FED4FIRE
Federation for FIRE Plus

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HYPERTECH S.A

ULYSSES

UtiLitY-based Slice Selection for video Streaming (ULYSSES)

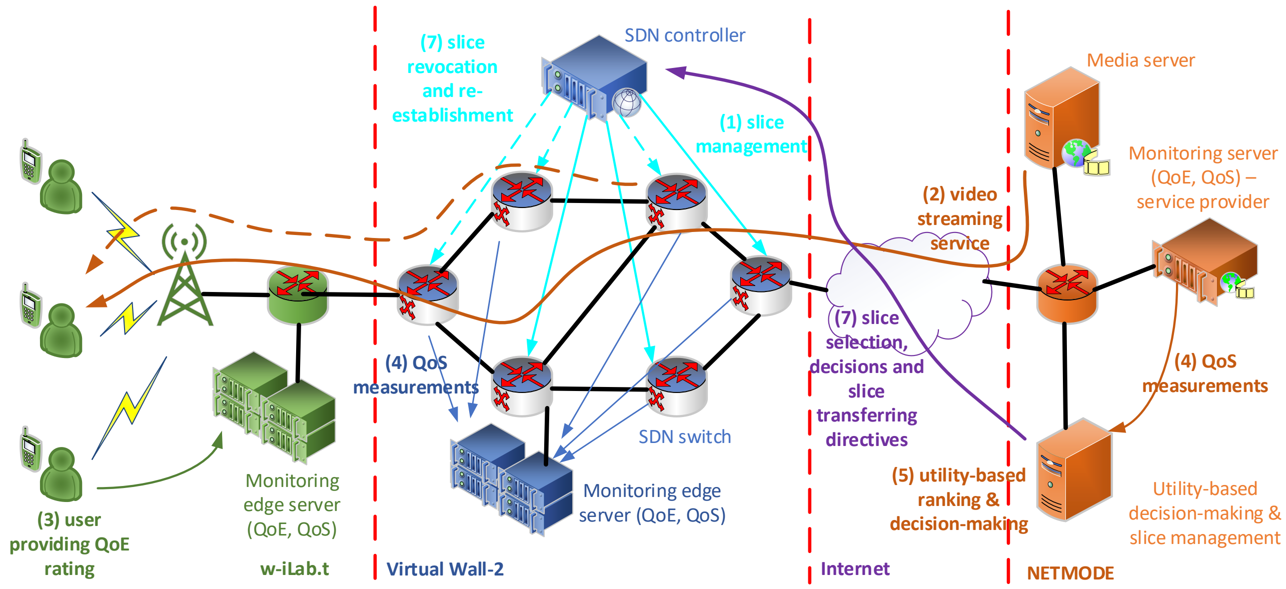
Review

Skype, 25/05/2021

Experiment Description

BACKGROUND AND MOTIVATION

- Providing advanced video streaming services to wireless subscribers while maintaining high QoE-QoS in a cost-efficient manner is critical for video streaming service providers.
- Ideally, the service provider should be capable of performing dynamic slice dimensioning, ensuring real-time adaption of the employed resources, given cost profiles and the instantaneous QoE-QoS experienced by the subscriber of the streaming service.
- In modern networks, dynamic slice dimensioning is still a complex and demanding task. ULYSSES aimed to contribute towards developing such mechanisms through an incremental approach that could set the foundations for optimal dynamic slice dimensioning.
- In this phase of the experiment, ULYSSES focused on the demonstration and experimentation with a preliminary dynamic slice selection mechanism, which can serve as cornerstone for an ultimately desired automated dynamic slice dimensioning approach.



ULYSSES aimed in the development and testing of novel **utility-based slice switching mechanisms** over the Fed4FIRE+ infrastructure, capable of determining the most appropriate resource profile for a video streaming service slice. The main activity was the **development, integration and performance evaluation** of a **slice selection** and **switching mechanism** for network slices serving a **video streaming service** based on a **utility function framework** capable of incorporating user satisfaction (via QoE), network state via (QoS) and other policies, e.g., related to pricing.

