An experimental evaluation of the impact of heterogeneous scenarios and virtualization on the available bandwidth estimation tools

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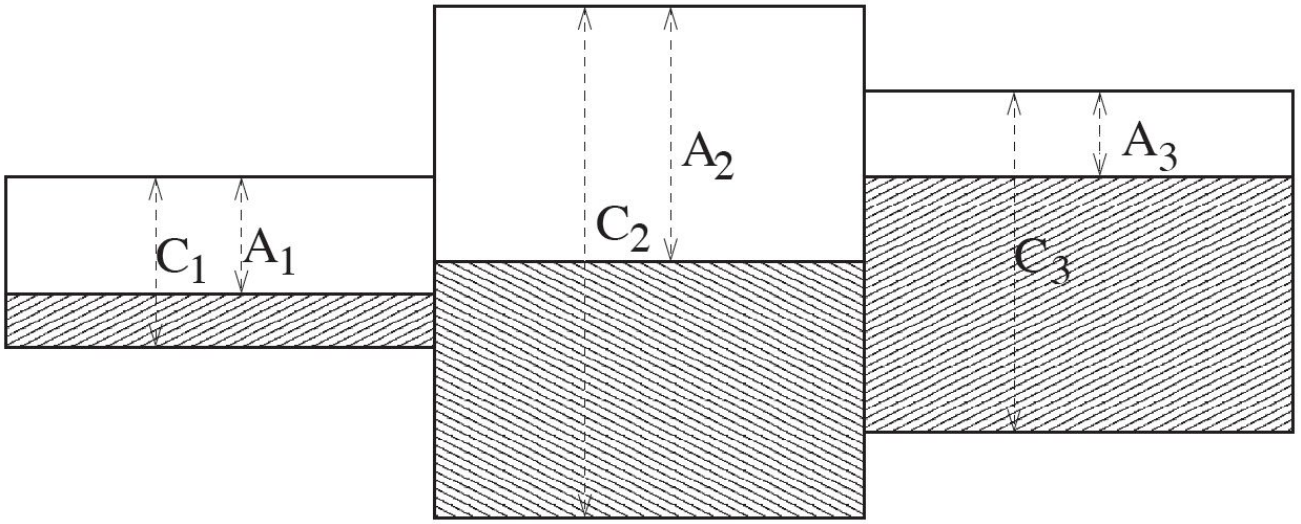
Bandwidth measurement at network layer: Capacity vs Available Bandwidth



- 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 formal definition

- At any time, network link is either fully utilized (u=1) or not used (u=0)
- Average utilization from time *t-α* to t is given by

$$\bar{u}(t-\alpha,t) = \frac{1}{\alpha}\int_{t-\alpha}^{t} u(x)dx$$

- Let $\bar{u}_i$ be the average utilization of the *link i*
- Let C_i be the capacity of the *link i*
- Then the available bandwidth during that period is

$$A_i = (1 - \bar{u}_i)\, C_i$$

- The available bandwidth along the path is then

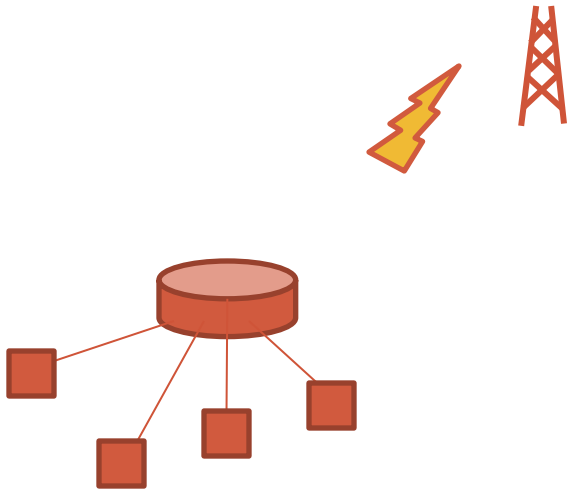
$$A = min_{i=1,2,...H}\, A_i$$

Available Bandwidth - Applications

- Measurement of bandwidth is important for applications that intend to adapt their behavior 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**: to route data over good-performing paths
  - **Verification of Service Level Agreements** (SLAs) between network customers and providers

