

Congestion Exposure in Mobility Scenarios

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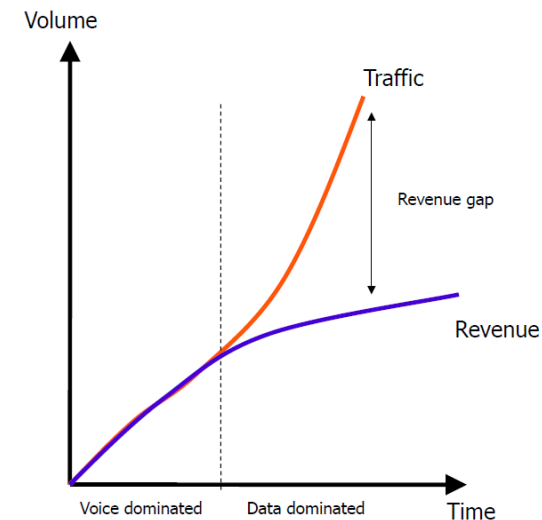
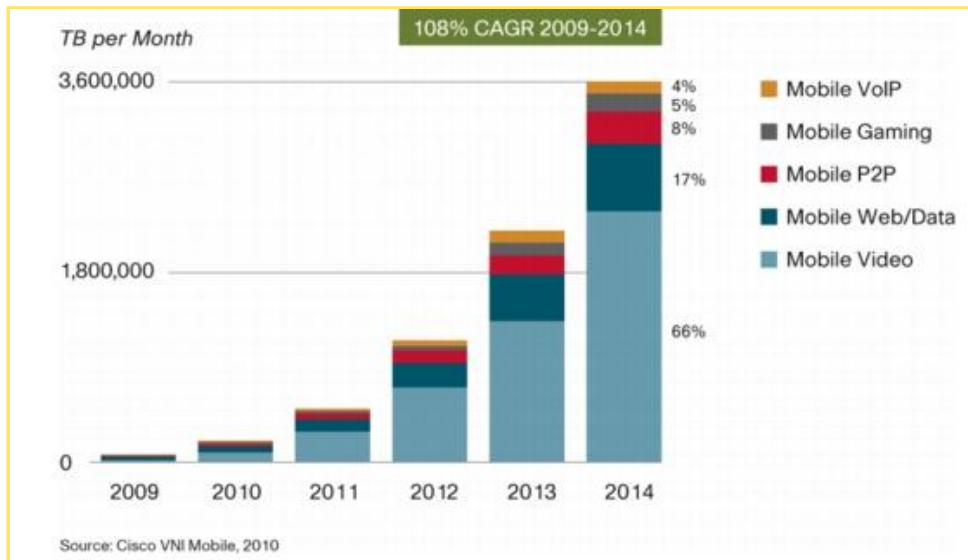
Outline

- Motivation
- Resource Management for Best Effort Data Traffic
- Congestion Exposure (overview) and previous work
- Mobility Aware Packet Marking Controller/Function
- Evaluation Setup
- Conclusions

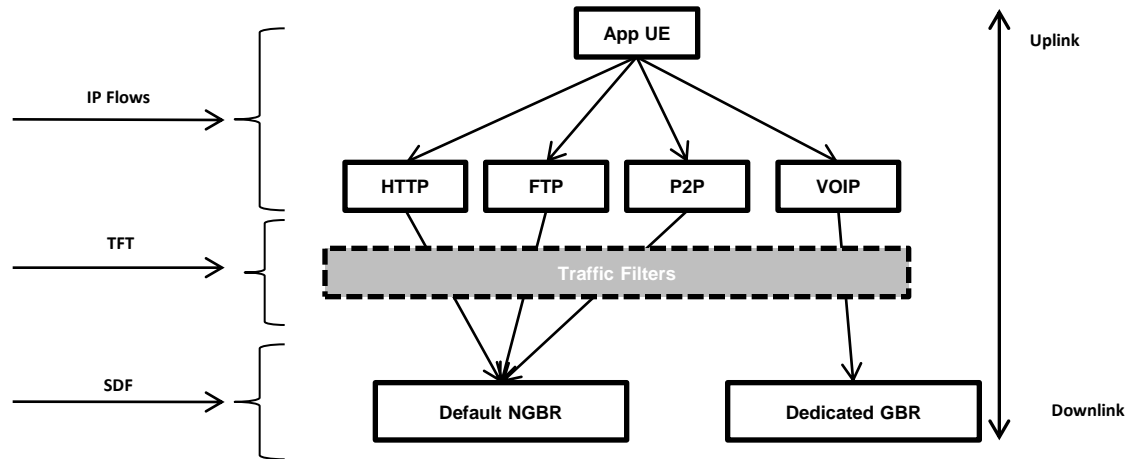
Resource Management for Best-Effort Traffic

