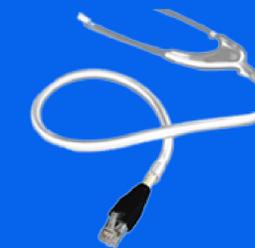
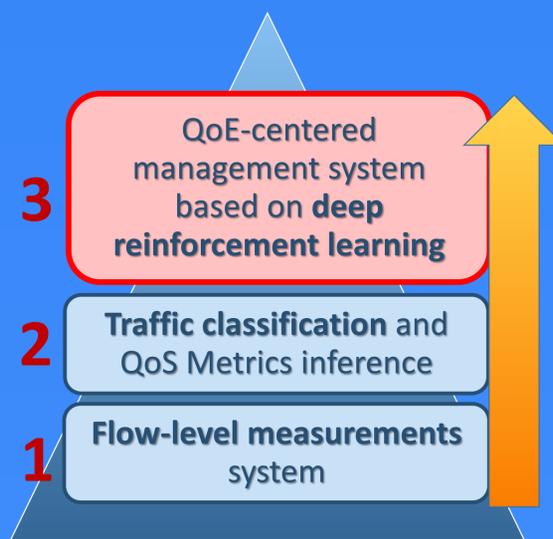


A QoE-aware management system for Software-Defined Networks



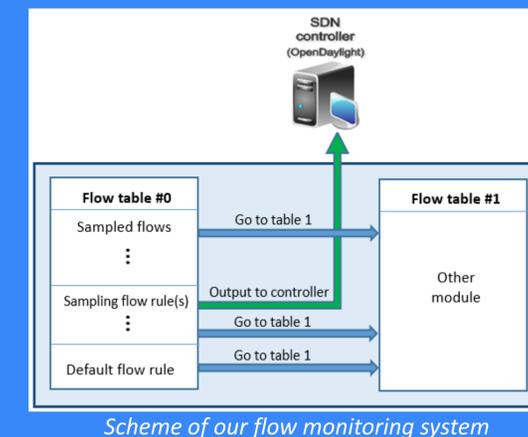
Introduction and motivation

- In the Software-defined Networking (SDN) paradigm, the centralization of the control plane enables to make decisions with a global view of the network
- With the advent of SDN, it is very important to perform a **fine-grained monitoring** to optimally exploit the possibilities that offers the centralized control plane
- In SDN, network management is performed in an external software (SDN controller) that provides a flexibility which enables to achieve Quality of experience (QoE) levels never seen before
- In order to achieve optimal QoE levels, it is necessary a comprehensive **traffic classification** where the system has information about the specific applications which are generating the traffic (e.g., mail, video streaming...)
- With the latest advances in artificial intelligence (e.g., **Deep Learning**), the SDN controller can act as a brain for the network and autonomously orchestrate all the devices under its control.



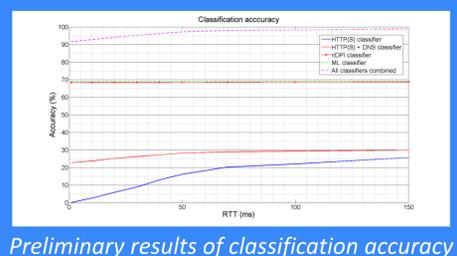
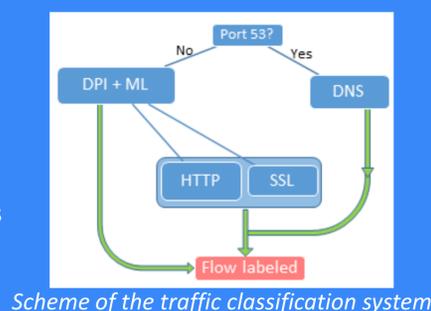
1 Flow-level measurements

- Flow-level measurement reports as in NetFlow/IPFIX
 - Scalable → Flow sampling
 - Transparent to other network tasks
 - OpenFlow compliant solution
 - Implemented in OpenDaylight and evaluated in a testbed with Open vSwitch
- ✓ **Already accomplished [1]**



2 Traffic classification

- Flow-level traffic classification (e.g., by application, services, protocols...)
- Combination of **Machine Learning** and **Deep Packet Inspection (DPI)** techniques
- Specific DPI techniques for **HTTP**, **DNS** and **SSL certificates** to obtain domain name information, as in [2]
- Leverages the information of packets reaching the SDN controller (**Low resource requirements**)



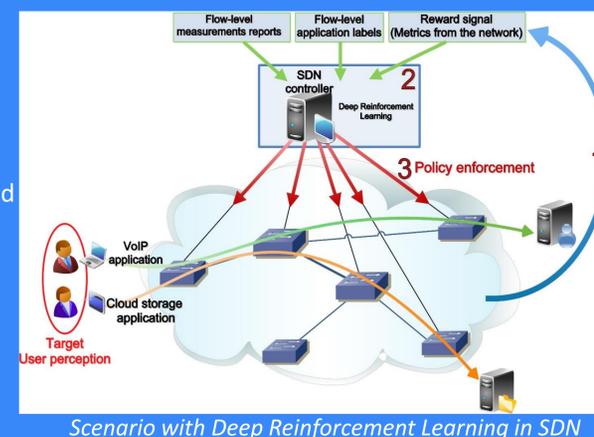
➤ **Work in progress**

3 Deep Reinforcement Learning

- The next step to improve the user perception is to apply policies directly targeted to the final perception of end-users → **Quality of experience (QoE)**
- Deep Learning + Reinforcement Learning → **Deep Reinforcement Learning**
- Inputs:
 - 1) Flow-level measurement reports
 - 2) Flow-level traffic classification
 - 3) Reward signal → metrics obtained as feedback from the network
- Objective:

Maximize the QoE

X Our next target



Conclusions and future work

- We propose a SDN management system which directly targets the QoE of the end-users
- **Complete solution** (Network measurements + traffic classification + Deep Reinforcement Learning)
- Our system leverages **Deep Reinforcement Learning** in order to maximize the QoE of end-users
- We will evaluate our system against other QoS-aware solutions (e.g., PQ-routing [3])

References

- [1] Suárez-varela, José, and Barlet-Ros, Pere. "Towards a NetFlow implementation for OpenFlow Software-Defined Networks" Accepted in the 29th ITC (2017)
- [2] Trevisan, Martino, et al. "Towards web service classification using addresses and DNS." In IWCMC (2016)
- [3] Choi, Samuel PM, and Dit-Yan, Yeung. "Predictive Q-routing: A memory-based reinforcement learning approach to adaptive traffic control." *Advances in Neural Information Processing Systems* (1996): 945-951.