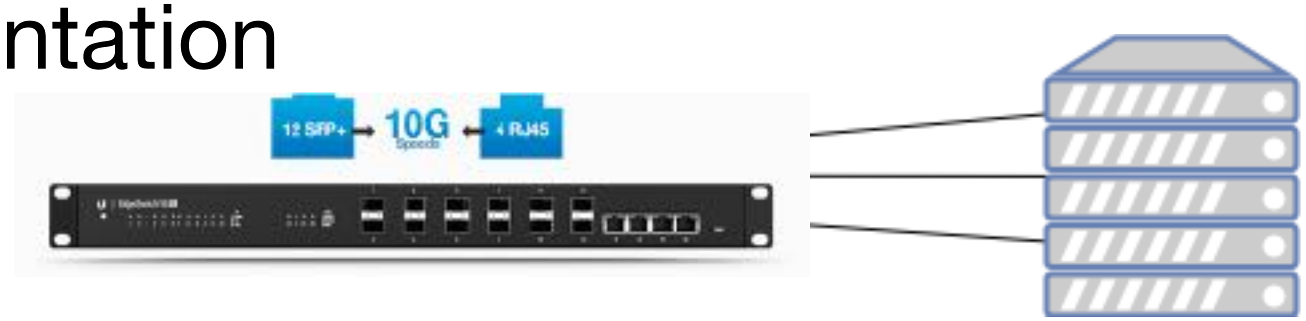
Today: Passive measurement of basic traffic characteristics like loss and latency often rely on information in the TCP header (e.g. SEQ#/ACK# and Timestamp Option)

Goals

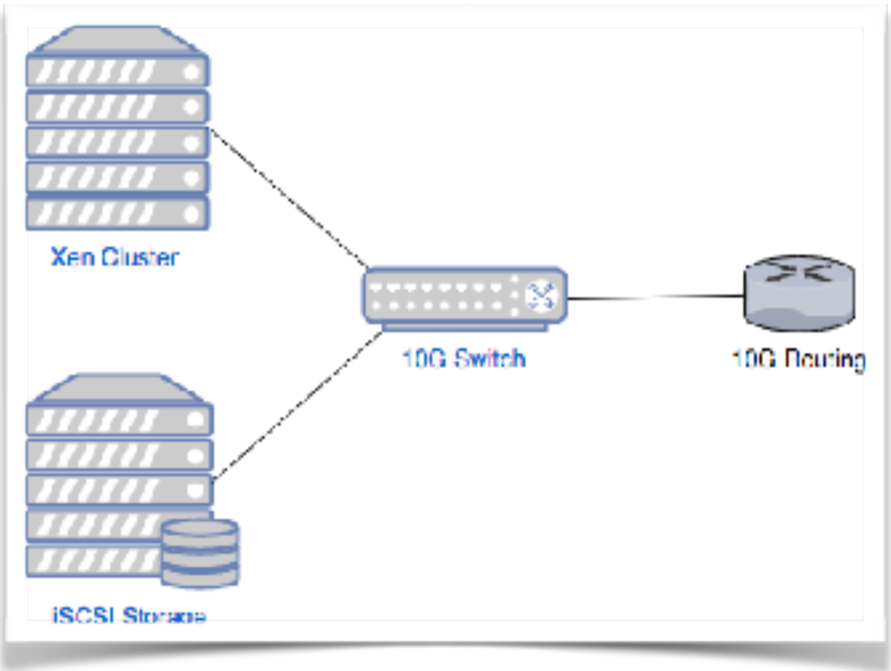
- Provide clear separation of transport functionality from measurement information in the protocol header space
  ➡Simplify the deployment of encrypted transport protocols for network operators
- Analysis of the properties of alternative designs for adding loss and latency measurability back to encrypted transport protocols
  - Overhead (computation and header space)
  - Scalability
  - Accuracy
  - Complexity of the endpoint as well as the network implementation
  - as well as privacy implications
- Investigation independently of a specific protocol design
  ➡Input to the QUIC design process as well as future transport protocol

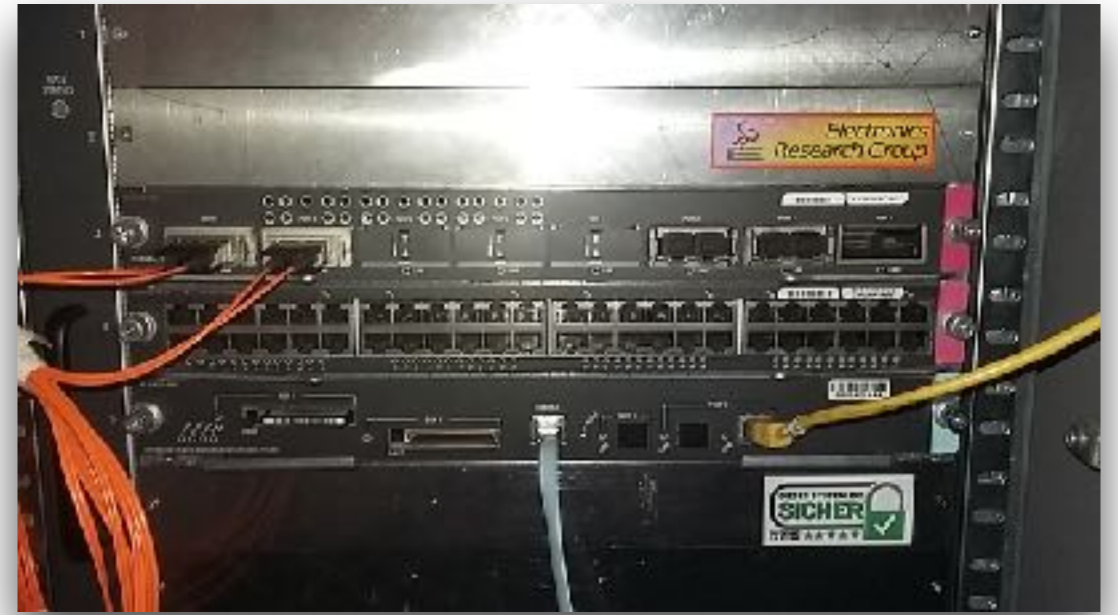
fd.io Testbed at Aberdeen

- Ubiquiti EdgeSwitch 16 XG (12x **SFP+** ports)
- Two **XenServer** nodes (DPDK compatible virtual NICs)
- **Intel X520-DA2** NICs (DPDK compatible)
- Custom *virtual topologies*
- Virtual network function *chaining*
- Dedicated IPv6 address space to mimic real deployment and for routing experimentation



fd.io Testbed Hardware





Publications

- "A First Look at the Prevalence and Persistence of Middleboxes in the Wild" (tracebox) at ITC 29, Genoa, 4-8 Sep 2017 (WP1/WP2)

Summary and Next Steps

- Foundations of middlebox modeling are done.
- Implementation of MB model in a simulator/emulator
  - fd.io implementation for NFV deployment (TID,ULg)
- MCP experimentation and assessment
  - LoLa/MTG experiments are ongoing
  - integration of MCP endpoint/middlebox impl and testing
  - assessment of other cooperation mechanisms