



QoS in Software-Defined Networking

Concepts and Experiences

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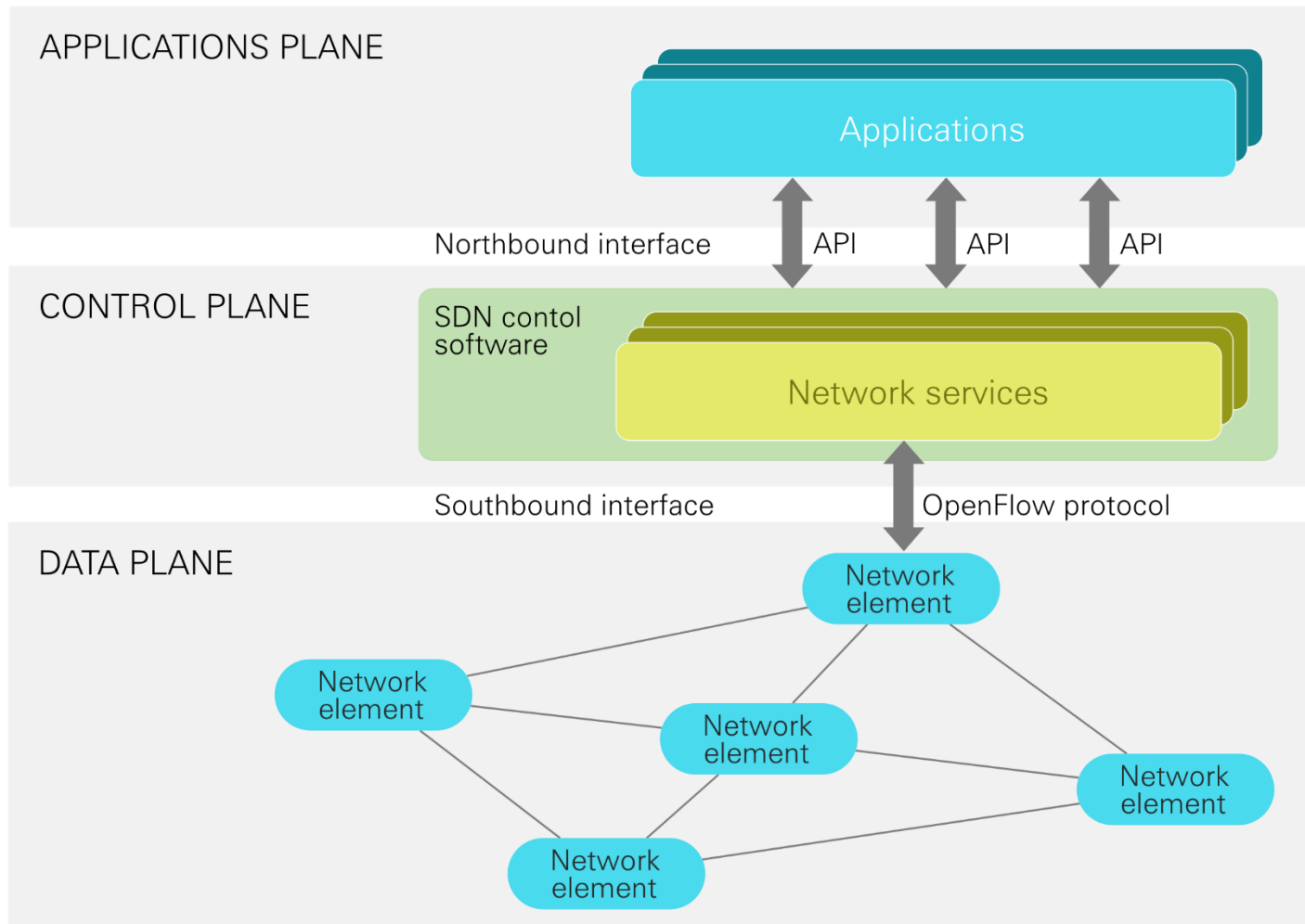


Content

- QoS in SDN
 - SDN Architecture
 - Configuration of OpenFlow-Queues in SDN
 - Prioritization of flows
- SDN-Applications exemplified for VoIP
- Experimental evaluation of QoS mechanisms in SDN
- Conclusion