ULYSSES

CONCEPT

Experiment Description

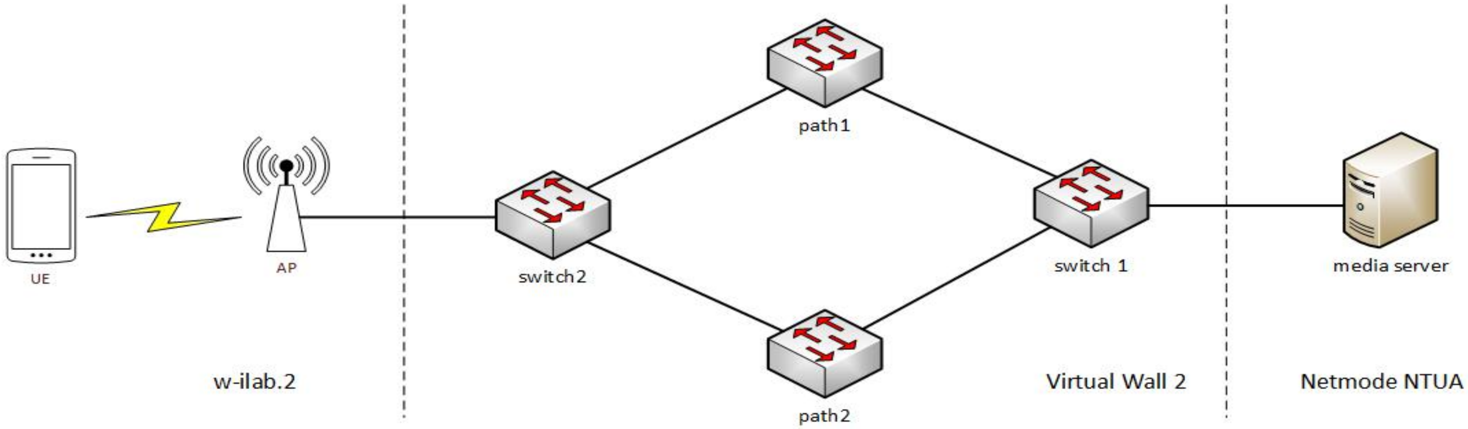
OBJECTIVES

Main Objectives	Achievements
1. Demonstrate in real conditions the feasibility and operation of a precursor to a utility-based slice selection approach, while identifying the hidden technological burdens that need to be overcome towards extending it to a feasible and efficient slice dimensioning approach.	1. Through the obtained results we were able to identify many of the hidden theoretical and technological burdens for realizing a dynamic slice dimensioning framework in real networks.
2. Develop QoS and QoE monitoring tools for slice-adapting video streaming services.	2. As part of the experiment we developed QoS monitoring indicators (which can be very straightforwardly extended with similar QoE indicators) for media content delivery, which can be potentially added in the portfolio of Fed4FIRE+ tools.
3. Pave the way for a fully automated dynamic slice management mechanism.	3. The utility-based slice ranking framework is now readily available, and ideally, it can be extended into a dynamic slice selection mechanism, fully integrated in the workflow for future experimenters.
4. Provide feedback on the use of Fed4FIRE+ testbeds, and contribute to the development & extension of its services & tools.	4. Provided feedback, which includes suggestions and aids towards an effective dynamic slice configuration mechanism.

Experiment Description

EXPERIMENT SETUP (1)

- A realistic *media streaming topology* over which it became possible to study with accuracy the proposed dynamic slice switching mechanism, evaluating its performance under realistic conditions and identifying the technological impairments that prevent a fully automated and adaptive SDN-based slice management framework has been constructed:



Experiment Description

EXPERIMENT SETUP (2)

