SOMETIME[1]

SOftware defined network-based Available Bandwidth MEasuremenT In MONROE

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Outline

- Motivation - SOMETIME
- Enabling technologies
  - ABw estimation tools
  - SDN
  - Virtualization
  - MONROE
- Experimental results

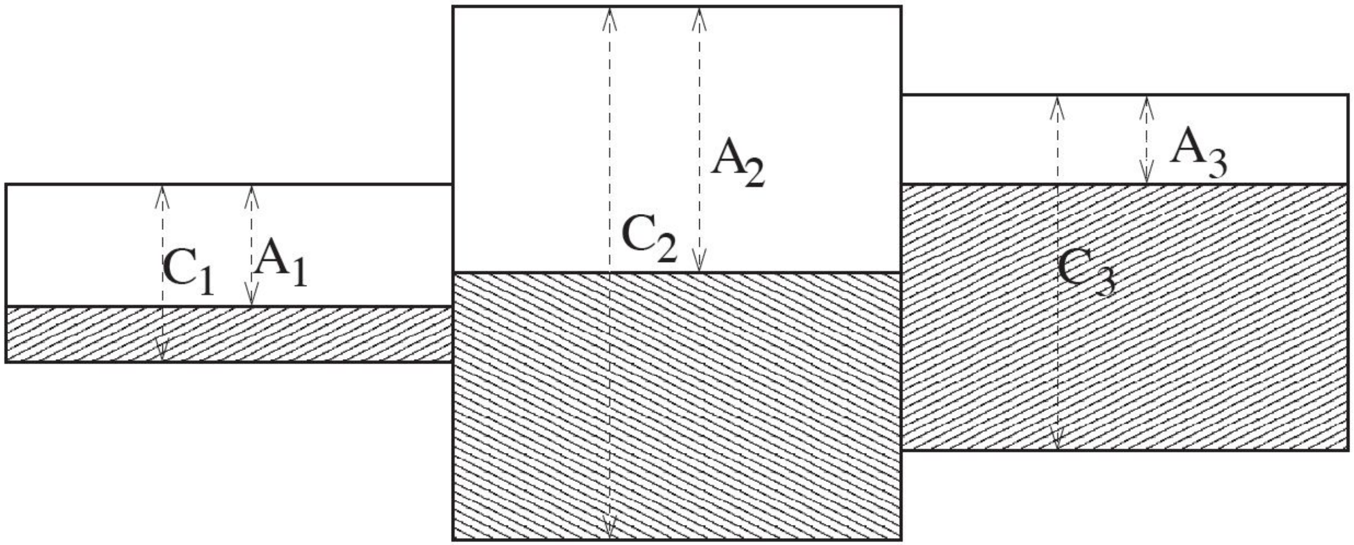
SOMETIME

- SOftware defined network-based Available Bandwidth MEasuremenT In MONROE
- ABw: highly sought-after metric
- SDN: flexible and standard approach
- MONROE: BroadBand Mobile testbed, leveraging virtualization (docker)

Focus on “bandwidth”

- Different “network bandwidth” concepts:
  - (upper bound) IP-layer **capacity**
  - (protocol independent) **Available Bandwidth**
  - (TCP-specific) **Bulk Transfer Capacity**
- Capacity and ABw can be referred to a *link* or a *path*
- BTC is referred to a *path*

Bandwidth measurement at network layer: Capacity vs Available Bandwidth



- Network path: a sequence of “pipes” characterized by capacity and usage
  (links not belonging to the path are not shown)
- Available Bandwidth (ABw) is the *spare capacity*
- Link with smallest capacity in the path is *narrow* link
- Link with smallest ABw in the path is *tight* link

Available Bandwidth - uses

- Measurement of bandwidth is important for adapting application traffic to the properties of the network
  - **Streaming media applications**: to adjust the transmission rate to the network bandwidth
  - **Server selection**: to find a server with an appropriate bandwidth connection to the client
  - **Estimating the bandwidth-delay product**: for use in TCP flow control
  - **Overlay networks/ multi-homing**: to route data over good-performing paths
  - **Verification of Service Level Agreements** (SLAs) between network customers and providers
  - **Admission control** for applications with bandwidth requirements

Available Bandwidth and wireless

- Measurement of available bandwidth is non trivial
  - *Passive* methods require **control** on all nodes on the path
  - *Active* methods