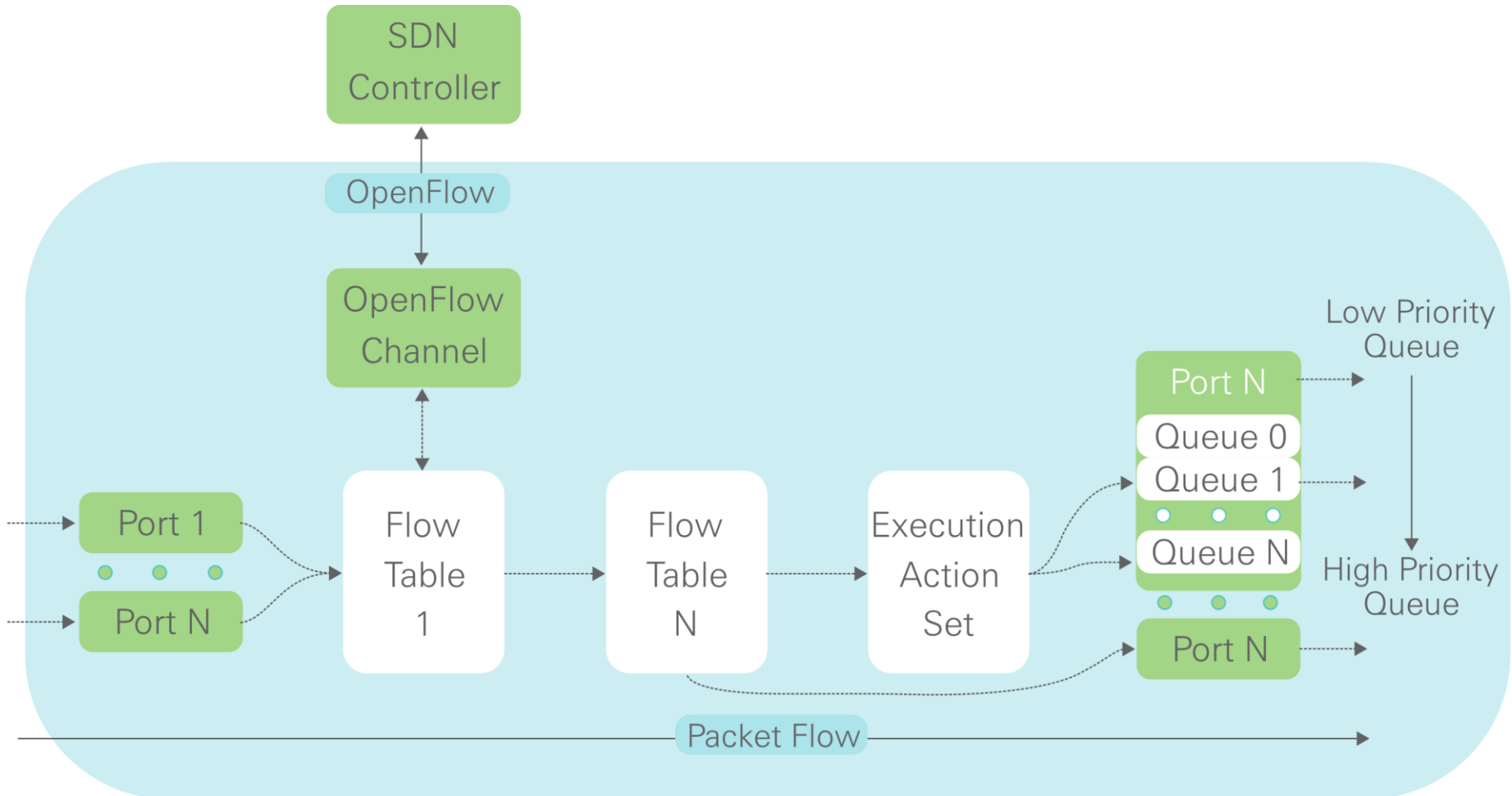
The Concept of Software-Defined Networks



Open Networking Foundation, Software-Defined Networking: The New Norm for Networks, April 2012.



Internal Architecture of an OpenFlow Switch



Open Networking Foundation, OpenFlow Switch Specification Version 1.3.5, 1 ed., March 2015.

Flow-Tables in SDN

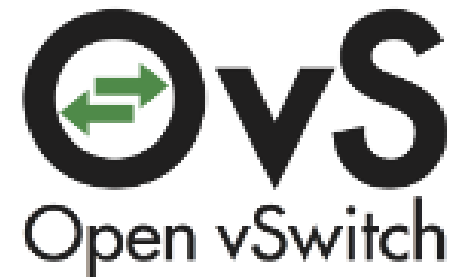
	Matching fields						Actions	Counter
	MAC src	MAC dst	IP src	IP dst	UDP port Src	...		
Flow entry 1	00:A0:C9:14:C8:29	00:B1:C9:18:C8:50	*	*	*		<ul style="list-style-type: none"> Send to port 	544
Flow entry 2	*	*	10.10.10.11	10.10.10.10	*		<ul style="list-style-type: none"> Send to queue Send to port 	457
...								
Flow entry N	*	*	*	*	5555		<ul style="list-style-type: none"> Send to controller 	623