Operator-perspective

- Wants to be attractive to customers: high-speed access, ubiquitous coverage, open to all applications, cost-competitive
- Has to match network infrastructure investments to achievable income
- Has to manage network resources to keep network usable for all users



Possible approaches for Best Effort Traffic (1/2)



Existing approaches can be classified (loosely) as: Static and Dynamic

Static approaches have problems:

- Volume Cap
- Deep Packet Inspection & Filtering
- Traffic filter templates in 3GPP PCC
 - Static configuration of QCI classes

Limitation: Network congestion and Resource availability is not taken into account

Possible approaches for Best Effort Traffic (2/2)

Dynamic approaches

- Takes into account resource usage and capacity into account
- The scheme kicks in dynamically based on parameters of interest

Comcast Congestion Management

- Protocol and Application agnostic
- Possibly applicable to any network: wired or wireless
- Based on periodically monitoring resource usage of individual users

Congestion Exposure

- Users are made accountable to congestion they cause on other users while sharing the network resources not based on resource usage alone:
Cost Fairness

General Approach: Congestion Exposure

Make congestion in the network visible

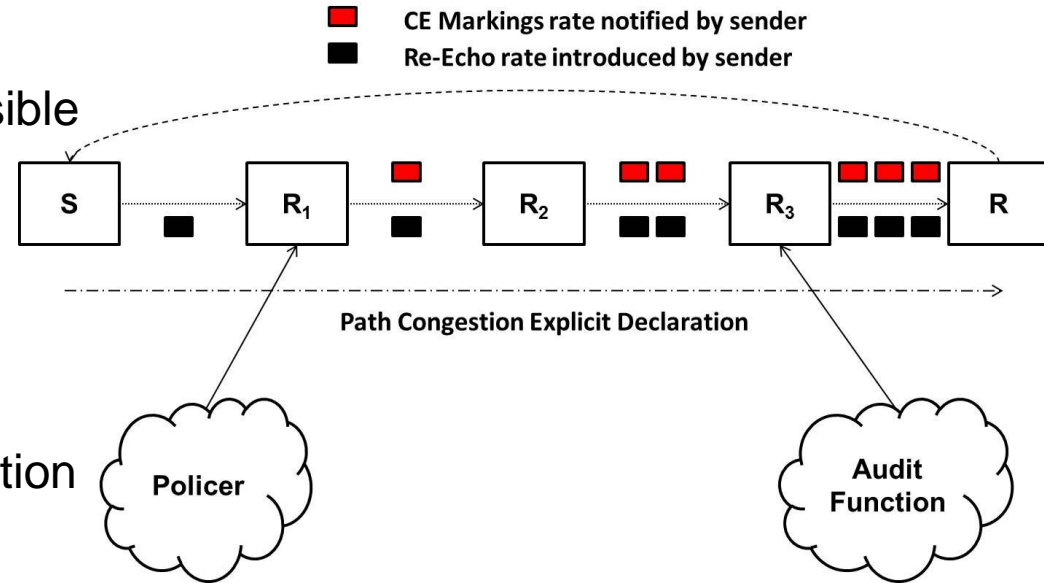
- Leveraging existing congestion notification mechanisms (ECN)
- Simple functions on routers, gateways and base stations

Senders act on congestion information

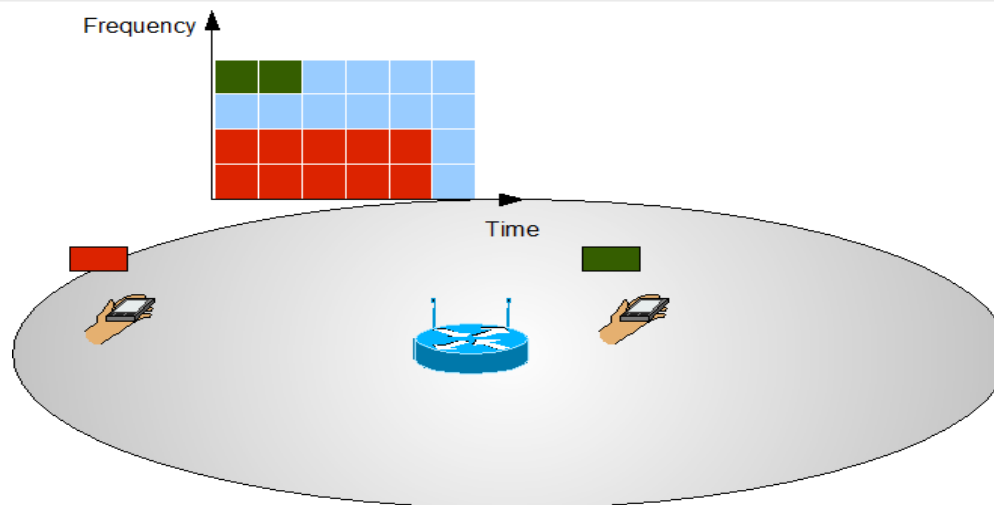
- Can declare current congestion contribution
- Can adapt sending behavior

