Experimentation in Heterogeneous European Testbeds through the Openlab Facility: The case of PlanetLab federation with the wireless NITOS Testbed

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Introduction

- **The Need:**

  the existence of experimental network facilities featuring heterogeneous resources is required for testing implemented schemes under real world settings.

- **The Key idea:**

  Federation of existing network testbeds.

- **Our Solution:**

  through Openlab project, we develop a federated environment that utilizes both wireless and wired infrastructure.

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Outline

- Testbed Federation
- Research Scenario
- Federation Framework
- Experimental Setup
- Experimental Evaluation
- Insights and Future work

Testbed Federation

Federation between heterogeneous testbeds introduces several issues that arise due to:

- the difference in the nature of experimental resources,
- the use of different software frameworks for resources management and controlling.

In this work, the federation between two inherently heterogeneous testbeds has been made possible, due to:

- The utilization of a common experiment control framework OMF (cOntrol and Management Framework)
- and the adoption of the slice abstraction.

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Testbed Federation

- Through the resulting setup, a researcher can utilize the Openlab facilities to run experiments, using resources of:

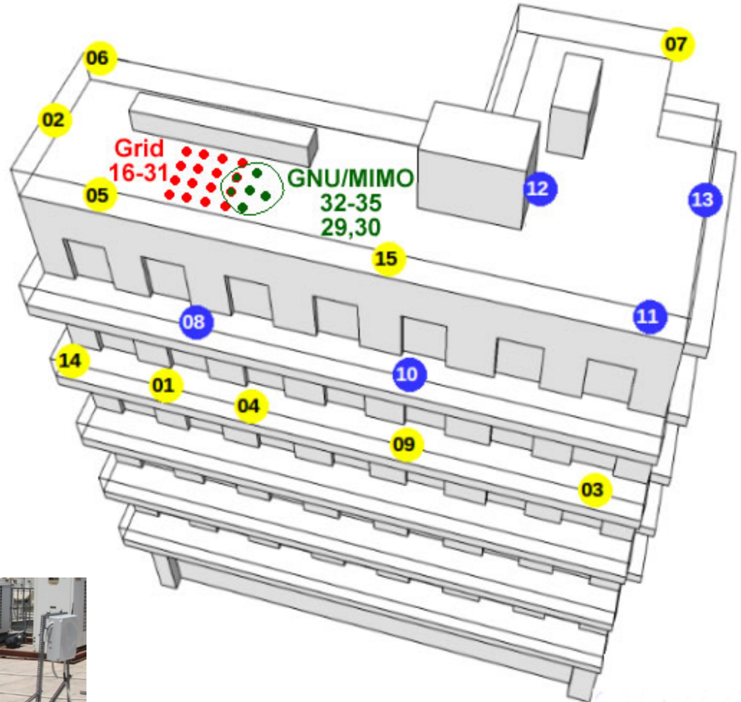
  - NITOS Wireless Testbed to reserve wireless nodes

  - Planetlab Europe Testbed to reserve wired nodes

NITOS Testbed

- NITOS is a large-scale outdoor deployed wireless testbed that currently consists of 50 wireless nodes and several other platforms:
  - USRP nodes
  - MIMO enabled nodes
  - Sensor nodes
  - Openflow switches

  - NITOS has adopted OMF as its testbed control and management framework.



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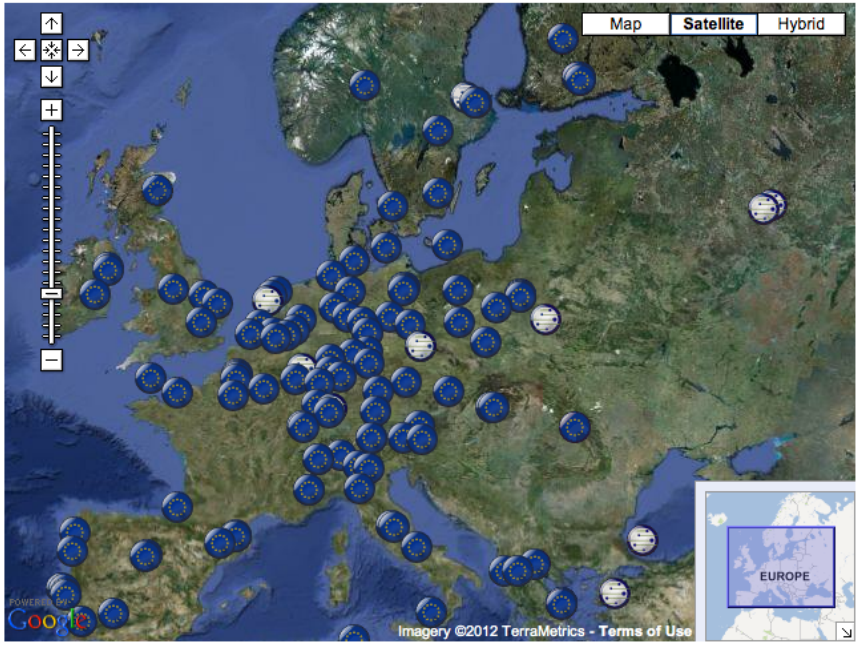
Planetlab Europe Testbed

- PlanetLab Europe is the European portion of the publicly available PlanetLab testbed, offering a total of 1000+ nodes worldwide.
- Did not support OMF!