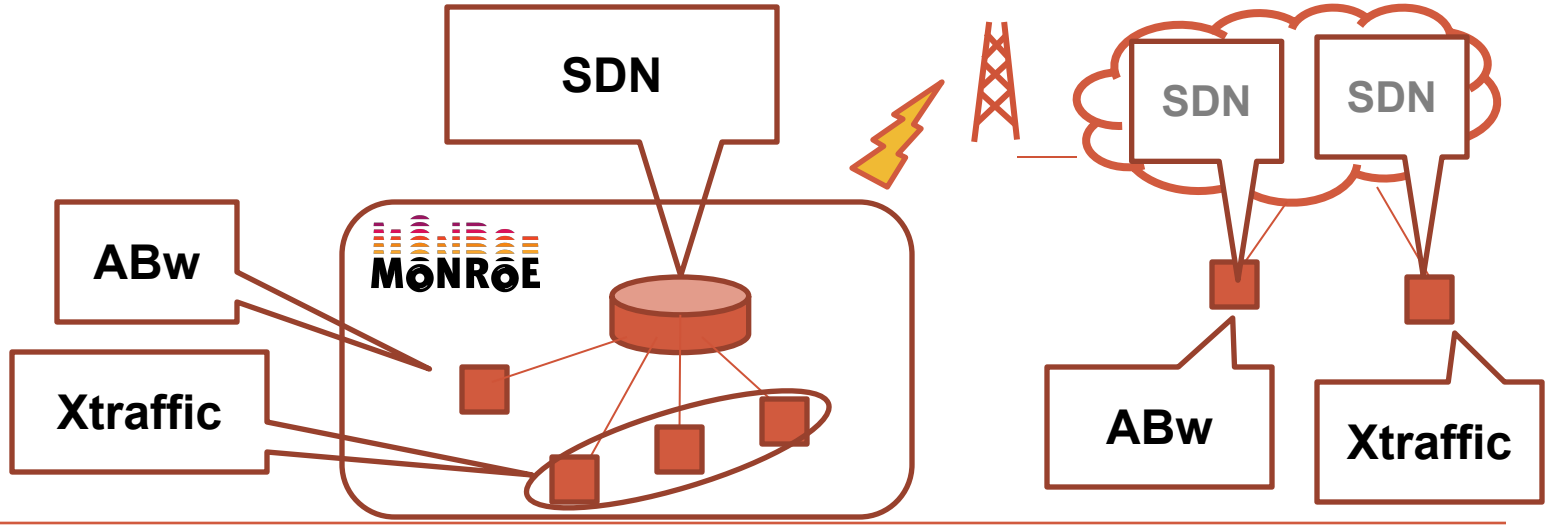
Notable Mobile Wireless scenarios

- Likely (further) diffusion of RAN link sharing scenarios
  - **Smartphone:** network access shared among multiple apps
  - **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



ABw estimation using SDN in MONROE

- **To account for interference with other applications, we investigate how to**
  - **add *controlled cross traffic* (Xtraffic)**
  - **monitor cross traffic and probe traffic**



Experimental evaluation of the impact of heterogeneous scenarios on **ABw estimation tools**