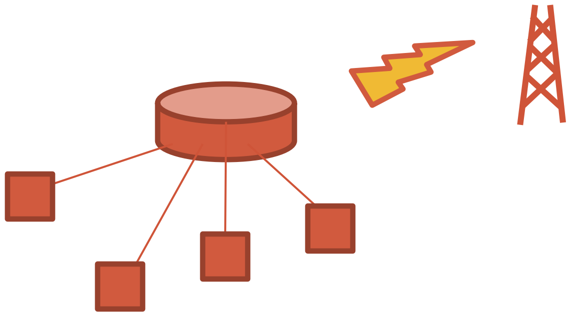
    (closed loop probe traffic injection and analysis)

    exhibit trade-offs among
    - **Accuracy**
    - **Intrusiveness**
    - **Timeliness**
  - **… already in <u>wired</u> setups.**

- **Wireless** scenarios introduce
  - further **inaccuracy** (dynamic capacity, scheduling, drops *not only* due to resource exhaustion)
  - high $ensitiveness to generated **volume** of (probe) traffic

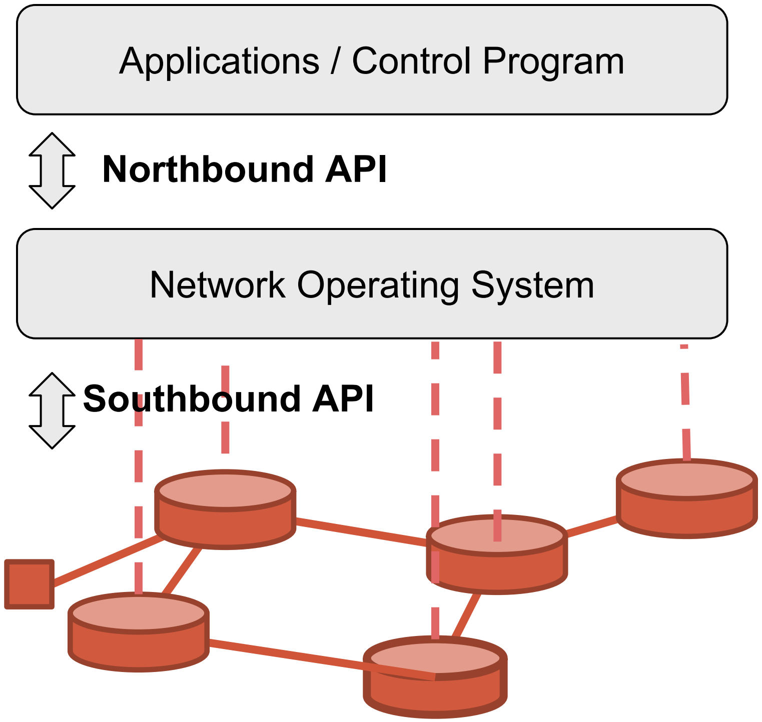
Notable Mobile Wireless scenarios

- Likely (further) diffusion of RAN link sharing scenarios
  - **Smartphone:** network access shared among multiple apps
  - **Tethering:** smartphone provides connectivity to a laptop, sharing the access
  - **Mobile Hot-spot (Mi-Fi)**: 3G/4G connectivity to the Internet shared via WiFi to multiple devices
  - **In-vehicle infotainment**: vehicles hosting a local network of devices, sharing 3G/4G connectivity to the Internet