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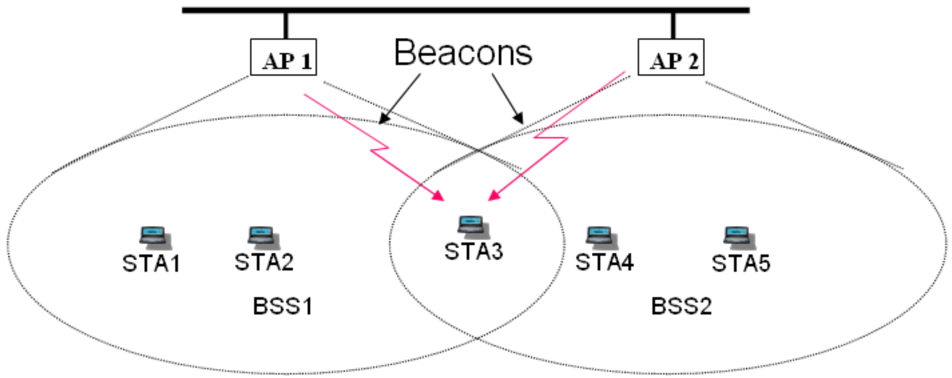
The Research Problem (1/2)

- In IEEE 802.11 WLANs, each station (STA) has to first associate with an access point (AP), before it can start transmitting data to other nodes in the network.

- IEEE 802.11 standard defines **RSSI – based Association Policy**



- A STA simply selects the AP from which it has received the strongest signal during the scanning process.

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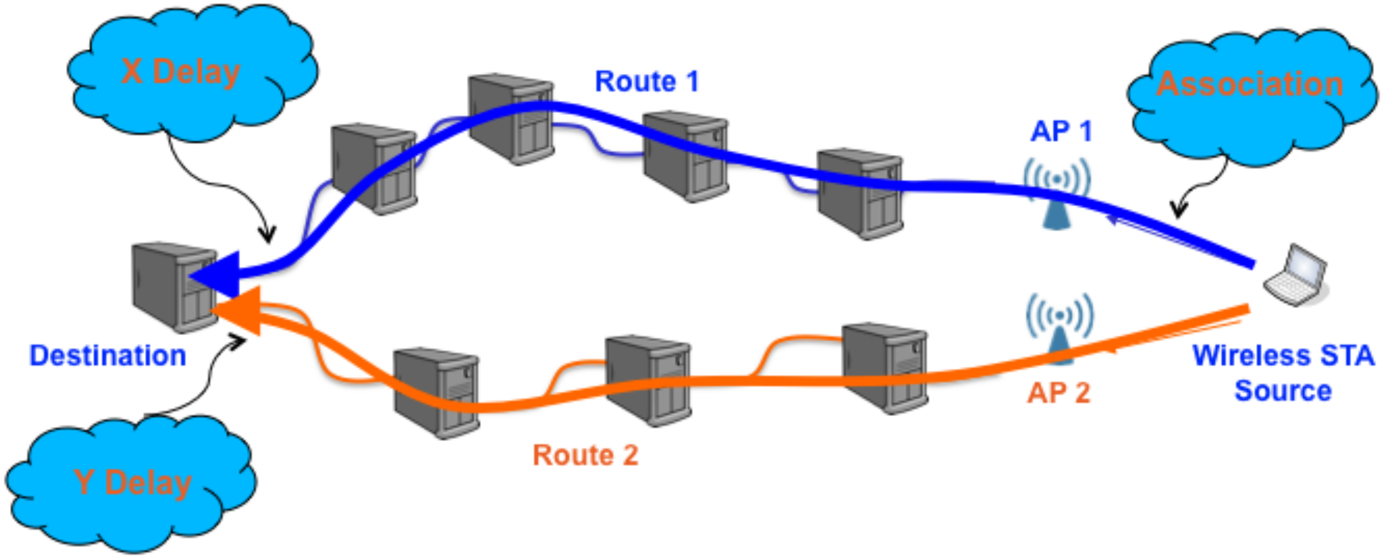
The Research Problem (2/2)

- We decided to implement the following research scenario:



- The wireless STA decides about its association based on the end-to-end delay on both the wired and the wireless part.