Comparing ABw-estimation tools for SOMETIME

Tools selection criteria

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

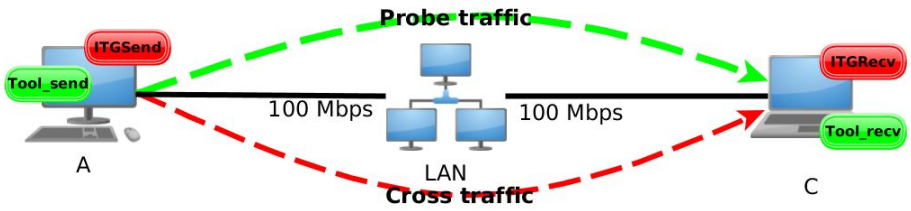
Selected Tools

- Pathload
- YAZ
- ASSOLO
- Pathchirp

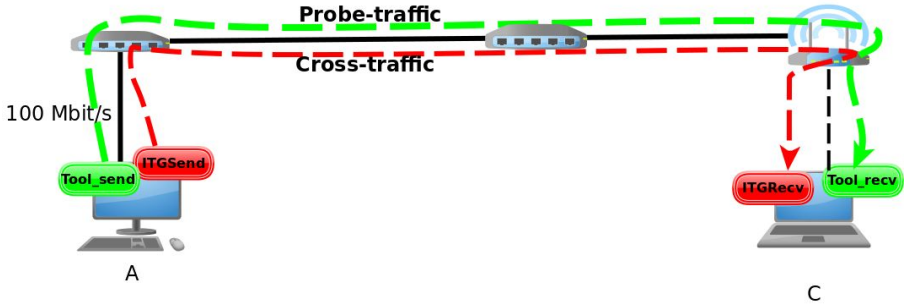
Experiment setup details (hosts)

	Node A (server)	**Node B (server)**	**Node C (client)**
CPU	I3-3200@3.3 GHz x 4	E5-2640 v2 @ 2.00GHz x 16	T4200@2.00GHz x 2
OS	Ubuntu 14.04.5 LTS 64 bit	Ubuntu 14.04.2 LTS 64 bit	Ubuntu 16.04 LTS 32 bit
Kernel	Linux 3.19.0-73-generic	Linux 3.13.0-24-generic	Linux 4.4.0-66-generic
RAM	4 GiB	16 GiB	2 GiB
NIC	Gigabit Ethernet Adapter	Gigabit Ethernet Adapter	Gigabit Ethernet Adapter Wireless Network Adapter

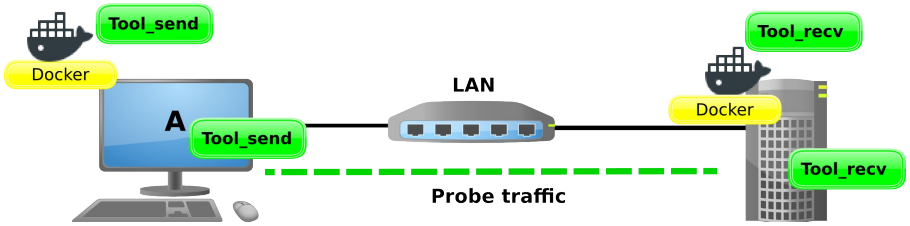
Heterogeneous setup scenarios taken into account



Wired
(A→C and C→A)