- A **video streaming server**, with public IPv4 address, was deployed in the *NETMODE* testbed at NTUA using Flask.
- The main part of the topology was constructed in *Virtual Wall 2*, comprising of **2 alternative paths**.
- **2 wireless nodes** of *w-ilab.2* were used, acting as an UE (the client requesting a video stream) and as an AP, respectively.
- AP was able to communicate with a router serving also the role of an emulated SDN switch (Switch2) in Virtual Wall 2 using an IPv4 in IPv6 tunnel.
- Communication between Virtual Wall 2 and the media server in NETMODE testbed at NTUA was established by reserving a public IPv4 address for a switch in the first testbed (Switch1) and employing IP masquerade to allow the nodes with private IP addresses to reach the media server.
- Switch1, was tasked with periodically monitoring them using the Iperf3 command line utility. The obtained loss rates and jitter values were used for calculating the respective utility scores, based on which the decision for the best route was made. Changes to the routing table were done using the iproute2 utilities.
- To verify the actual path of the packets, traffic was captured at suitable points using the tcpdump packet analyzer.
- During testing, in order to change the loss, delay, and/or jitter of chosen links and verify that the proposed framework actually detects those changes and choses the best path, we used the netem kernel module through the tc utility.

Experiment

VIDEO DEMO

Project Results (1)

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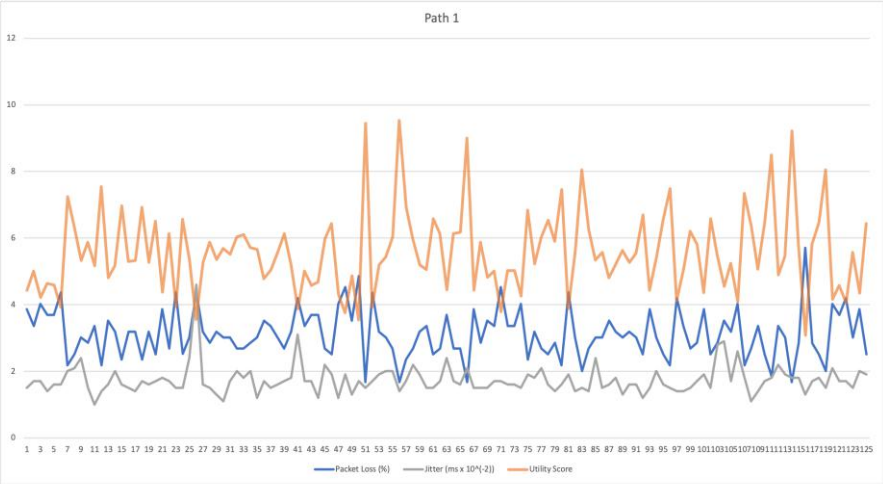
UTILITY FUNCTION

$$U = \frac{1}{w_1 \cdot \frac{p}{p_{max}} + w_2 \cdot \frac{j}{j_{max}}}$$

- *p* (“packet loss”) is a *percentage* and *j* (“jitter”) is measured in *msec*.
- $w_1 = 0.55$, $w_2 = 0.45$, $p_{max} = 10$ and $j_{max} = 0.5$
- Serves the purpose of demonstrating the feasibility of the employed utility-based mechanism for slice switching.
- Can be extended to accommodate more QoS/QoE related parameters.

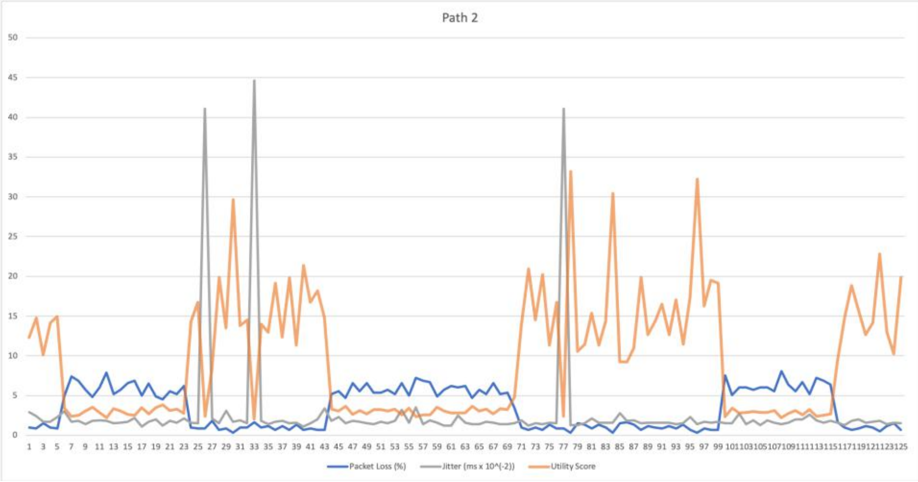
Project Results (2)