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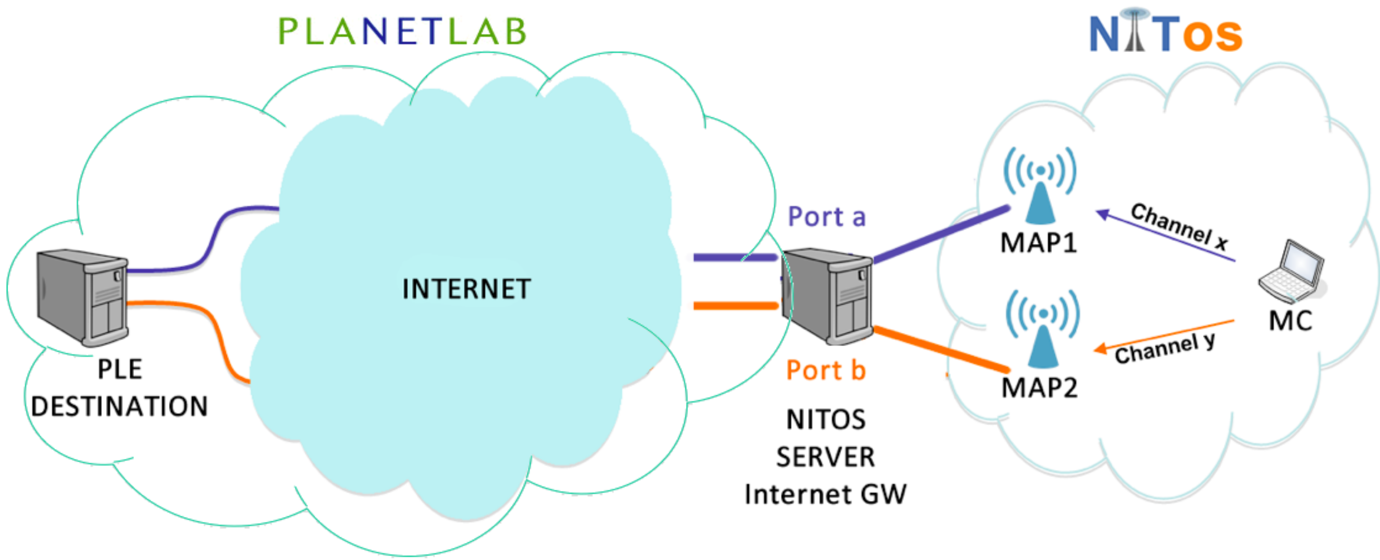
The Solution

- We developed the following experimental setup to fulfill the researcher's needs:



- The experimental scenario is implemented in the federated **NITOS - Planetlab Europe** testbeds

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Federation Framework

The basic components that enabled the federation between NITOS and PLE consist of:

- **Single Sign Up** procedure
- Deployment of **OMF/OML** at **PLE** resources
- **XMPP** Communication using slices

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Deployment of OMF/OML at PLE

The team of Max Ott, Thierry Rakotoarivelo and Thierry Parmentelat worked on enabling the PLE resources to run OMF.

- As a result, Planetlab users are able to run OMF on PLE resources, by simply enabling the OMF-friendly tag for their slice.

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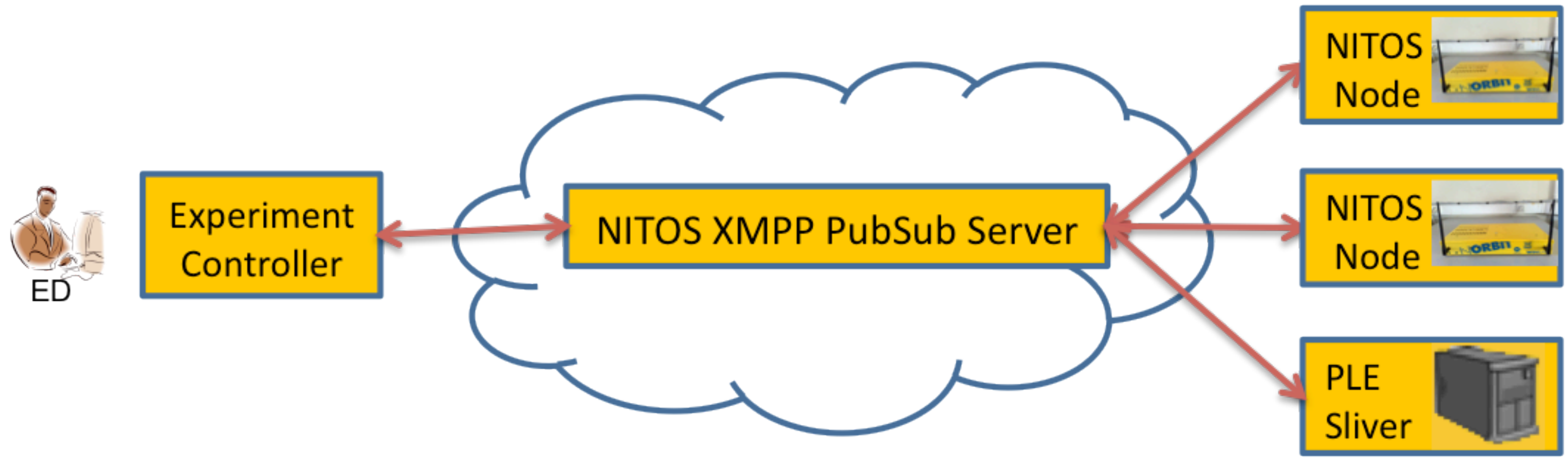
XMPP Communication (1/2)

- In order for all the resources to be able to communicate with the EC, they must be registered in the same XMPP server ...