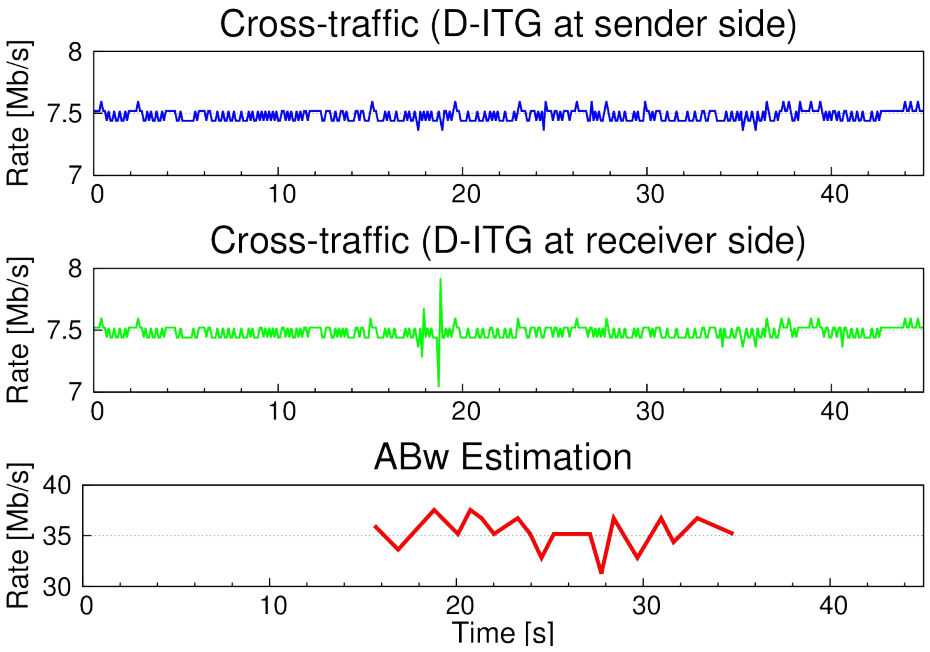


Wireless



Virtualized

Measurement procedure

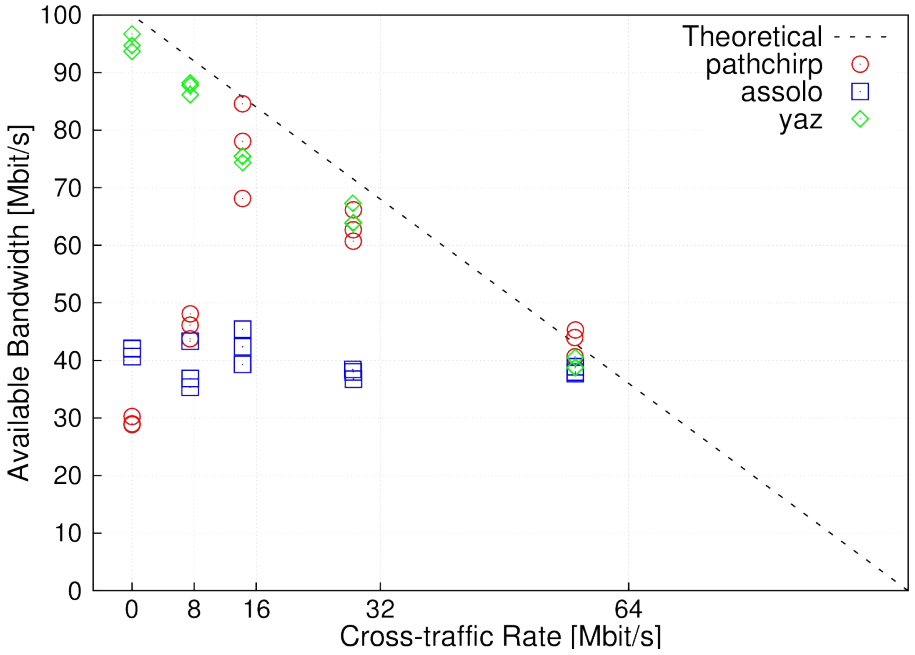


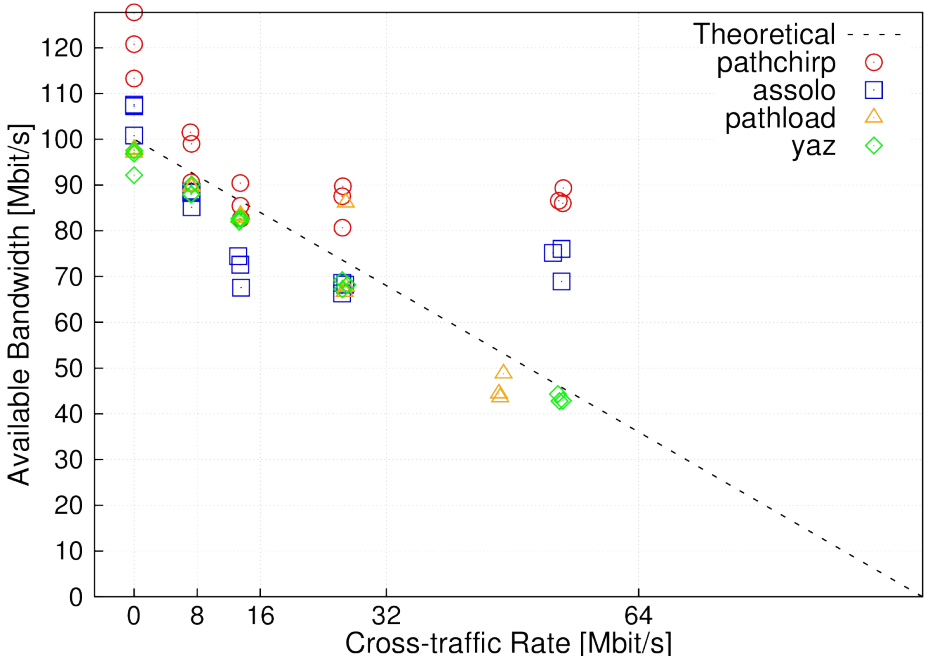
D-ITG generates cross-traffic between hosts