Configuration of OpenFlow-Queues

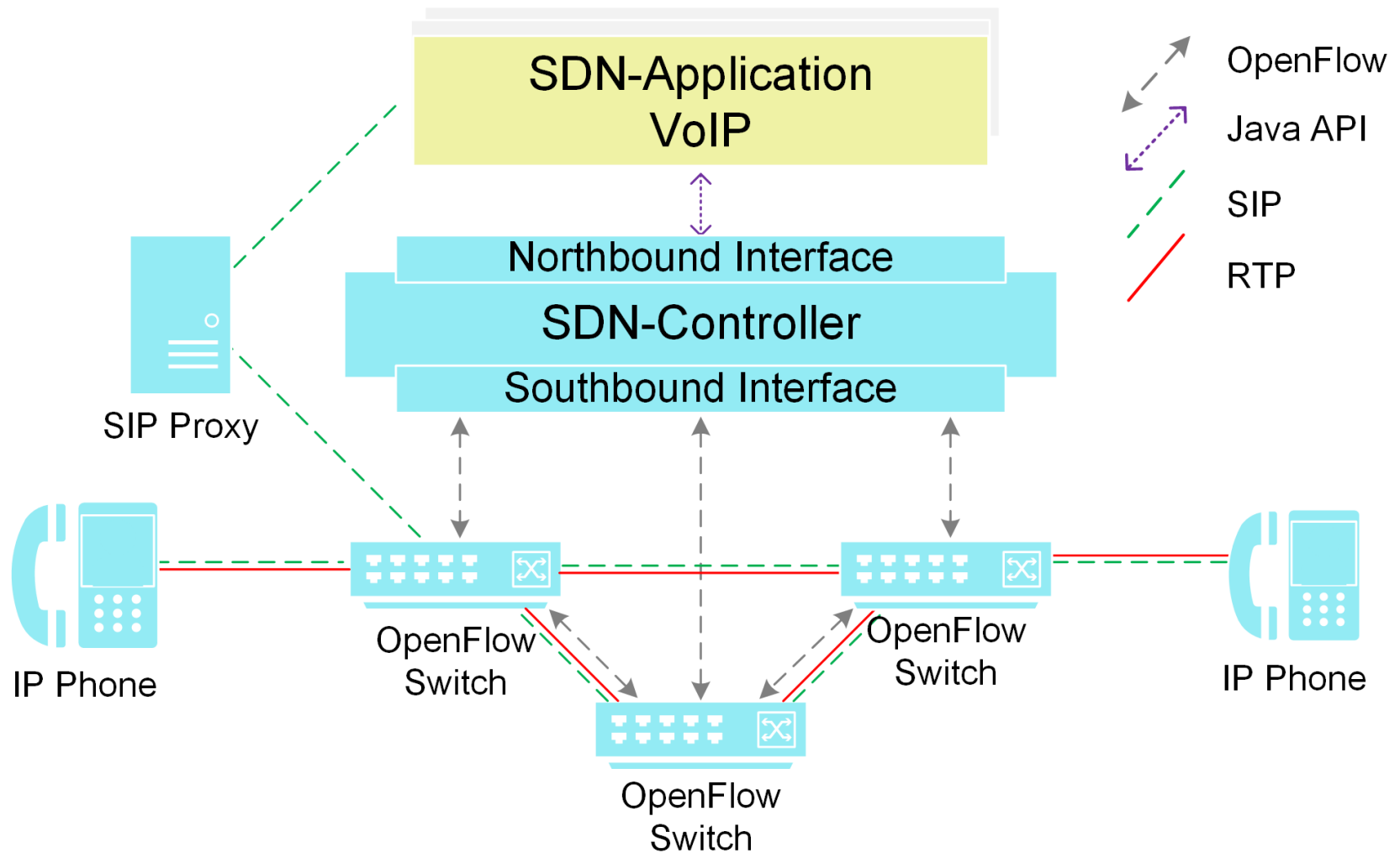
Example: OpenVSwitch on Baremetal Switches

```
ovs-vsctl set port <port> qos=@newqos
— —id=@newqos create qos type=PRONTO_STRICT
    queues: 0=@lowpriority
    queues: 7=@highpriority
— —id=@lowpriority create queue
    other-config: min-rate=<min-rate>
    other-config: max-rate=<max-rate>
— —id=@highpriority create queue
    other-config: min-rate=<min-rate>
    other-config: max-rate=<max-rate>
```