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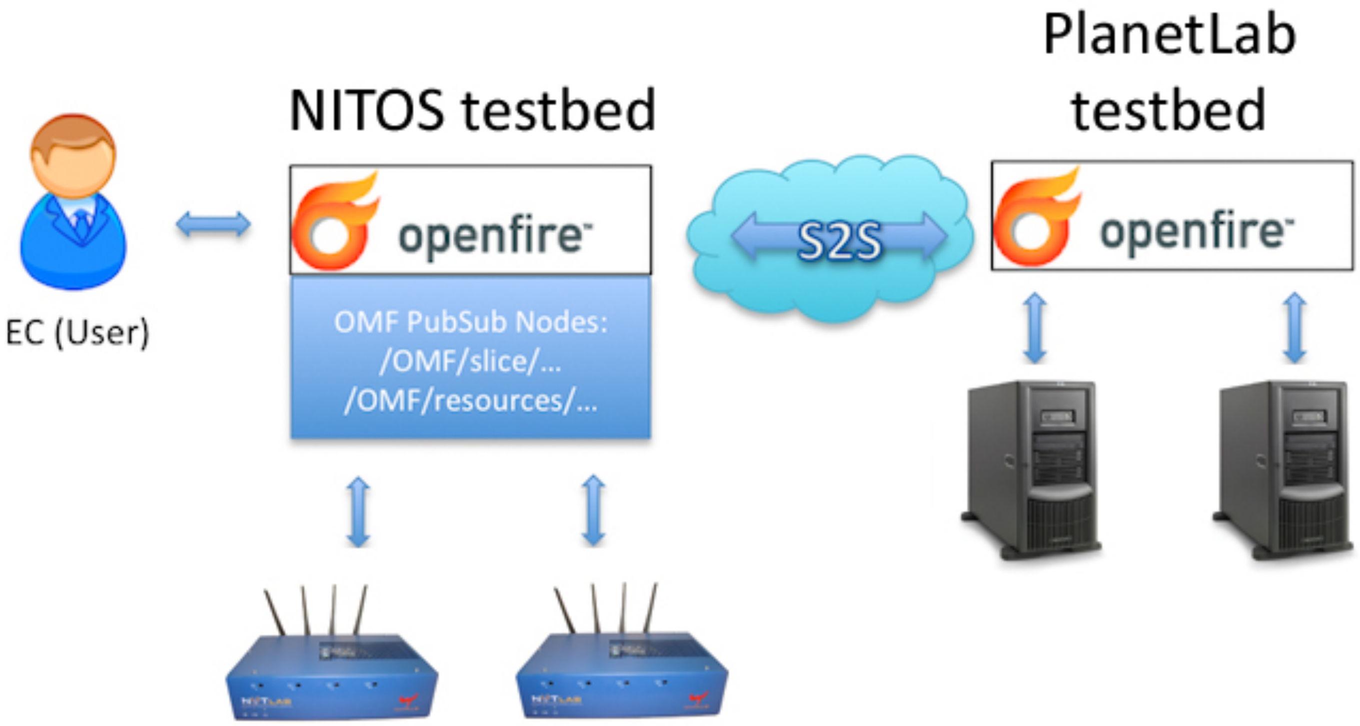
XMPP Communication (2/2)

- … or to a set of XMPP servers that are peered with each other



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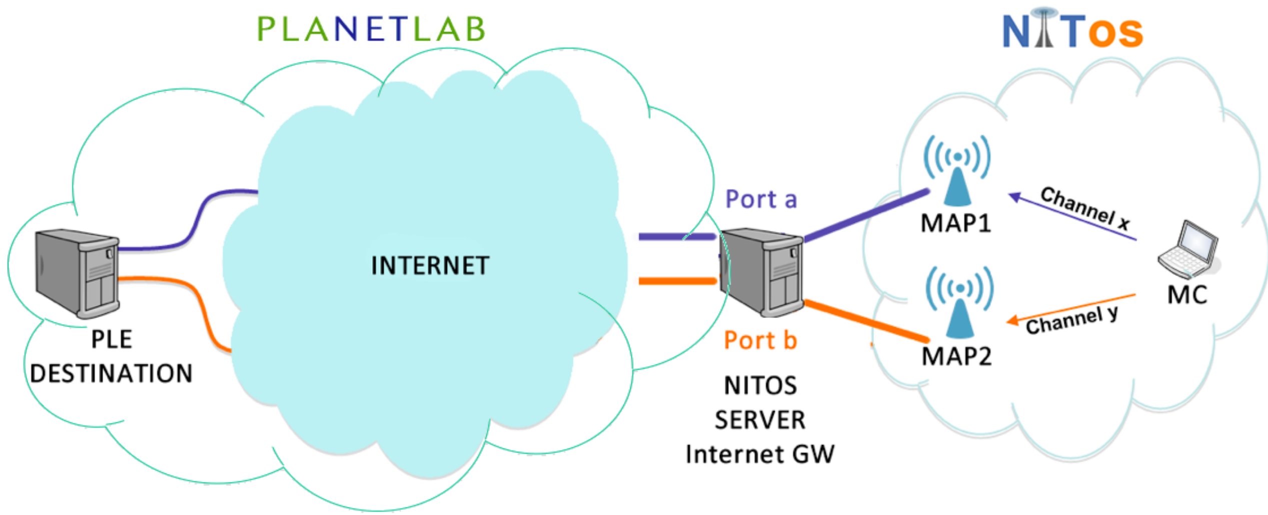
Experimental Setup