Network functions proposed by congestion exposure:

- Rate-limit traffic based on declared congestion: **Policer**
- Enforce correct operation: **Audit Function**



Previous Work



Congestion Exposure benefits for mobile communication networks

Dirk Kutscher, Faisal Ghias Mir, Rolf Winter, Suresh Krishnan, Ying Zhang IETF Draft, Mobile Communication Congestion Exposure Scenario

Wireless resource-usage-aware ECN marking for Congestion Exposure

Dirk Kutscher, Henrik Lundqvist, Faisal Ghias Mir, Congestion Exposure in Mobile Wireless Communications. Globecomm 2010. pp 1-6

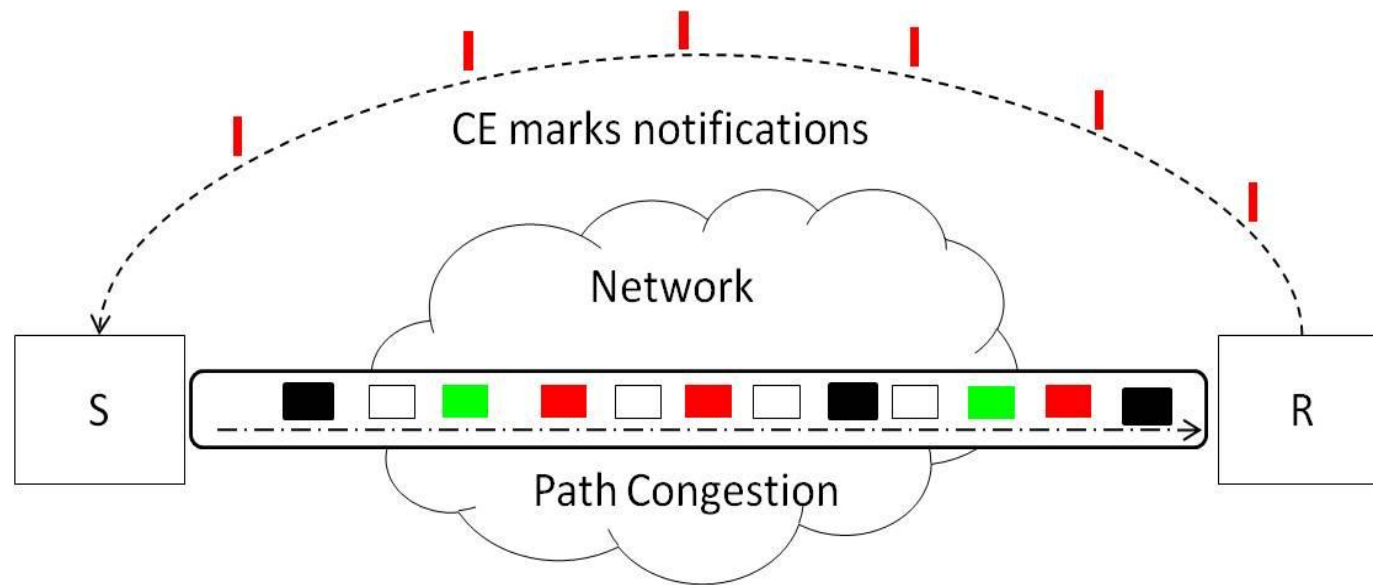
Efficient audit function implementation for Congestion Exposure

Faisal Ghias Mir, Dirk Kutscher, Rolf Winter, Marcus Brunner, A framework for efficient Dropper implementation for Congestion Exposure, (To appear Globecomm 2011)

Investigating effects of dynamic path characteristics changes on Congestion Exposure

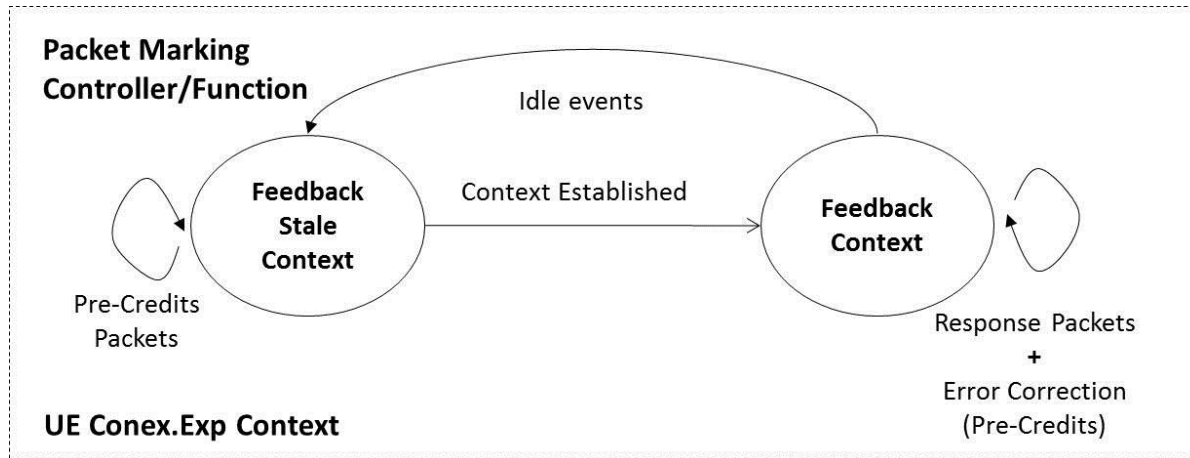
Faisal Ghias Mir, Dirk Kutscher, Marcus Brunner, Congestion Exposure in Mobility Scenarios. NGI 2011, Kaiserslautern