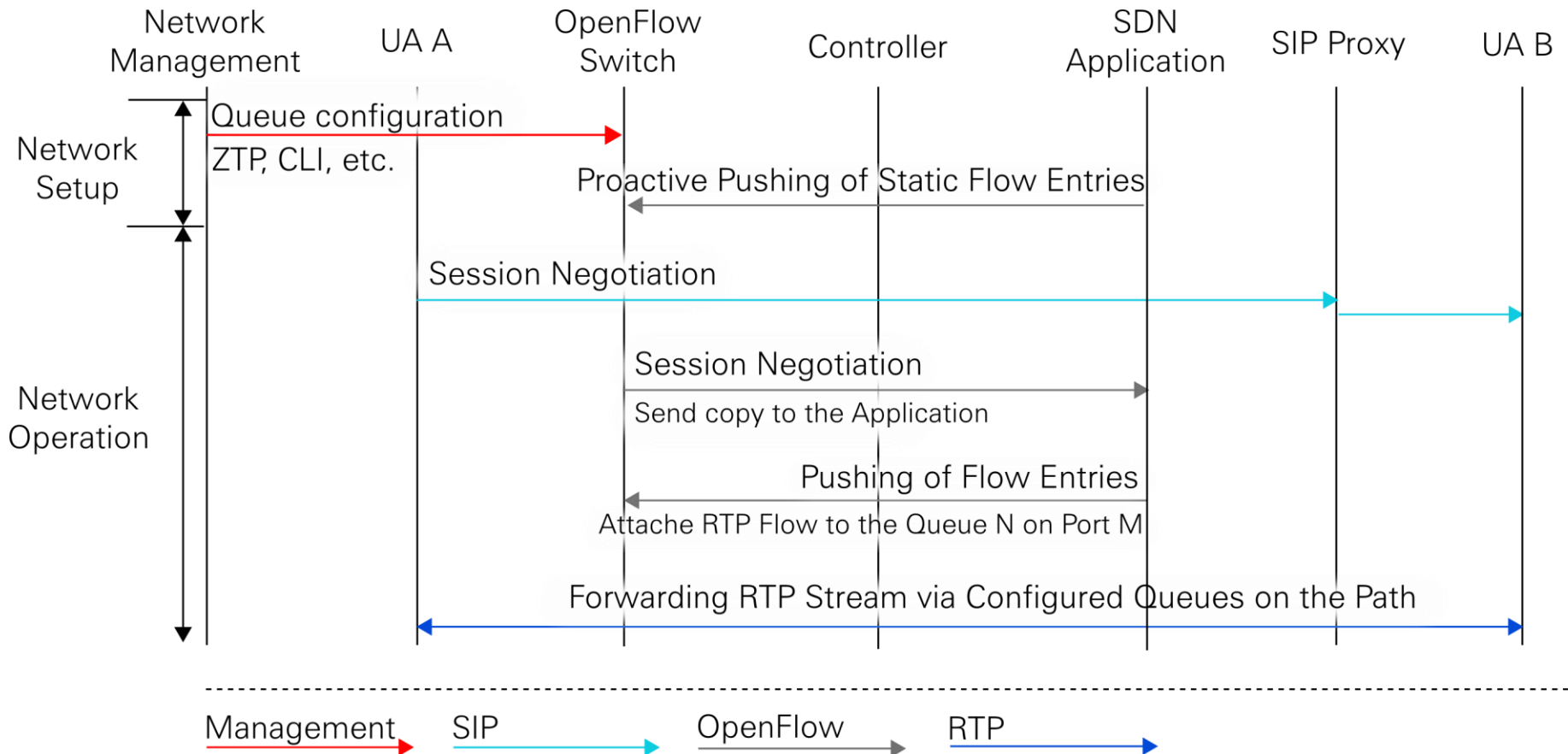


SDN-Applications Exemplified with VoIP



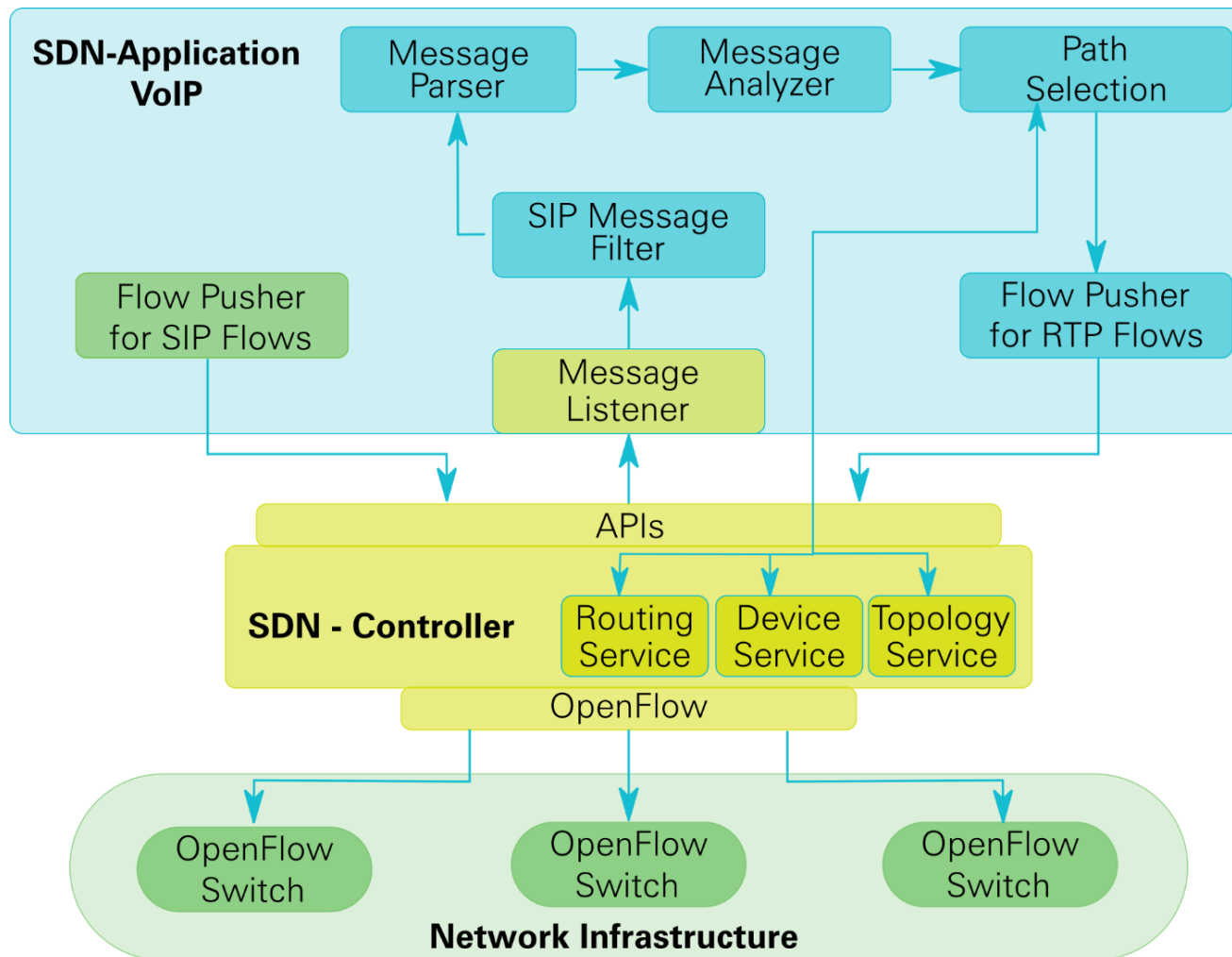


Proactive Flow Pushing of VoIP/RTP Streams



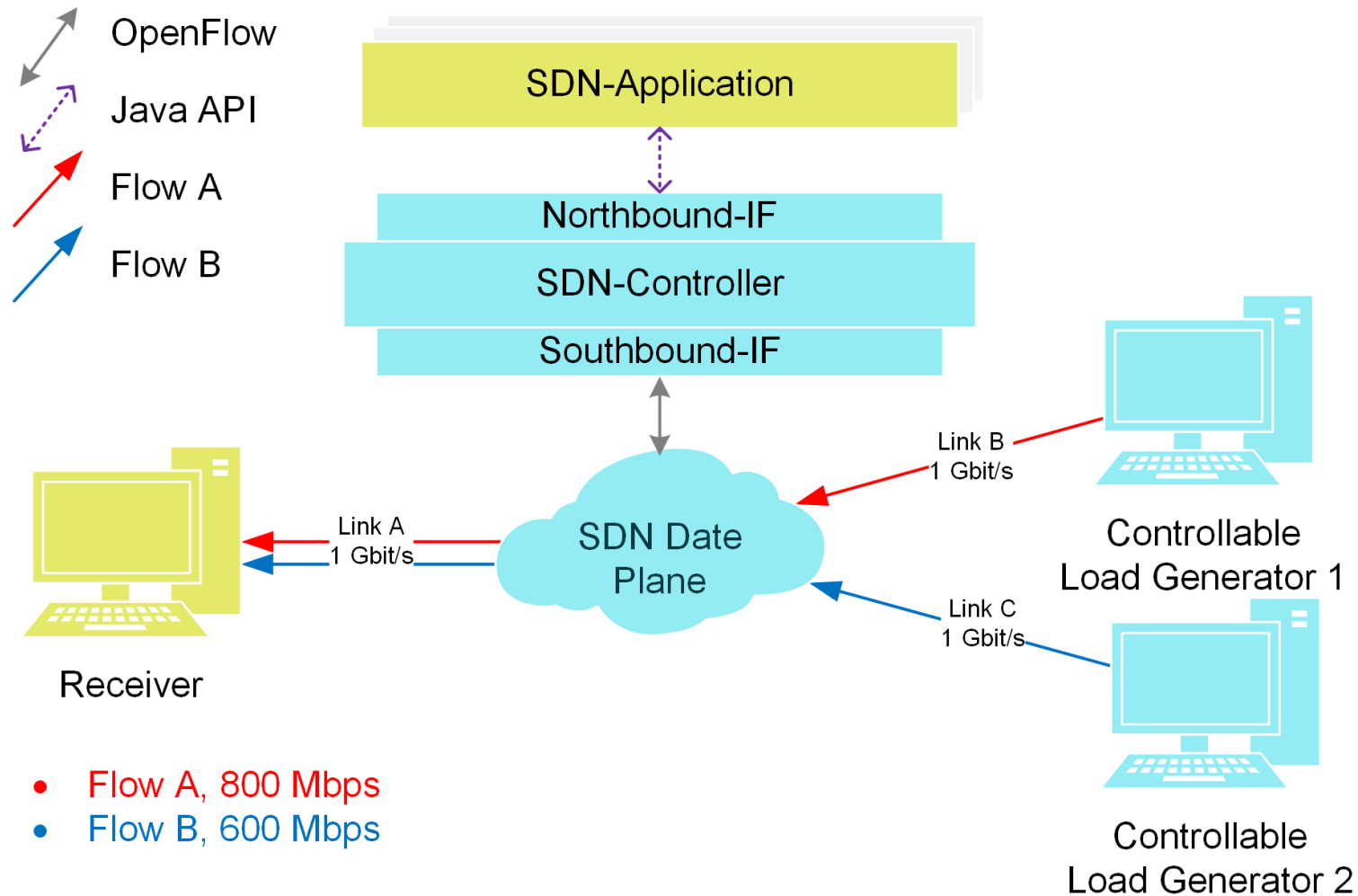


Structure of the SDN-Application





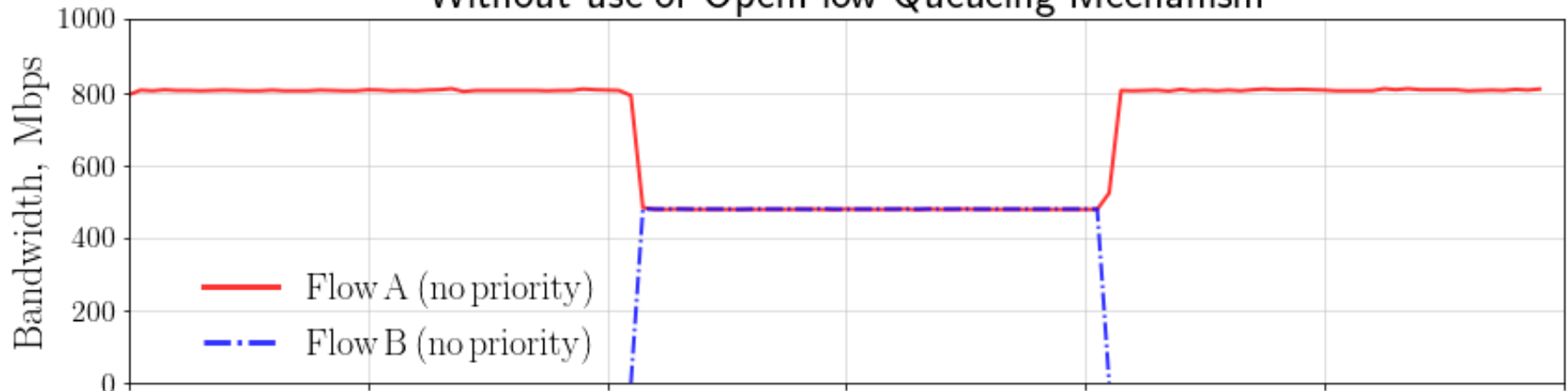
Evaluation Setup