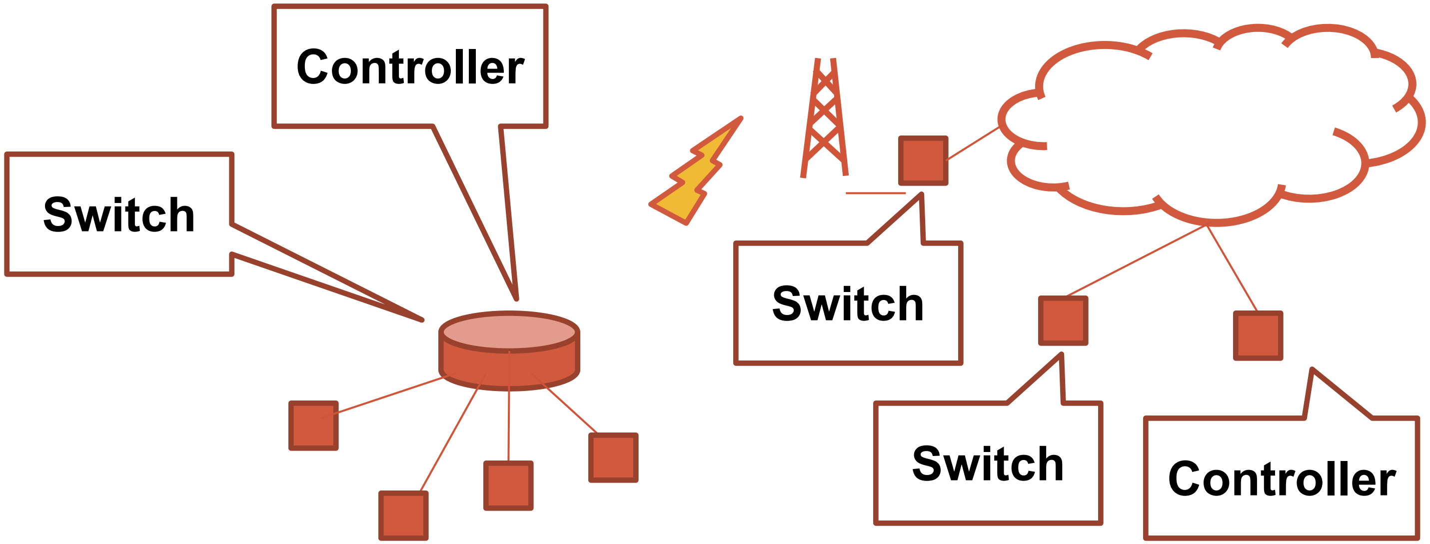


What SDN brings to the scenario

- **Flexibility** (controller: local/remote/hierarchical)
- **Standardization**: extensible to real scenarios, no point in using an ad-hoc solution
- **Hot**: active scientific research, ongoing evolution of standard



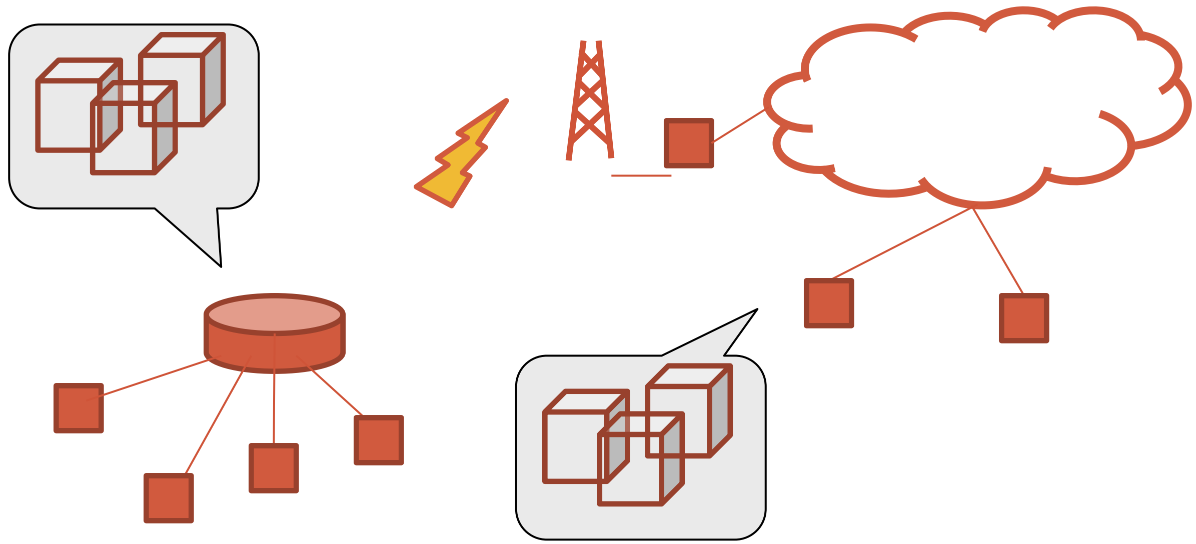
SDN and Mobile Wireless scenarios



- network local to the mobile node
- local controller (recommended)

- logically centralized control
- VLAN/Overlay
- private cloud
- datacenter
- managed servers