Multiple ABw estimations in each tool run
(~20 depending on tool)

For each tool, 3 subsequent runs (**interleaved** with other tools)

Results in WIRED scenario





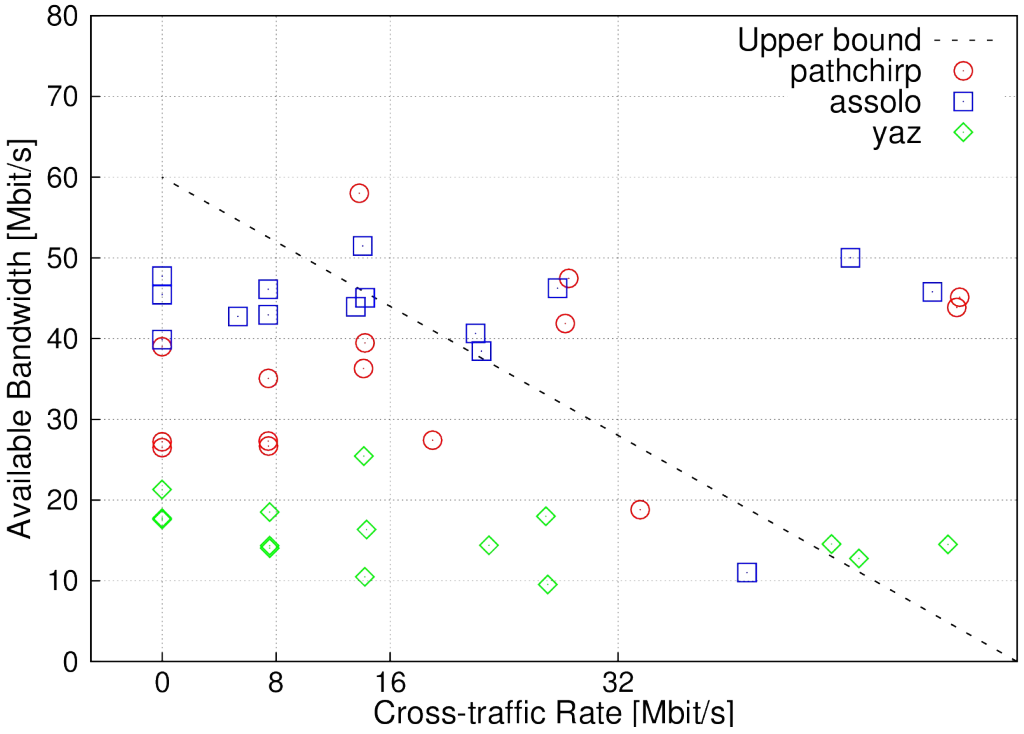
Traffic direction: A→C

Pathload does not converge!