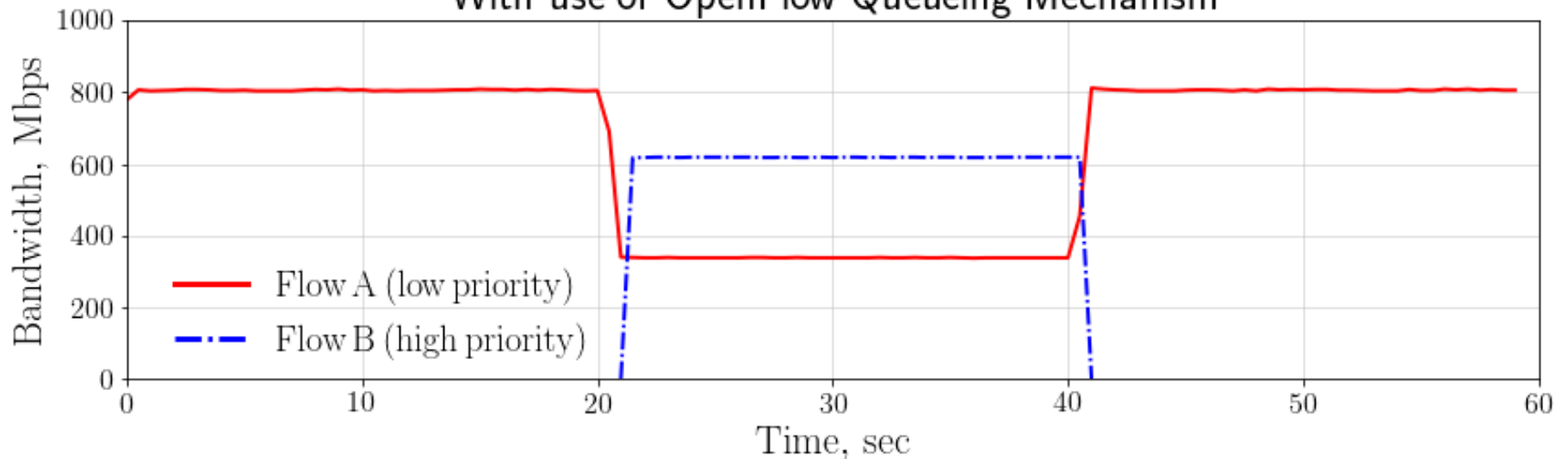


Bandwidth Distribution

Without use of OpenFlow Queueing Mechanism



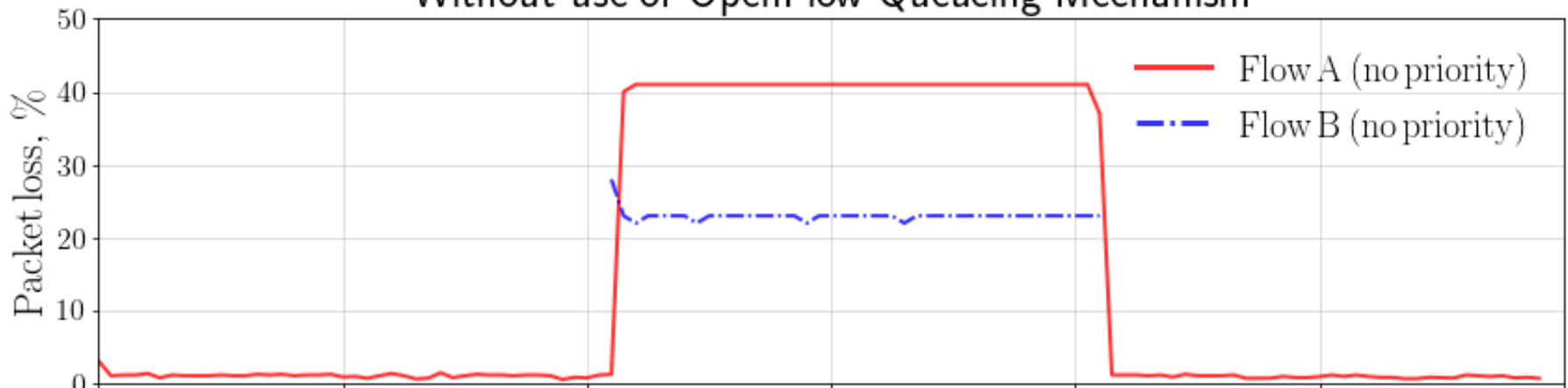
With use of OpenFlow Queueing Mechanism



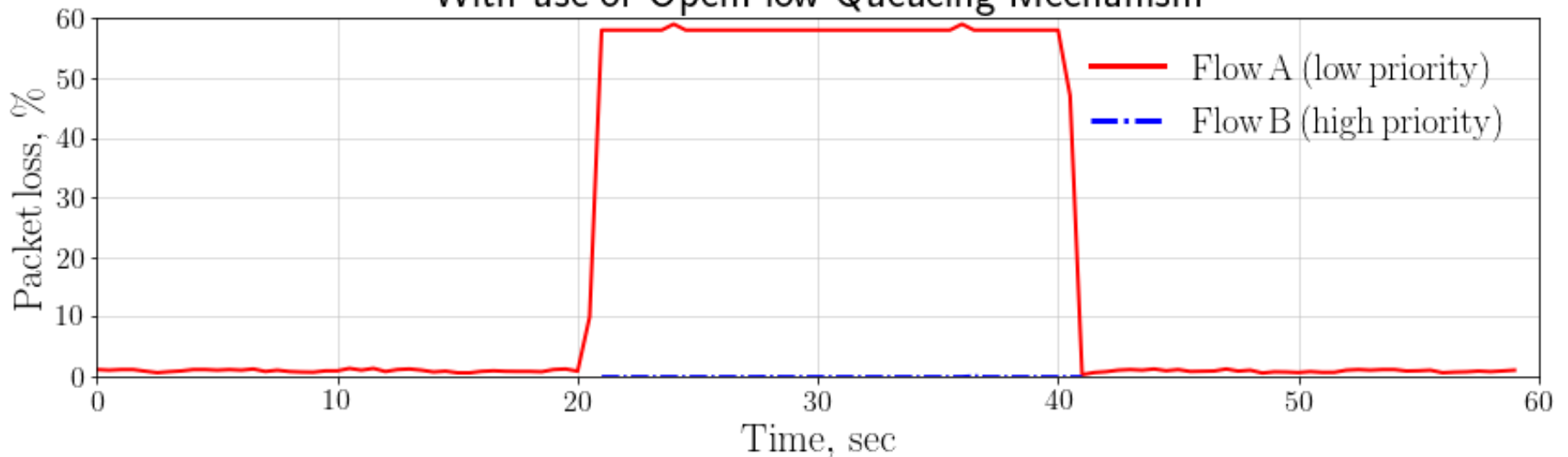


Packet Loss

Without use of OpenFlow Queueing Mechanism



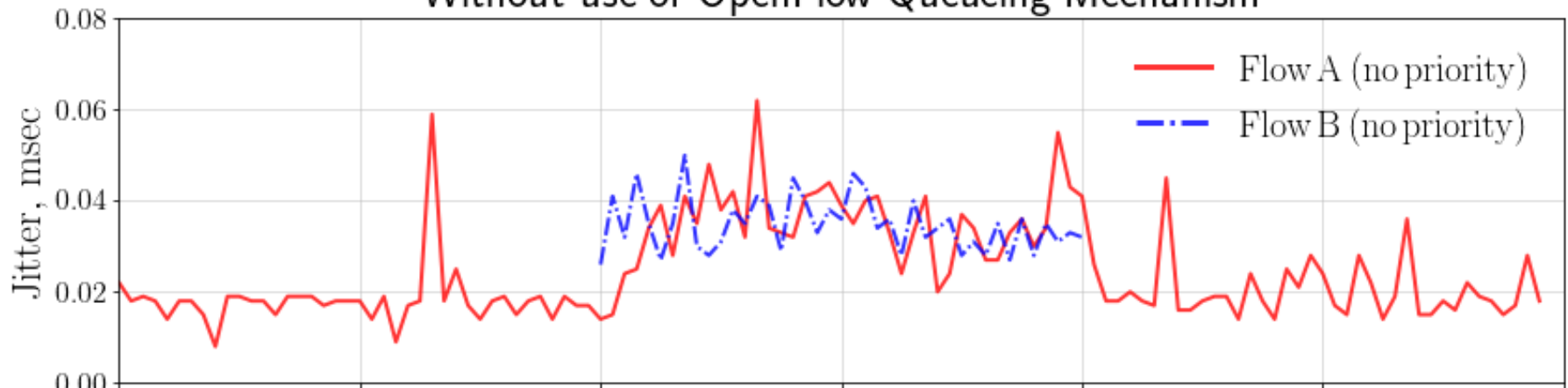