Virtualization

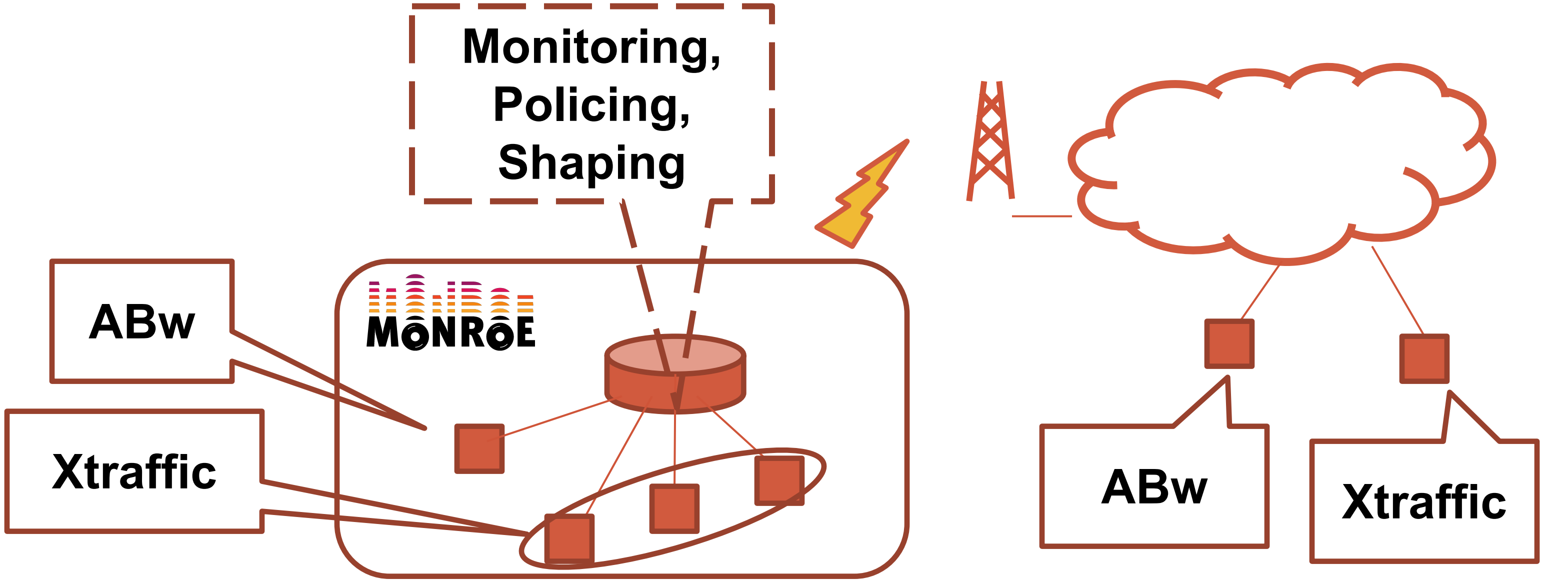


- **Cloud Computing** has widely spread virtualization technologies
  - not considering **virtualized endpoint** in path measurement would result in unreasonable limitation of applicability
- virtualization allows unprecendented flexibility, support for easy horizontal scaling...
- ... but it also potential source of **inaccuracy** of ABw estimation tools

… hence:

- BBM testbed, experiments and measurements inside docker containers
- leveraging MONROE testbed we can deploy, test and tune ABw estimation tools, on real BBM
  - as in real life mobile communications, **data quotas are a concern**: research for tools and tuning for minimum intrusiveness

Notable Mobile Wireless scenarios, emulated in MONROE



- **ABw estimation**, in presence of other applications that generate traffic, in virtualized nodes.

SOMETIME project roadmap

A. Evaluation of publicly released **ABw estimation tools** for MBB test platform
B. Evaluation of the impact of **HW and virtualization** on traffic-generation accuracy
C. Evaluation of the impact of **SDN technologies** on traffic-generation accuracy

D. Definition, setting, and evaluation of an SDN-enabled ABw estimation tool tailored for the MONROE measurement scenario
E. Deployment on MONROE testbed

