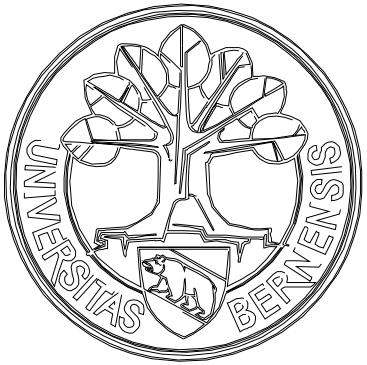
Virtual Router:
A Tool for Emulating IP Routers



Florian Baumgartner

Institute of Computer Science and Applied Mathematics
University of Bern

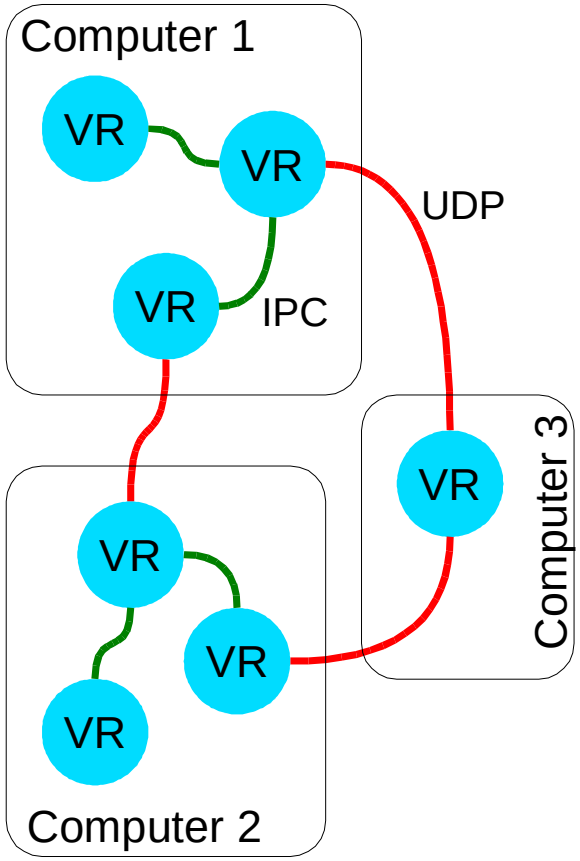
Department of Computer Sciences
Purdue University

Motivation

- Laboratory experiments are costly and time consuming. Especially during development, software tools simplify the setup of experiments crucially.
- Simulators like ns2 are great for large scenarios, but for typical lab-size experiments a more realistic environment is advantageous.
- To provide a convenient development environment, the integration of real world devices and applications has to be possible.

Virtual Router
Emulation of Networks

- Emulation of a single IP router: Virtual Router
- Multiple Virtual Routers per computer
- Virtual Routers can be connected to set up network emulations.
- Connections to real networks allows the integration of real network equipment.