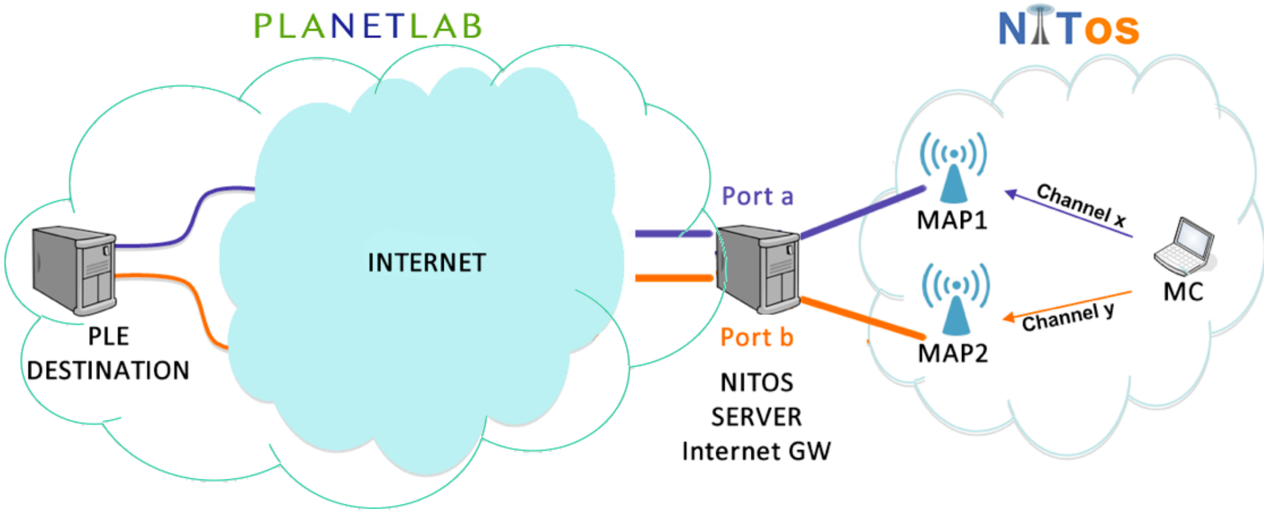


RTT_{WIRED} **$RTT_{WIRELESS}$**

- **RTT_{WIRED}** : estimated through probe packets that are transmitted from the APs and are destined to the PLE node

- **$RTT_{WIRELESS}$** : estimations are based on consideration of channel contention generated by neighboring nodes

Experimental Setup



- **Driver level** modifications, so that APs are able to broadcast **RTT_{WIRED}** estimations in their Beacon frames and also at the STA mode, so that the STA detects channel contention on each channel.

- Packet Forwarding through **Iptables (NAT)** settings at both the:
  - APs
  - NITOS Server

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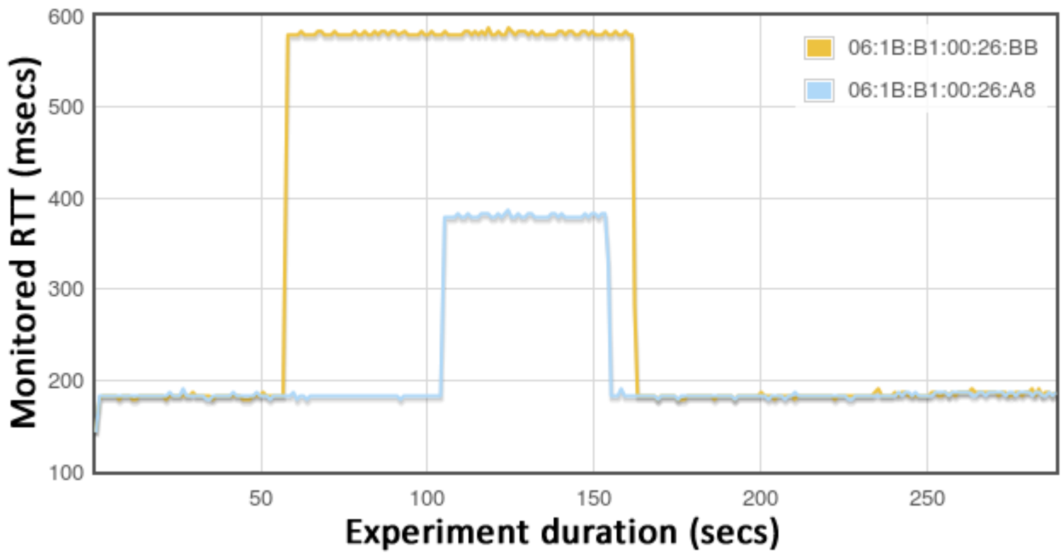
Experimental Setup