Congestion Declaration (1/2)



- Lag between the forward and feedback path
- Congestion is not stationary and changes with offered load
- Sender responsibility to match congestion with response
 - Pre-Credits + Post-Credits \geq Deficit

Congestion Declaration (2/2)



Congestion Exposure context at the sending host

- Path Adaptability i.e. $cwnd = 1$
- Estimate of congestion from received acknowledgements

The context applies to one half of TCP connection

No activity on connection invalidate the context

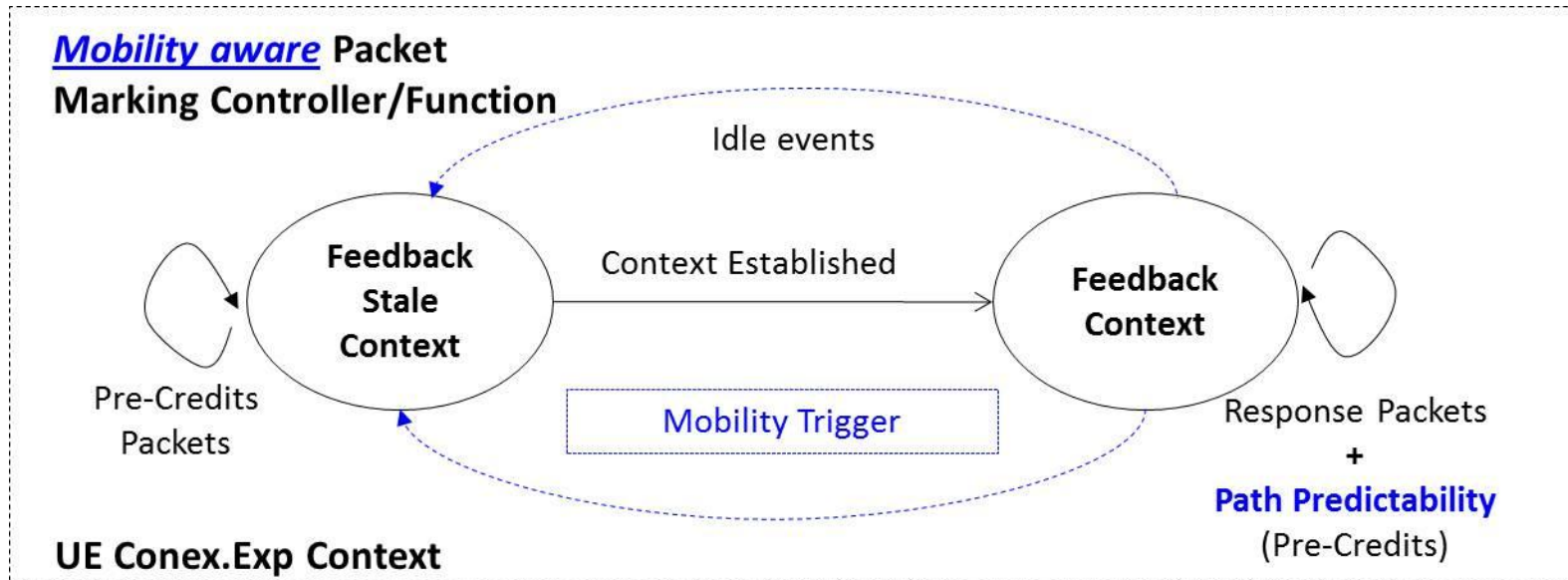
Mobility aspects for Congestion Exposure