With use of OpenFlow Queueing Mechanism



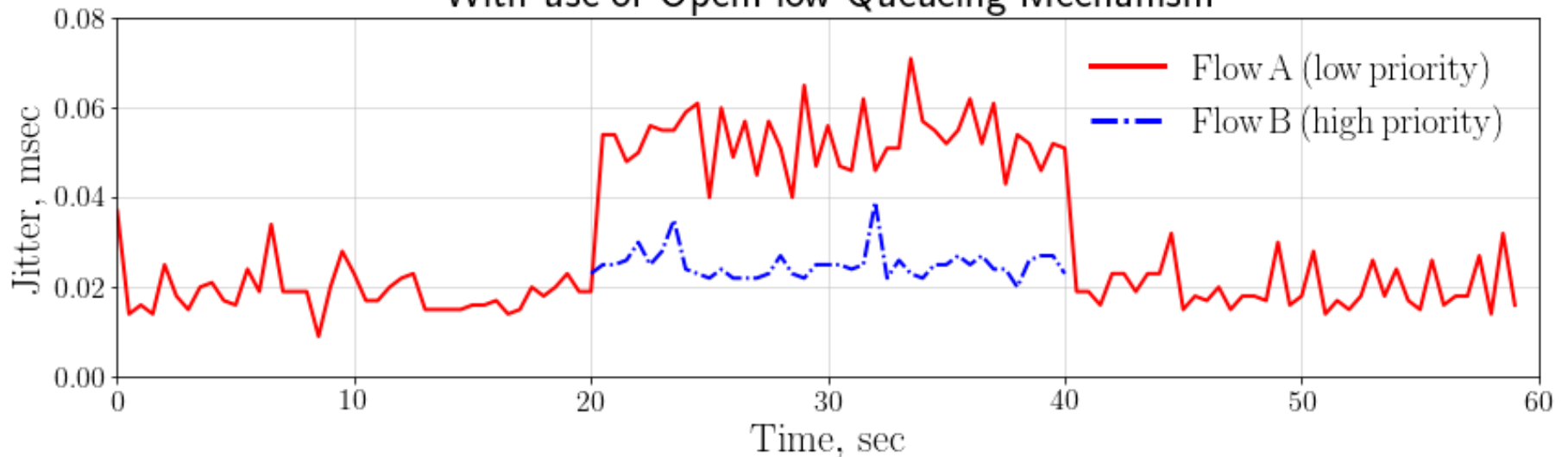


Jitter

Without use of OpenFlow Queueing Mechanism



With use of OpenFlow Queueing Mechanism





Conclusion

- OpenFlow is prepared to support QoS mechanisms
- OpenFlow-Queueing mechanism improves QoS of prioritized traffic

BUT

- The degree of network abstraction provided by SDN, as specified by ONF, is considered insufficient by the ITU [ITU-T, FG IMT 2020, 2015]
- Specification of OpenFlow is not finished:
 - OpenFlow Queues are not a mandatory part of the specification
 - Configuration of OpenFlow Queues is not handled by OpenFlow Protocol
 - Numbers and priority of the Queues are vendor depended



Thank you for your attention!



Future Work

- Investigate and evaluate further QoS mechanisms in SDN like
 - OpenFlow metering
 - OpenFlow queue statistics
- Examine more SDN-Switches of different vendors in terms of QoS



SDN and M2M protocols