- Packet Discrimination at the PLE based on port numbers (**NMAP**)

- Based on the incoming flows port number we inject artificial Delay for packets received at the PLE node (**Dummynet**)

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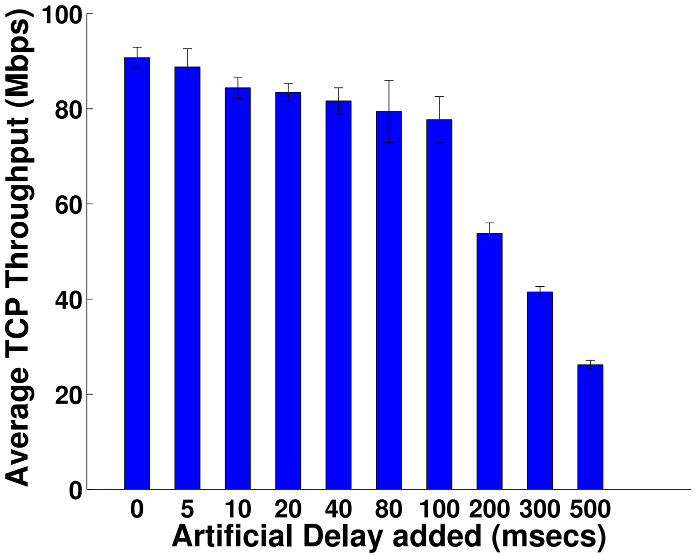
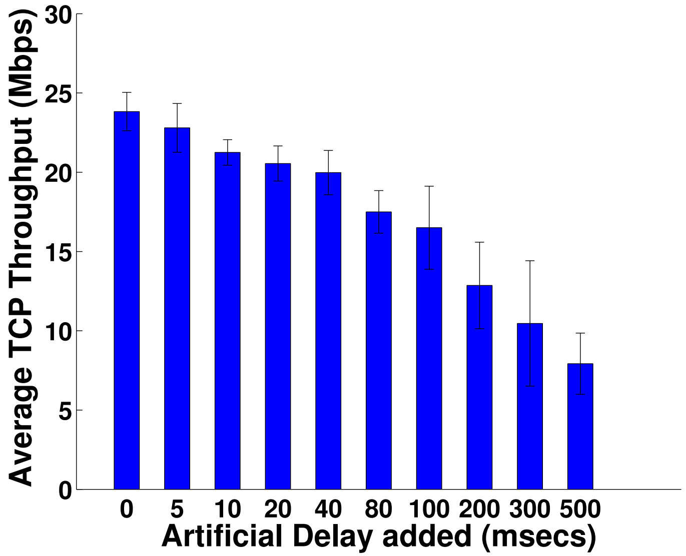
1st set of Experiments (1/2)





- Even small variation of delay in the wired part significantly affects TCP throughput

- The wireless access link acts as the performance bottleneck that significantly limits yielded performance.

- Higher deviation values when conducted in the combined topology, for the cases of 200, 300 and 500 msecs of delay.

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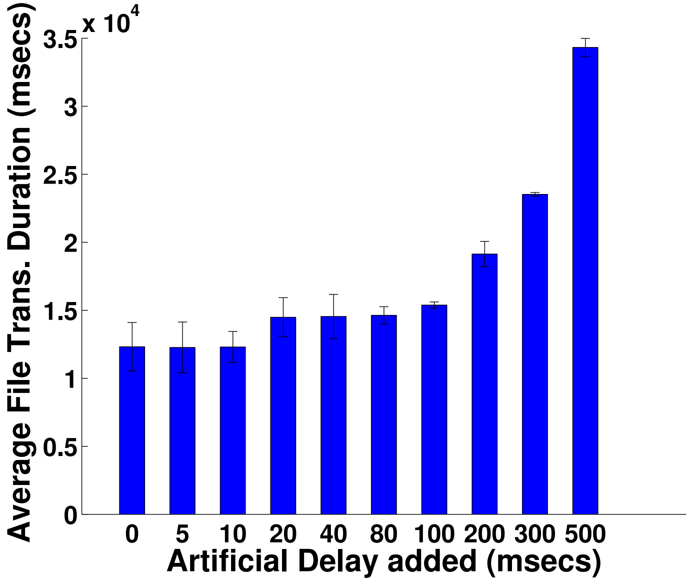
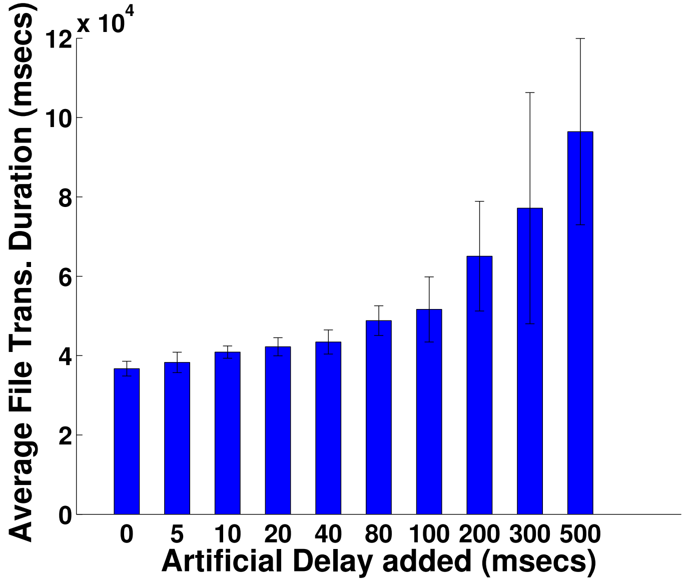
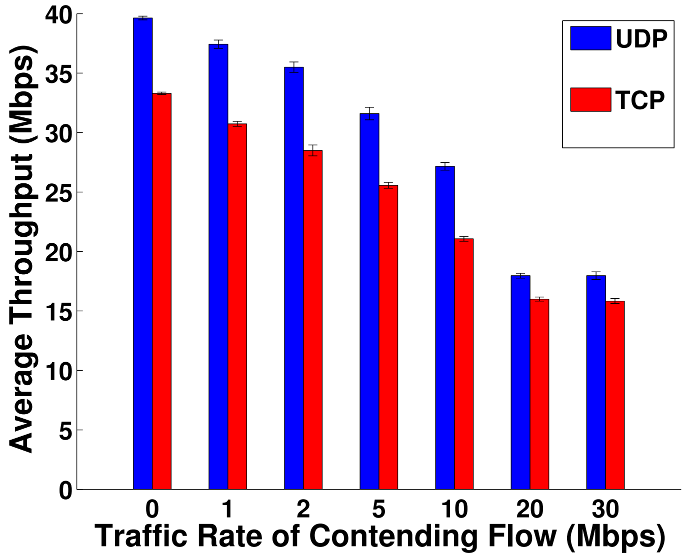
1st set of Experiments (2/2)