■ Path adaptability vs. path changes

■ Issues with path changes

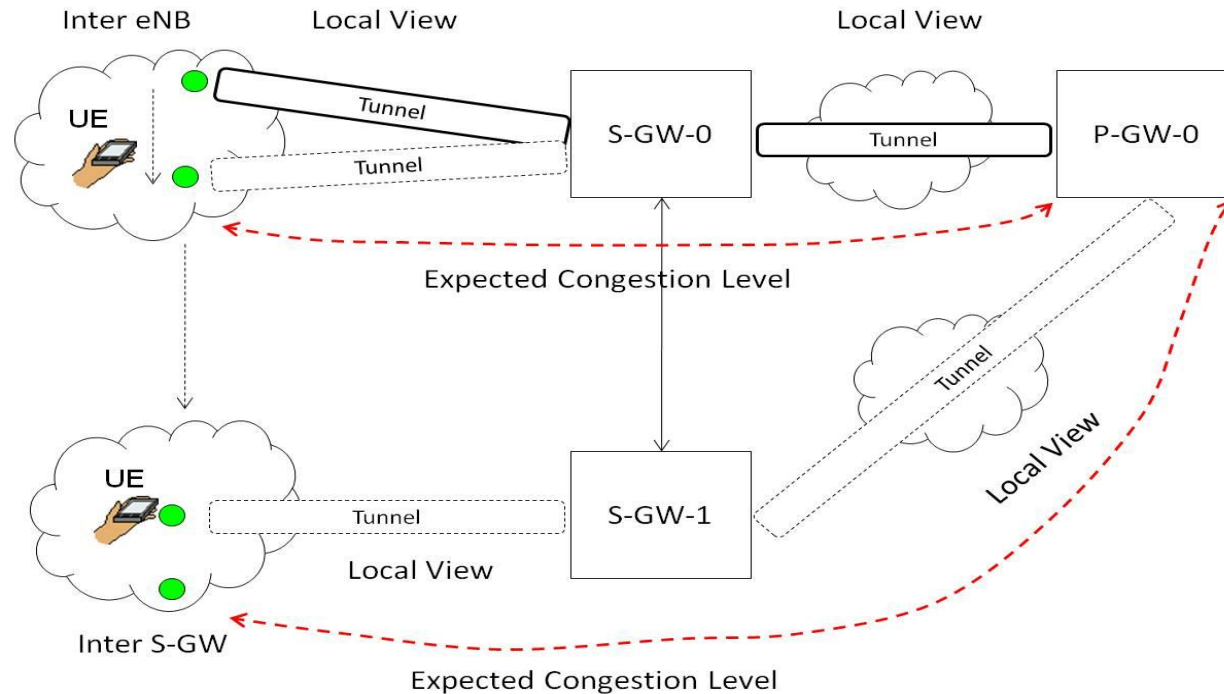
- New path state is unknown
- In-flight packets
- How much the actual path has been changed e.g., horizontal vs. vertical handover
- How to estimate congestion on the new path?

Mobility Aware Congestion Declaration



- With path changes, congestion estimate may no longer be valid
- Invalidate the context for the sender to “*adapt*” to the new path
- User may move between different congestion regions with path changes
- Use Path Predictability Factor for estimating congestion

Exploiting Network Topology



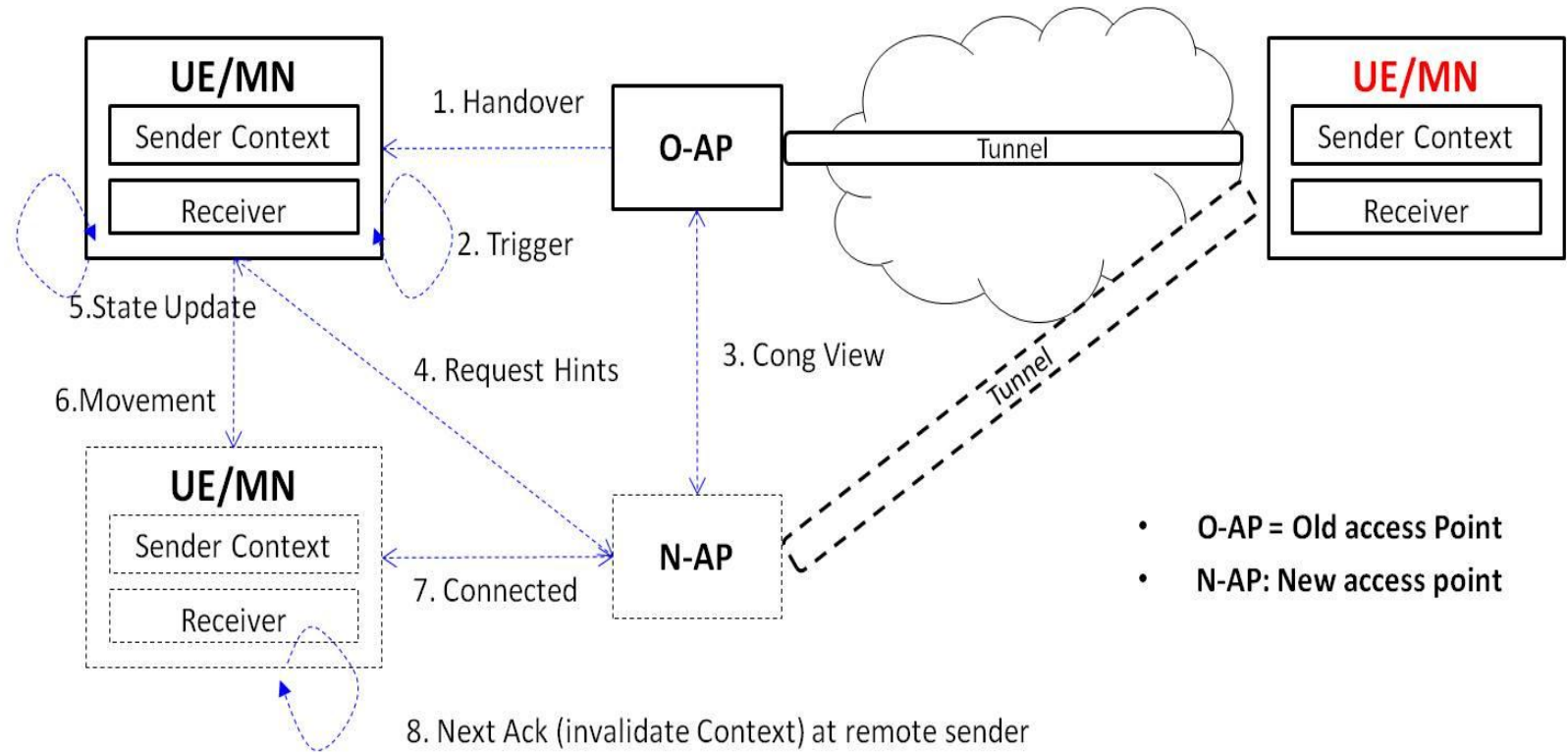
Congestion may occur in any part of a network, access or core