Relation between packet loss - jitter and the utility score for path 1.

- Total experiment duration: 1250*sec*
- Interval duration: 10*sec*

✓ <u>Utility function score peaks when packet loss and jitter decrease</u>:
⟶ captures the QoS characteristics correctly
⟶ can be used as a proper indicator for dynamic slice switching

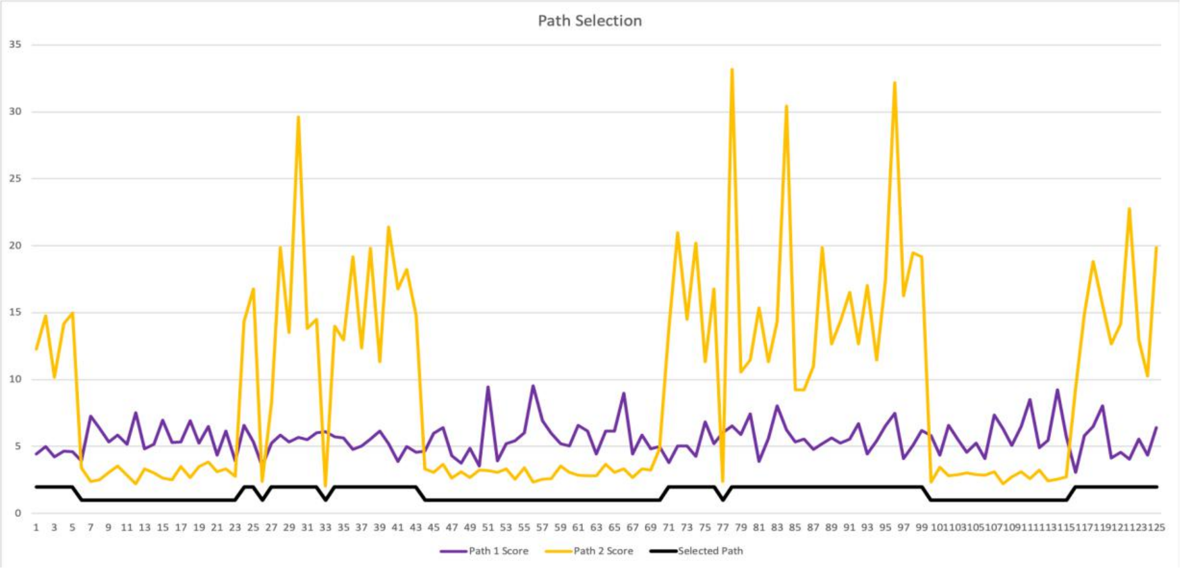


Correlation of packet loss, jitter and utility score when artificial impairments are introduced in the network.

- Path packet loss impairments change every 5*min*
- Range of variation between 1% and 6% packet loss

✓ <u>Utility score peaks when packet loss and jitter are at their lowest:</u>
⟶ indicates successfully, rapidly and with good correlation the changes in network conditions
⟶ can be safely used to drive any slice switching modifications

Project Results (3)



Real-time slice switching capability achieved
(implemented as a basic path switching functionality).

- ✓ Correctly selects the best path ⟶ capable of adapting on the fly to variations of the network state.
- ✓ Sensitive enough to detect the best path ≠ not too sensitive to oscillate between paths (stable behavior).
- ➢ Desired feature for multimedia and other content streaming ⟶ frequent slice switching could have caused worse QoE to the user.

