SOMETIMES\textsuperscript{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 wired setups.

- Wireless scenarios introduce
  - further inaccuracy (dynamic capacity, scheduling, drops not only due to resource exhaustion)
  - high sensitivity 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
Cloud Computing has widely spread virtualization technologies. Not considering virtualized endpoint in path measurement would result in unreasonable limitation of applicability. Virtualization allows unprecedented 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
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

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<td>1.5</td>
<td>2</td>
<td>33%</td>
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<tr>
<td></td>
<td>5</td>
<td>1.5</td>
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<td>1000</td>
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<td>118</td>
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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 packet 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)

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<tr>
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<th>Flow1</th>
<th>Flow2</th>
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<tr>
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<tr>
<td>Host-OVS</td>
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<tr>
<td>Docker-OVS</td>
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Bit rate (**CBR** traffic)

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- 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

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<td>Norway</td>
<td>Telenor</td>
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<td>19.56</td>
<td>137.51</td>
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<td>TelenorS</td>
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<td>18.43</td>
<td>122.33</td>
<td>10.55</td>
</tr>
<tr>
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<td>Spain</td>
<td>Voda ES</td>
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<td>18.04</td>
<td>133.61</td>
<td>11.52</td>
</tr>
<tr>
<td>119</td>
<td>Italy</td>
<td>I WIND</td>
<td>3.16</td>
<td>19.73</td>
<td>122.68</td>
<td>10.58</td>
</tr>
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- 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