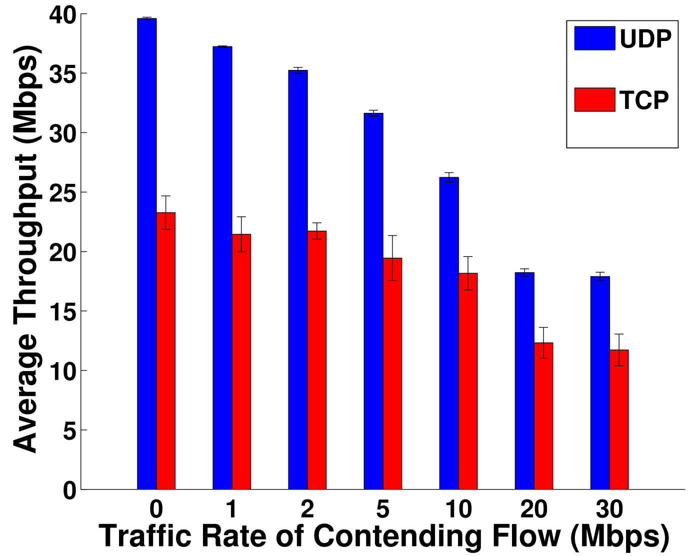




- Even a low increase in RTT values of 20 ms increases file transmission duration up to 5,5s (15%).
- UDP experiments were conducted as well.
- However, UDP performance in terms of throughput, packet loss and jitter is not affected by the artificial RTT delay.

2nd set of Experiments (1/2)





- Even contending flows of low traffic rate highly impact performance in both cases.

- In the TCP case, we observe lower throughput performance yielded in the combined network. (TCP limits the rate of injected traffic, as it is adaptive to RTT variations.)

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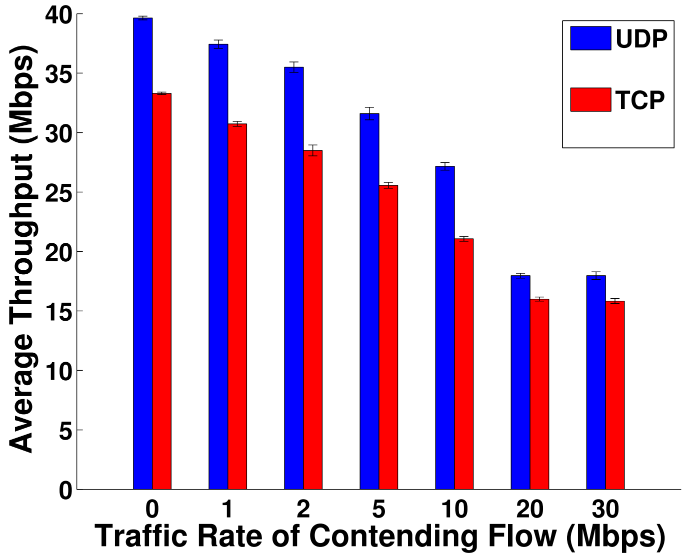
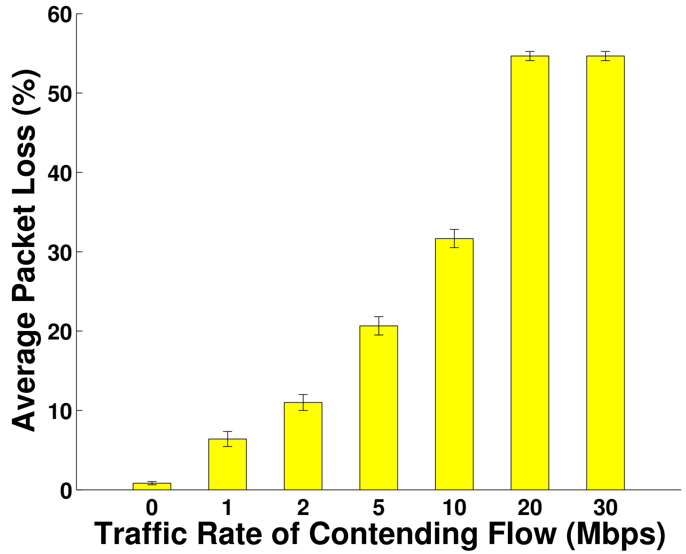
2nd set of Experiments (2/2)