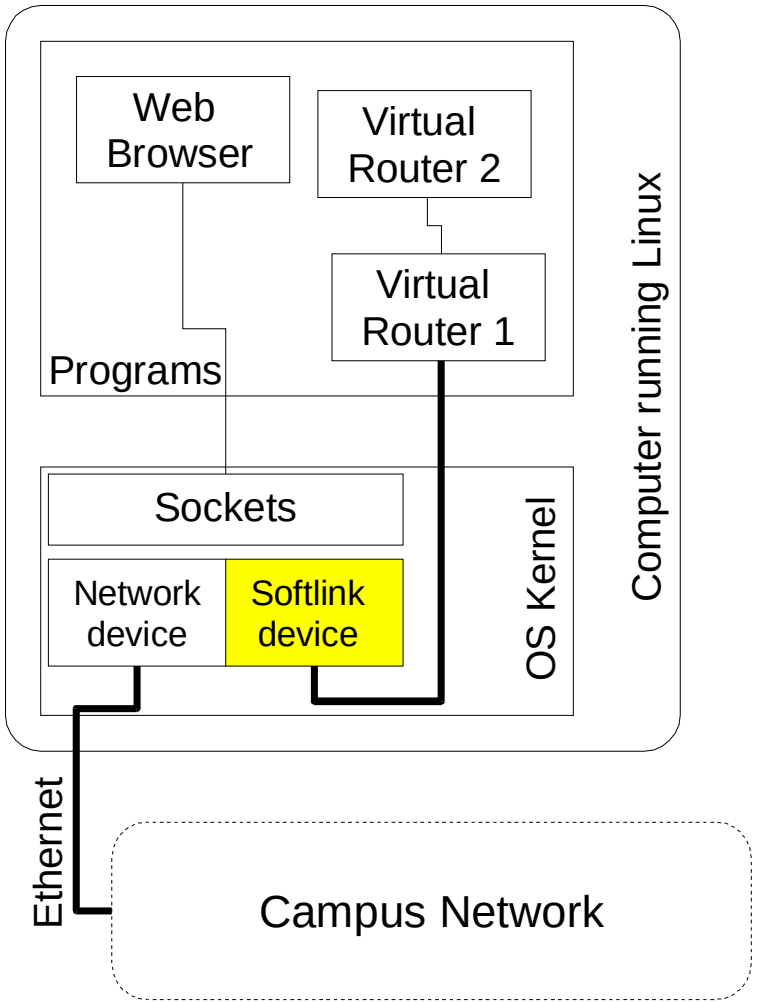


Virtual Router
Functions

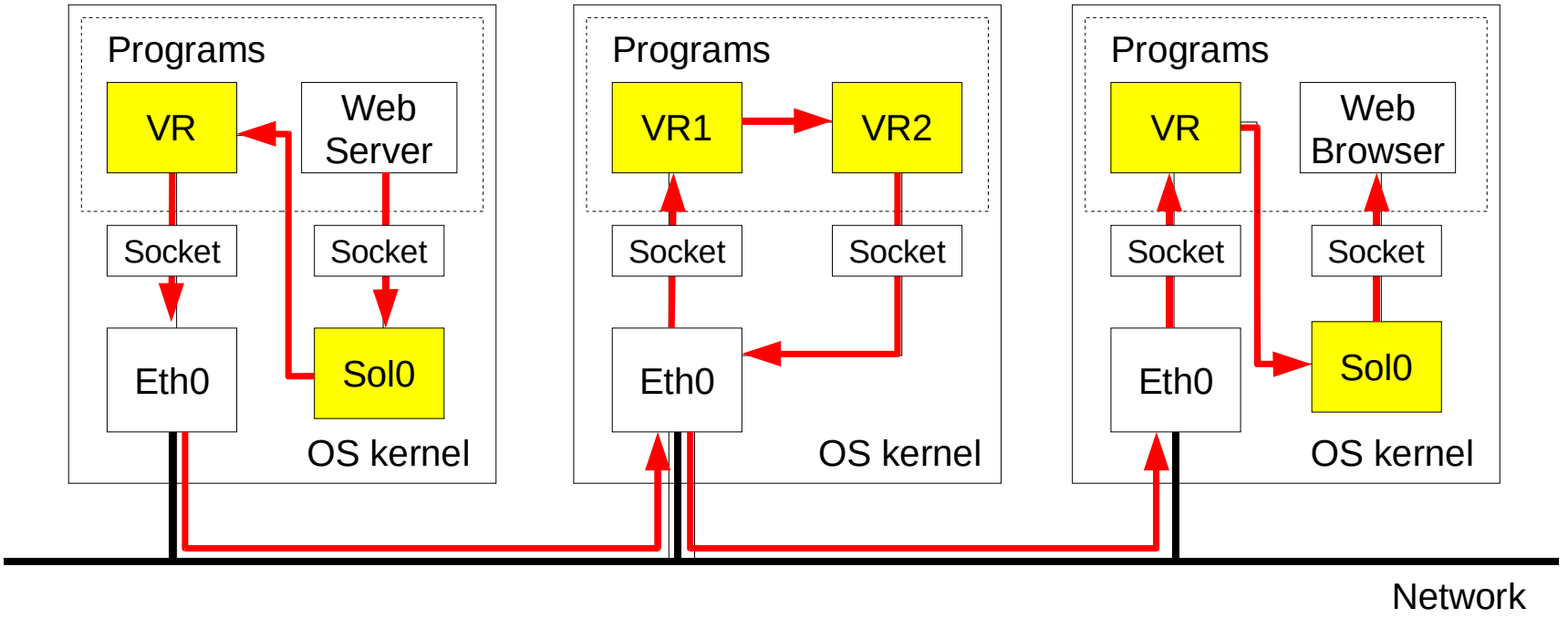
- Differentiated Services
- Tunneling
- Flexible routing (based on DSCP, protocol, ...)
- Configurable interface speeds
- Configuration by command line interface
- WWW Setup Tool (Swiss Virtual Campus)
- Plugin concept, additional mechanisms can be loaded and unloaded without restart of the Virtual Router.

Integration of Real End-Systems

- Softlink device can be used like a normal ethernet NIC
- Packets, sent to the Softlink device, are forwarded to the Virtual Router.
- No differences between normal NIC and Softlink device visible.