COVERED BY THIS PRESENTATION

Comparing ABw-estimation tools in SDN

Tools-selection criteria

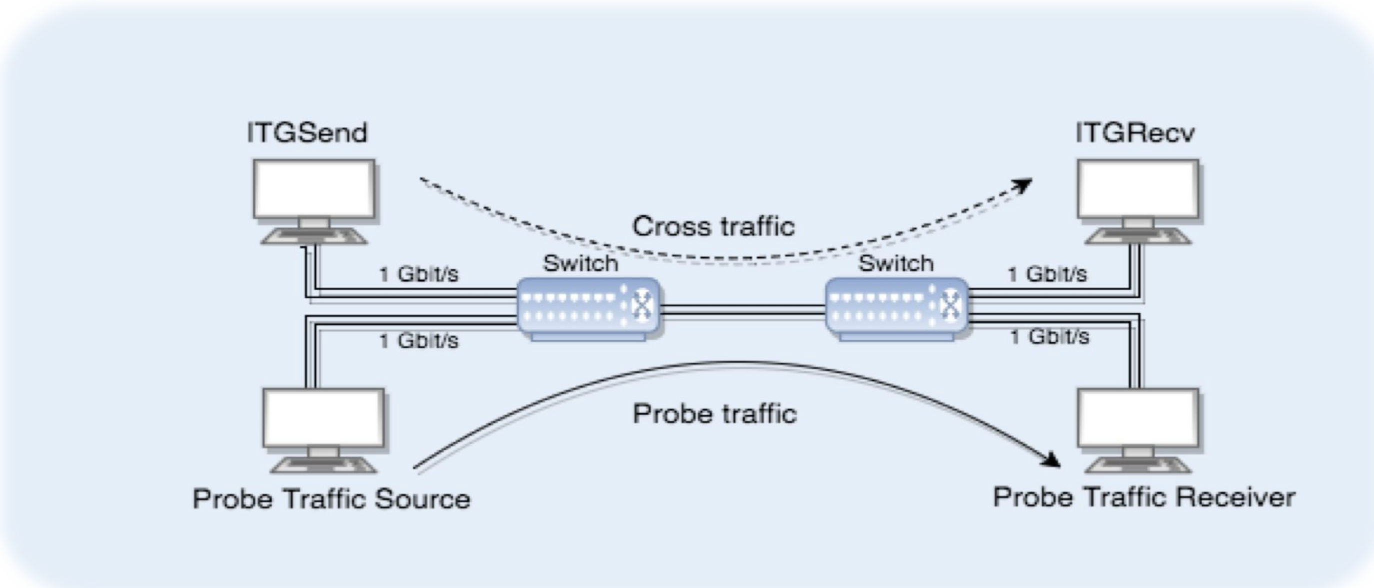
- availability of **source code**
- possibility to correctly compile it for Debian **jessie** (same as deployed on MONROE);
- enhancement **technique** adopted by each tool to improve accuracy and to mitigate intrusiveness

Selected Tools

- Pathload
- YAZ
- ASSOLO
- STAB

Comparing ABw-estimation tools in SDN

- Mininet Emulation environment
  - LXC (LinuX Containers) kernel-based virtualization, analogous to Docker (used in MONROE)
- **Open VSwitch** SDN switch implementation
- **D-ITG** to generate cross-traffic



Comparing ABw-estimation tools in SDN

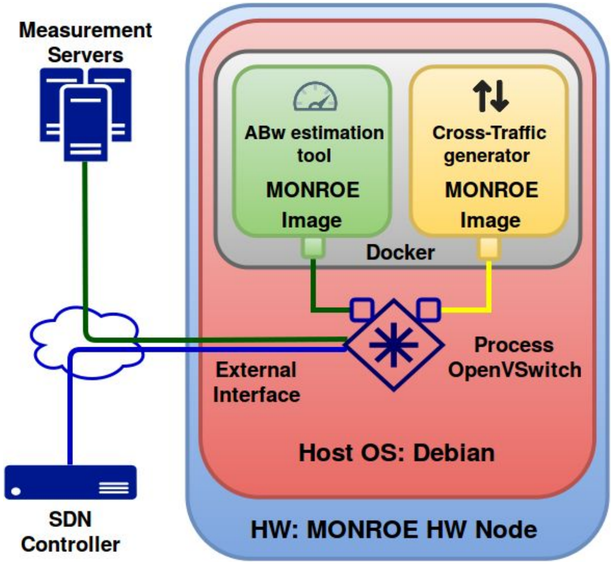
Tool	Capacity [Mbps]	Cross-traffic [Mbps]	Estimation [Mbps]	Relative error
Pathload	3	1.5	2	33%
	5	1.5	2.5	-28%
	100	74	20	**-23%**
Yaz	10	4	2.4	-60%
Assolo	10	2	34	**325%**
	20	6	34	142%
	100	76	48	100%
STAB	5	1.5	3.7	50%
	10	4	4.7	**-21%**
	100	74	32.6	25%
	1000	74	118	-87%