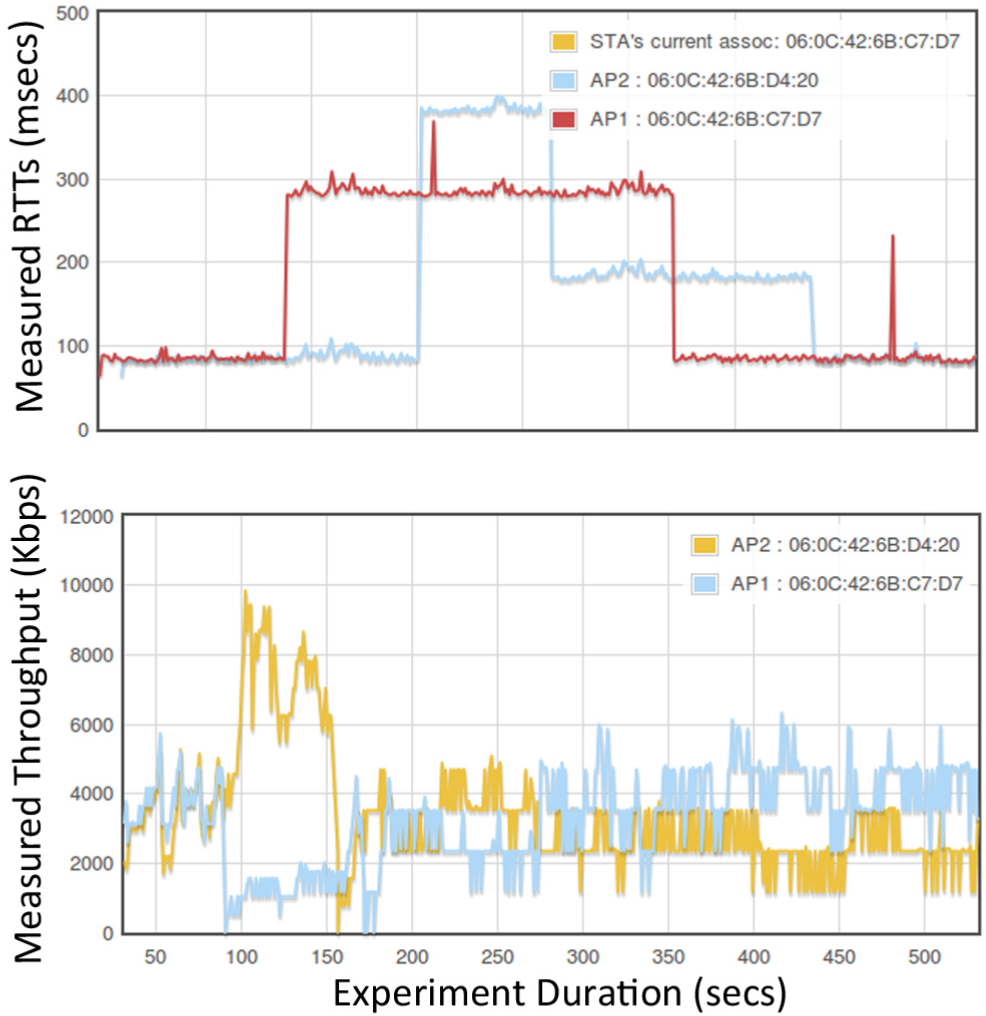


- UDP performance is directly related to loss of packets.

- As the STA injects packets with higher traffic rate, the wireless network capacity is exceeded due to the simultaneous transmissions of contending flows.

- UDP does not restrict the rate of data entering the network within the network capacity region.

OMF Visualization



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Insights and Future Work

- Experimental Insights:
  - UDP performance in terms of throughput, packet loss and jitter is not affected by the artificially injected RTT delay.
  - High variation of RTT delays also impacts performance and has to be further investigated.

- Future Work:
  - Test UDP performance in setups of multiple PLE destination nodes, located across different locations and thus featuring diverse RTT values.
  - Test video performance in terms of successfully delivered frames ratio and delivered PSNR.
  - Test performance of more specific metrics.

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Thank You!