Exploit exposed congestion information on the path

- Network may estimate congestion for traffic passing going to a particular gateway node

Pass this information to UE's for adapting to expected congestion levels

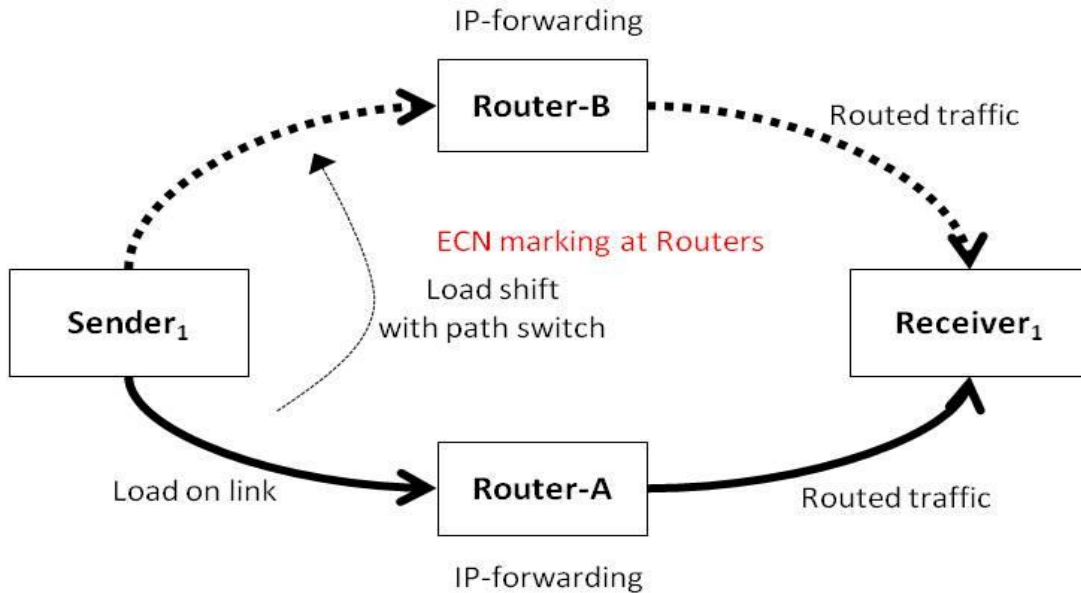
Procedure for Exploiting Congestion Information