ABw estimation tools: recap

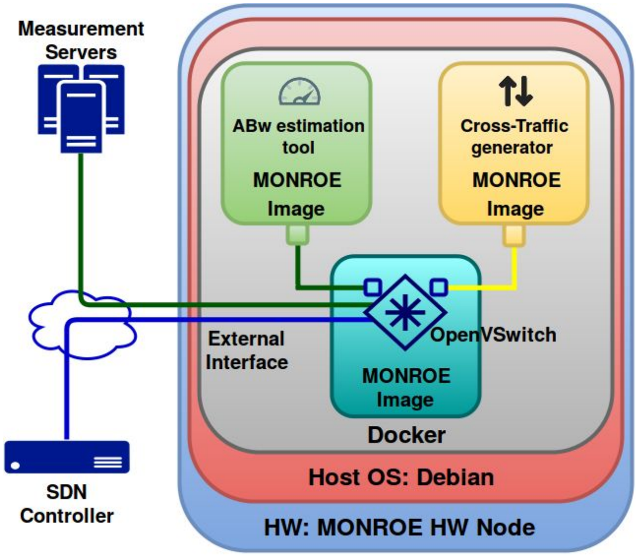
- ABw estimation tools perform poorly (or do not even produce an estimate) in **virtualized environment**
- further investigation revealed that major issue was with **traffic generation** accuracy
- other issue is with **auto-tuning** mechanisms that do not always work
- this led to investigation of **generation accuracy** in scenarios modeled by SOMETIME

Setups for packet generation limits

- Native (just OVS, no virtualization)
- Host-OVS
- Docker-OVS



Host-OVS Setup

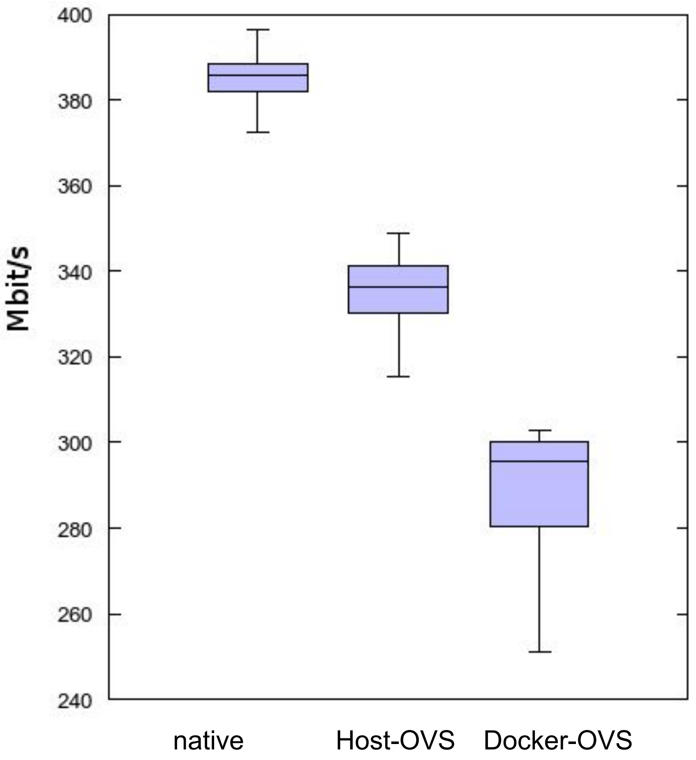


Docker-OVS Setup

Impact of virtualization on packet generation

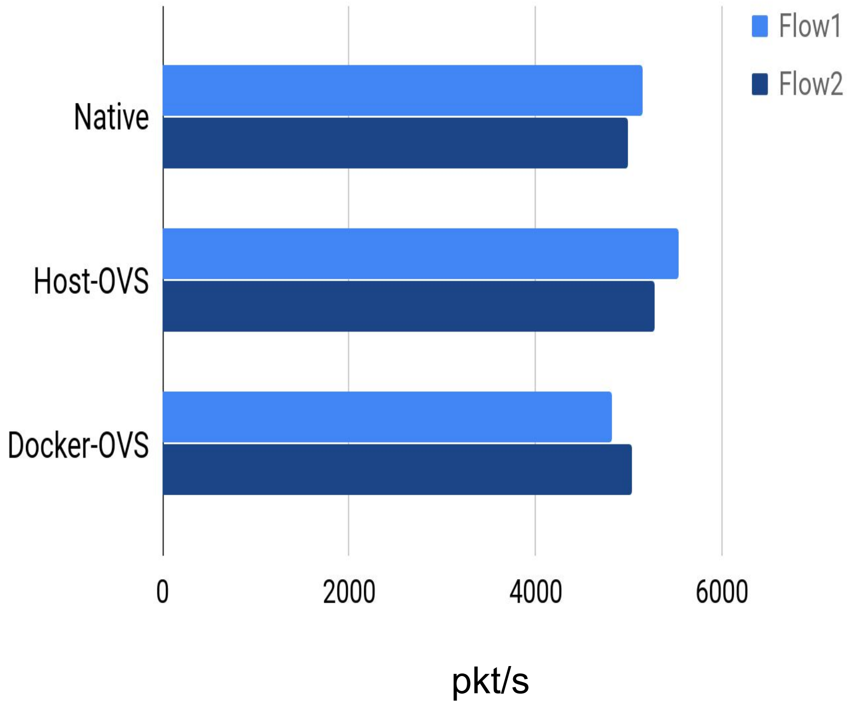
- UDP upstream achievable throughput
- D-ITG used at maximum paket rate, size 1470B