Traffic direction: C→A

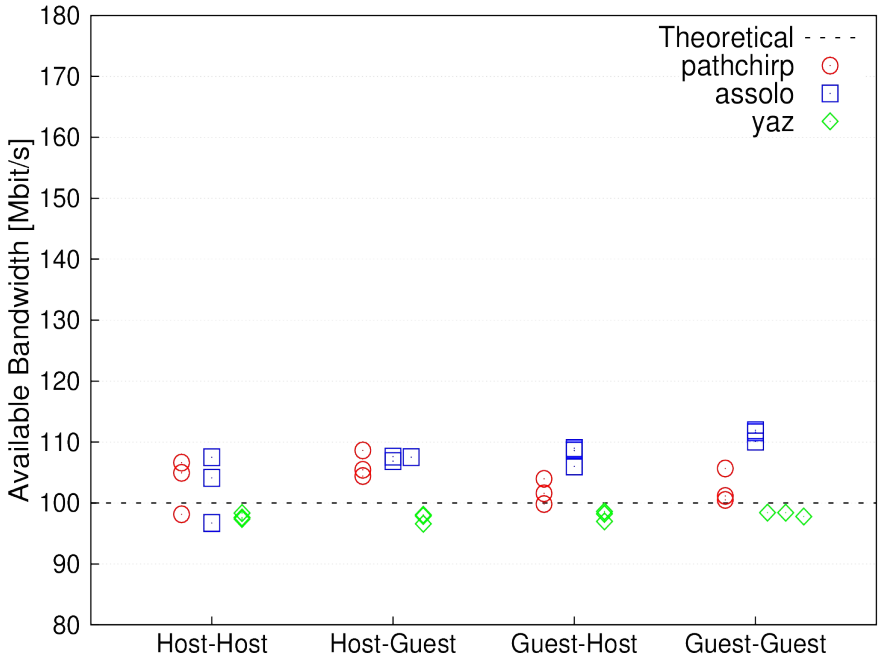
Pathload *does* converge!

Results in WIRELESS scenario

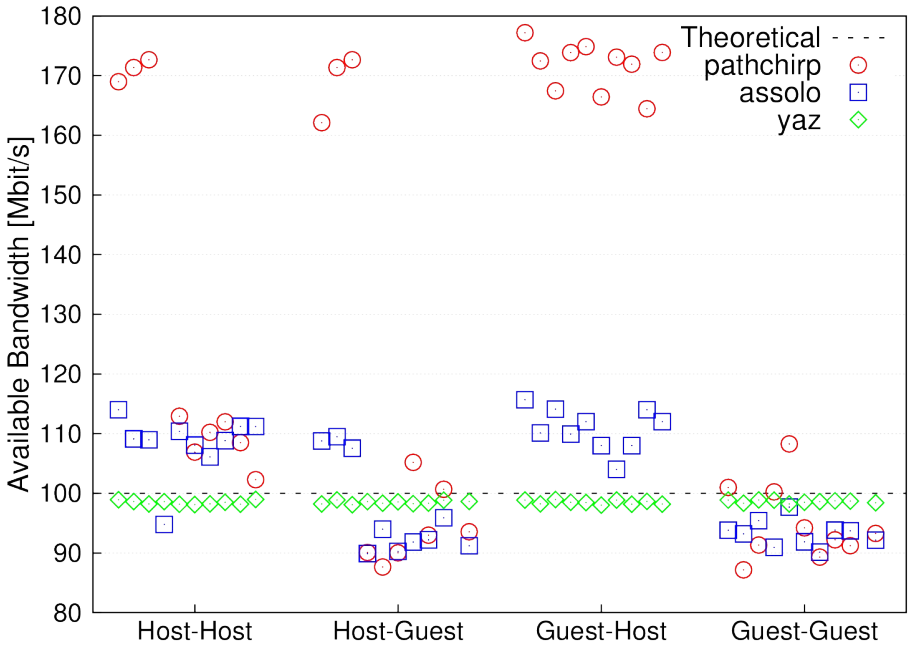


Pathload still does not converge!

Results in the VIRTUALIZED scenario (no Xtraffic)



Traffic direction: A→B



Traffic direction: B→A

pathchirp completely off-track (except for guest-guest tests)

ABw estimation tools: take-home messages

- Setup (wired, wireless, CPU freq) heavily affects tool accuracy (even base functionality)
- further investigation revealed that major issue was with **traffic generation** accuracy
- other issue is with **auto-tuning** mechanisms that do not always work

THANKS!

Q&A