Hints pushed from base stations to the UE

Base stations exchange congestion information e.g. X2 interface in LTE

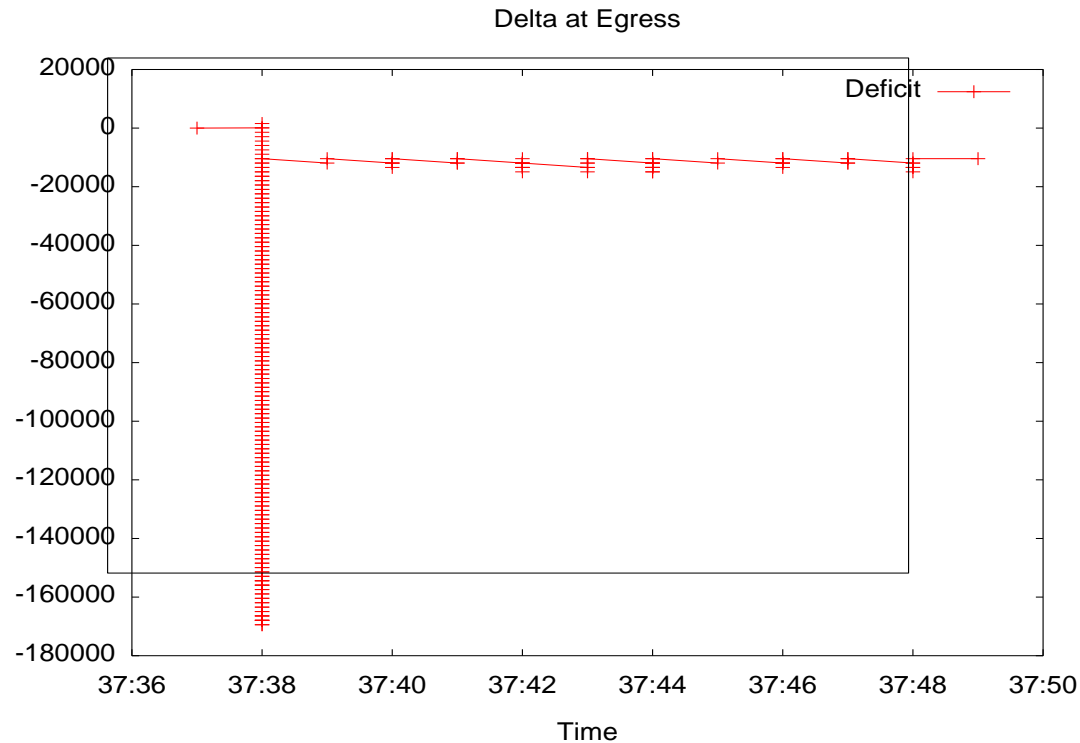
OpenFlow-based Test Bed



**NEC IP-8800
OpenFlow Switch**

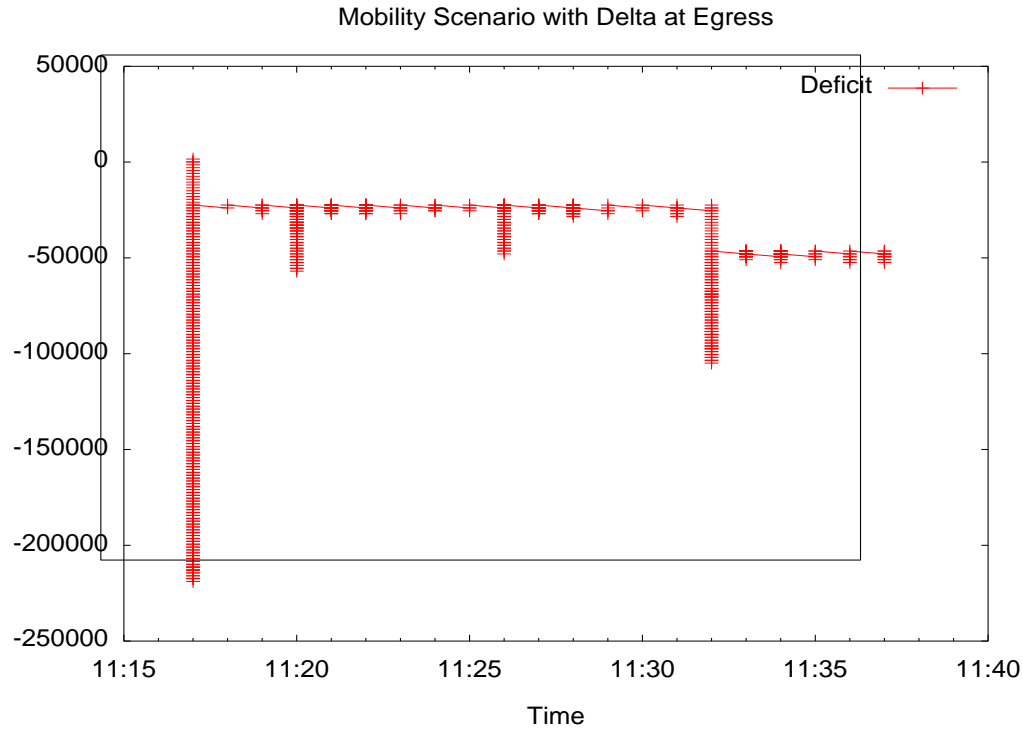
- The goal is to measure deficit close to the receiving host on path changes
- NEC IP-8800 OpenFlow switch for dynamic load shifting
- NOX controller for switching path between hosts
- RED Queues in Linux Routers for congestion markings