- Notable discrepancy between the *required* bit rate and inter-packet time and *generated* ones (even for achievable rates)

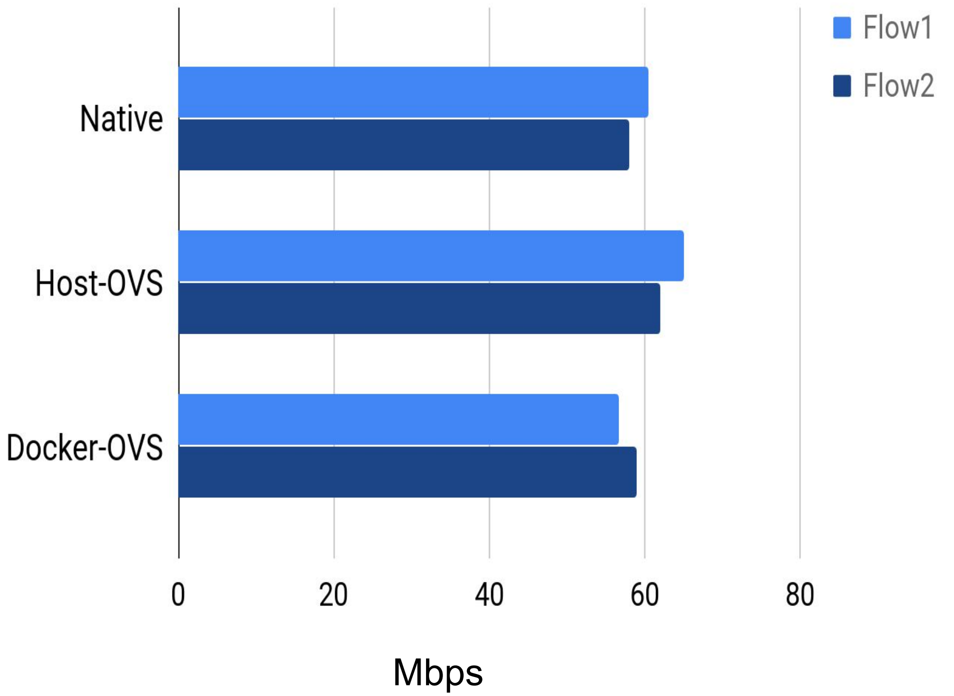


Impact of SDN on fairness (1/2)

Packet rate (**CBR** traffic)



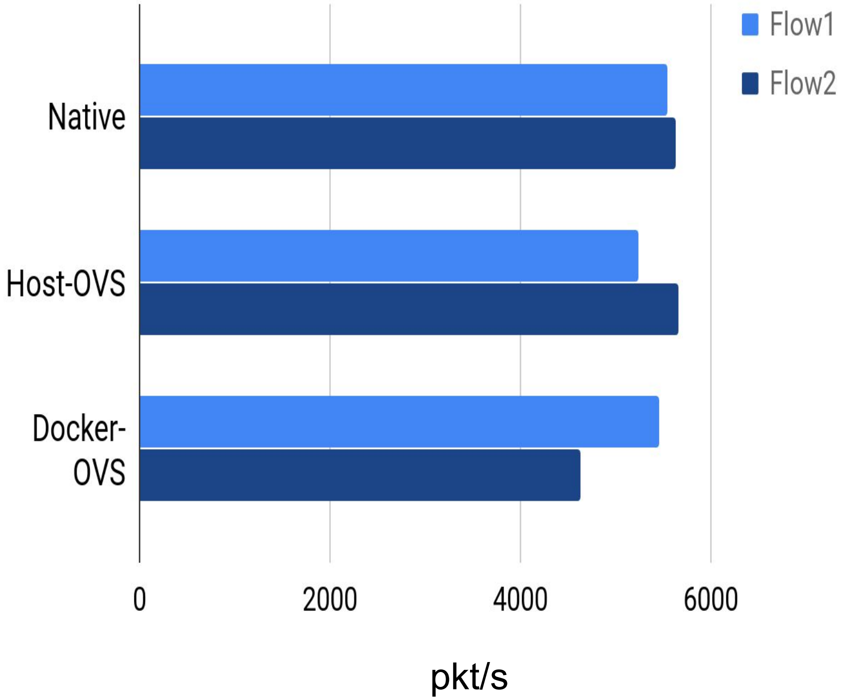
Bit rate (**CBR** traffic)