Business Impact (1)

IMPACT FOR HYPERTECH (1)

- HYPERTECH plans to offer high quality news-related video streaming services over mobile devices over 5G infrastructure in Greece. HYPERTECH ambitioned to make an initial validation of the ULYSSES technology through FED4FIRE+ experimentation.
- HYPERTECH collaborates with multiple cultural heritage institutions in Greece, for which it has developed in the past a series of AR/VR applications and virtual tours. All these applications work in an indoor environment and demand for WiFi connectivity. HYPERTECH expects to be able to leverage ULYSSES technology to create more enhanced versions of such AR/VR applications that can be supported by 5G networks in outdoor settings, thus opening up additional opportunities for upselling such video-based solutions to cultural heritage institutions.
- HYPERTECH has significantly advanced its know-how in multimedia streaming and network slicing through the interactions with the two patrons with expertise in the corresponding fields.

Business Impact (2)

IMPACT FOR HYPERTECH (2)

- HYPERTECH had the opportunity to fine tune through experiments in ULYSSES the suggested utility function and obtain insights on its performance.
- This was considered as the primary step towards validating the feasibility of its concept and its potential for realization, given further development and testing, in commercial 5G deployments.
- The experimental results although limited due to time constraints have provided the necessary initial validation of the utility-based slice selection framework for video streaming.

Business Impact (3)

VALUE PERCEIVED

The executed experiment aided HYPERTECH to obtain considerable added value in the following sense:

- It allowed **becoming familiar** with federated and publicly available testbed infrastructures. This can be further utilized in the future in a **multitude of future experimentation activities** that will emerge as part of applications that HYPERTECH is currently active (e.g., media content streaming services over 5G).
- Secondly, it allowed **reducing considerably the required time and financial costs** that would be associated with the specific experiment, if HYPERTECH decided to setup its own testbed infrastructure. The execution of this experiment, as well as its potential extension, will be a core experience tank for our company.
- Considerable new competences were acquired by members of HYPERTECH through their **involvement in the setup of the experiment and the collaboration with the testbed owners**, sharing advice and technical knowledge that would be leveraged by HYPERTECH in its future projects.
- The developed topology used for the experiment can itself constitute a solid basis for extending the knowledge and competencies of the company. It can be readily reused by HYPERTECH over the Fed4FIRE+ testbed for more **advanced studies of slice switching and adaptation** to improve content streaming and obtain market leverage.

Feedback (1)

USED RESOURCES

Testbed	Wired/Wireless	Amount	Type
Virtual Wall (imec)	Wired	5	Generic Node
w-iLab.t (imec)	Wireless	2	APU
NETMODE (NTUA)	Wireless	1	Generic Node

Feedback (2)

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ADDED VALUE OF FED4FIRE+

- Almost all of the features and components offered by Fed4FIRE+ proved to have their own contribution to a successful experiment in a timely manner, which saved a lot of financial and time resources for HYPERTECH. Ranking them from the most important to the less, the following list is compiled:

1. Combining infrastructures
2. Tools offered
3. Support and documentation
4. Easy setup of experiments
5. Diversity of available resources

Feedback (3)

REMARKS

- **jFed:** The experience using jFed was rather positive, especially the fact that all resources could be accessed from a single point and it was not necessary to get down to the details of all testbeds in order to perform simple tasks as reserving nodes.
- In a few nodes, when the selected OS was Ubuntu 18.04 or later, the initial update and upgrade of the software components (the simple "**sudo apt**" commands) would take too much time to finish due to the fact that the nodes utilize ipv6 communication by default. Thus, even a single testing of the compatibility of a specific hardware/OS combination would sometimes take over an hour to complete, making the initial stages of the experimentation really strenuous. To overcome this issue, we have enabled NATted IPv4 Internet access. The hardware components were more than adequate.
- One part of the experiment regarding an SDN-enabled switch, was not possible to be implemented since OVS did not work out of the box for us. Providing up to date images with **preconfigured OVS** and enhancing the existing **tutorials** is suggested for enabling seamless usage.

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THANK YOU!!!

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