Impact of TCP Slow Start



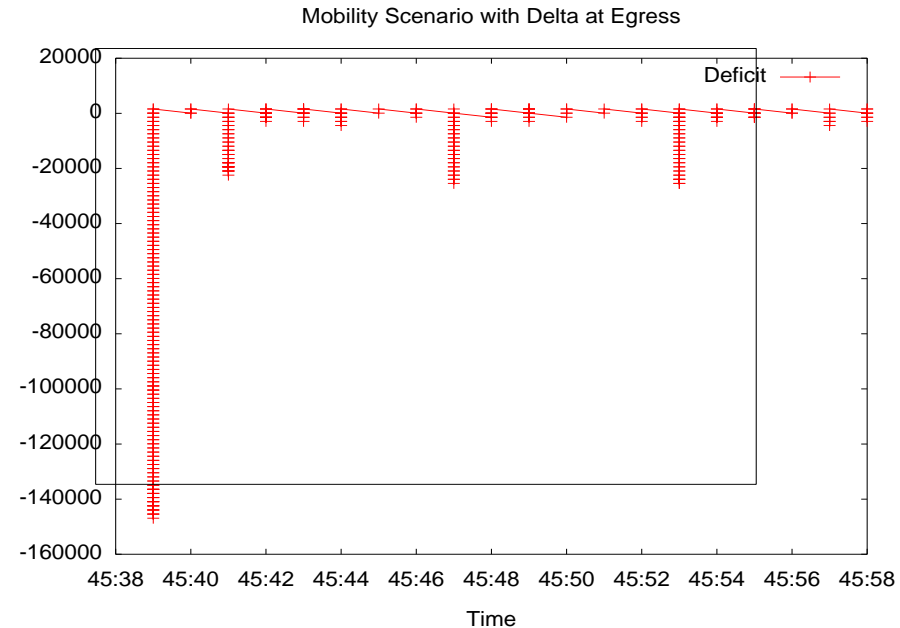
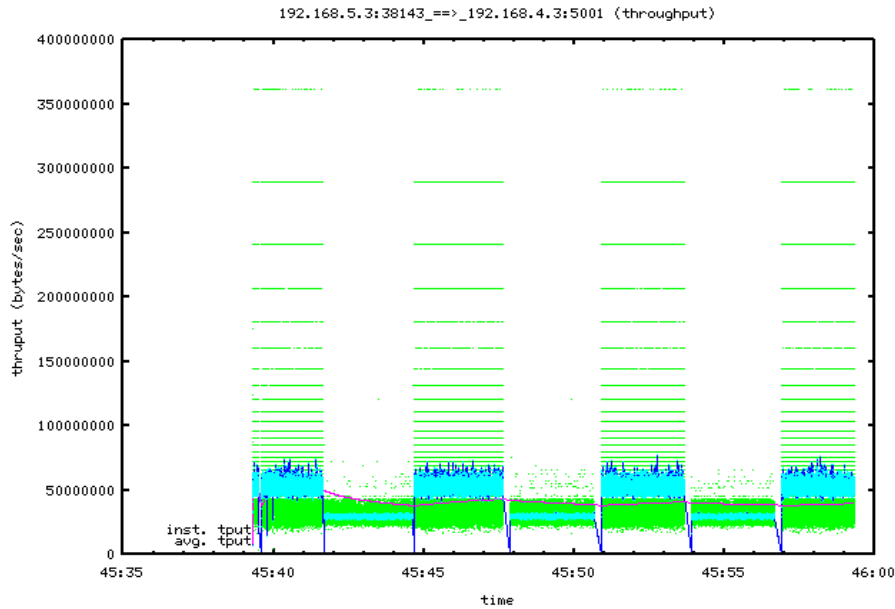
- TCP exponential increase during Slow Start causes lots of congestion
- During congestion avoidance deficit remains low
- Characteristic of the transport on how bandwidth is probed

Loss of Marked Packets



- Response packet loss causes deficit not recoverable
- Audit Function would classify such traffic as non-conformant

Path Changes with different capacity Regions



- Load shift on 3 second interval
- Capacity is varied by 50% for a single TCP flow
- Deficit is recorded for scenario when load is shifted from lower to higher congestion regions

Conclusions

Congestion exposure can be done on different time scales and with different granularity levels

- For effective capacity sharing and sender adaptivity, accurate and timely congestion exposure is required

Sender should take mobility into consideration

- Need some flexibility for dynamic changing of path characteristics
- Congestion estimate may not be valid after changes

A slightly more tolerant policer configuration

- Avoid policing/accounting for probing traffic

Relaxed Audit Function configuration for short time scales

- Tradeoff between accurate enforcement and accommodating mobility

Empowered by Innovation

NEC