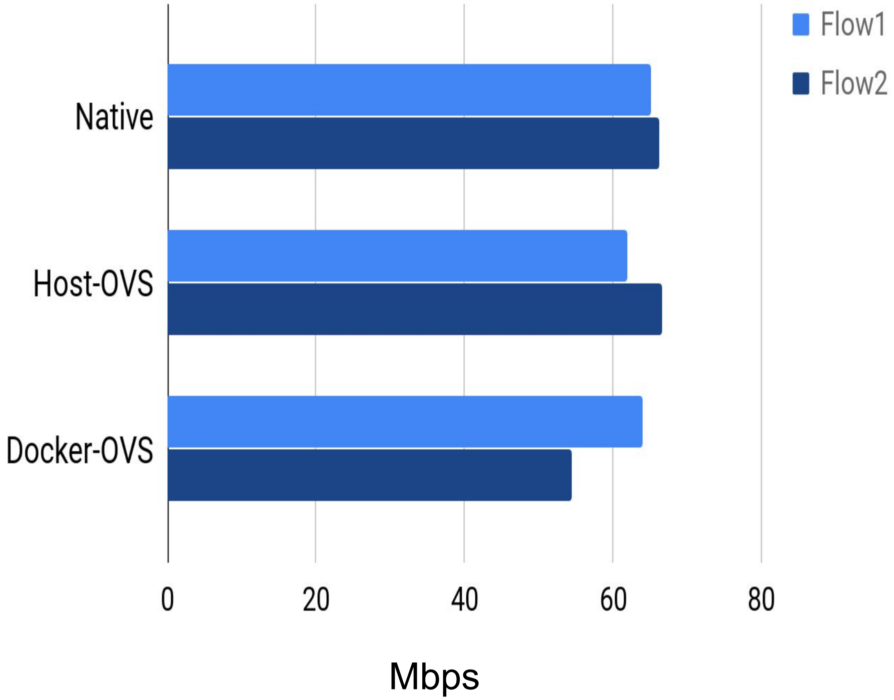
- 10s runs, results averaged over 100 runs

Impact of SDN on fairness (2/2)

Packet rate (**Poisson** traffic)



Bit rate (**Poisson** traffic)



- 10s runs, results averaged over 100 runs

Preliminary on-field experiments

Sender-side results for MONROE testing nodes

			payload: 1B		payload: 1450B	
Node ID	**Country**	**Operator**	**Bit rate [Mbps]**	**Packet rate [Kpkt/s]**	**Bit rate [Mbps]**	**Packet rate [Kpkt/s]**
201	Norway	Telenor	3.13	19.56	137.51	11.85
248	Sweden	TelenorS	2.95	18.43	122.33	10.55
58	Spain	Voda ES	2.89	18.04	133.61	11.52
119	Italy	I WIND	3.16	19.73	122.68	10.58

- note: results are *generated* rates
  (received goodput is ~ 22Mbps at most)

Traffic generation tests: recap

- Rate generation is **significantly lower** than required (timing mechanisms need tuning).
- Generated data rates on NIC are **enough** to test ABw in 4G scenarios (also on deployed MONROE nodes).
- SDN (OVS) and virtualization (Docker) do apply a toll (up to **~23%**) on UDP achievable throughput
- OVS **affects fairness** in sharing the outbound link (up to ~15% less byte throughput)

Next steps

- ~~move ABwET testing from completely emulated testbed to physical testbed~~ (OC1 Meeting)
- ~~evaluate impact of SDN and virtualization at different sending rates in MONROE setup~~ (OC1 Meeting)
- ~~evaluate usage of SDN to shape traffic in MONROE setup~~ (OC1 Meeting)
- implement more accurate ABw estimation tool (accounting for requested/generated rate difference, and context switch detection)
- inform the estimation tool with passive measurements

Questions and comments