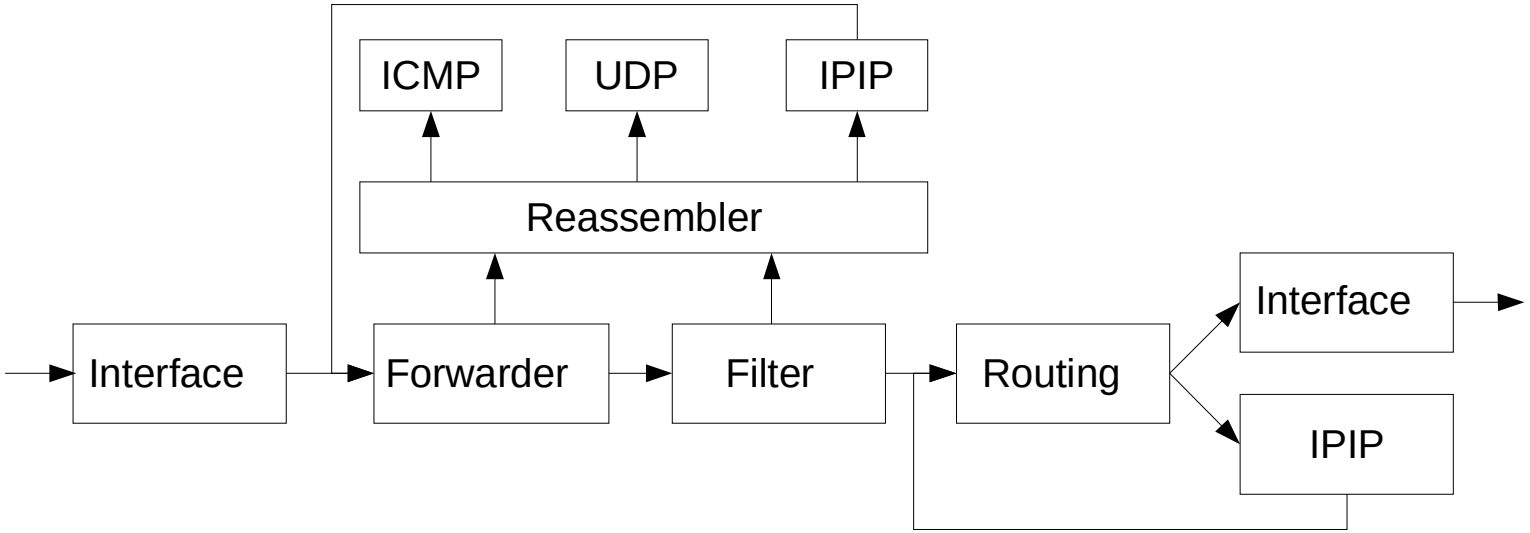


Packet Transport through VR network



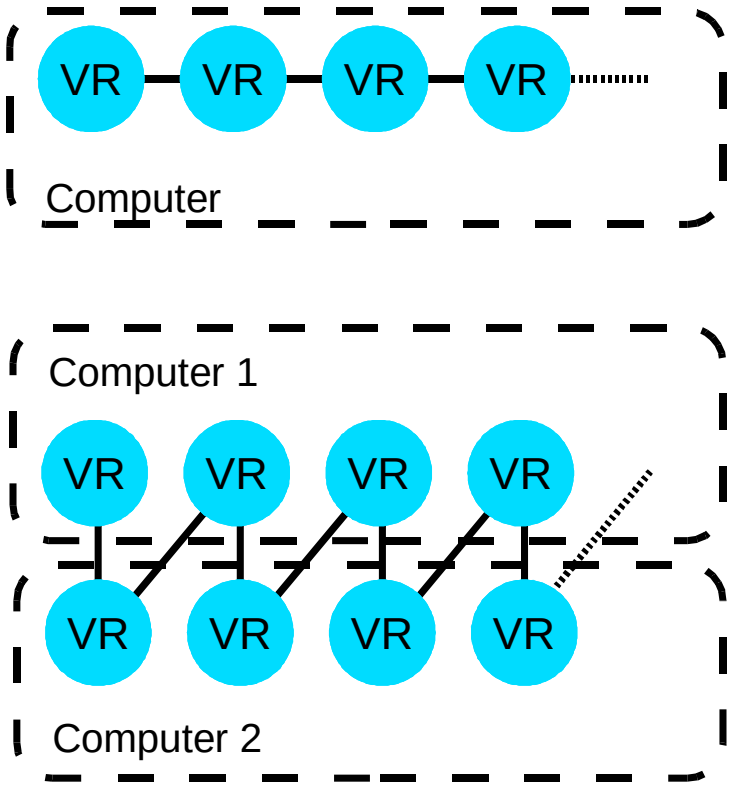
- Access to VR topology by Softlink devices (solX)
- Connections to remote VRs by normal network

Packet flow within a Virtual Router

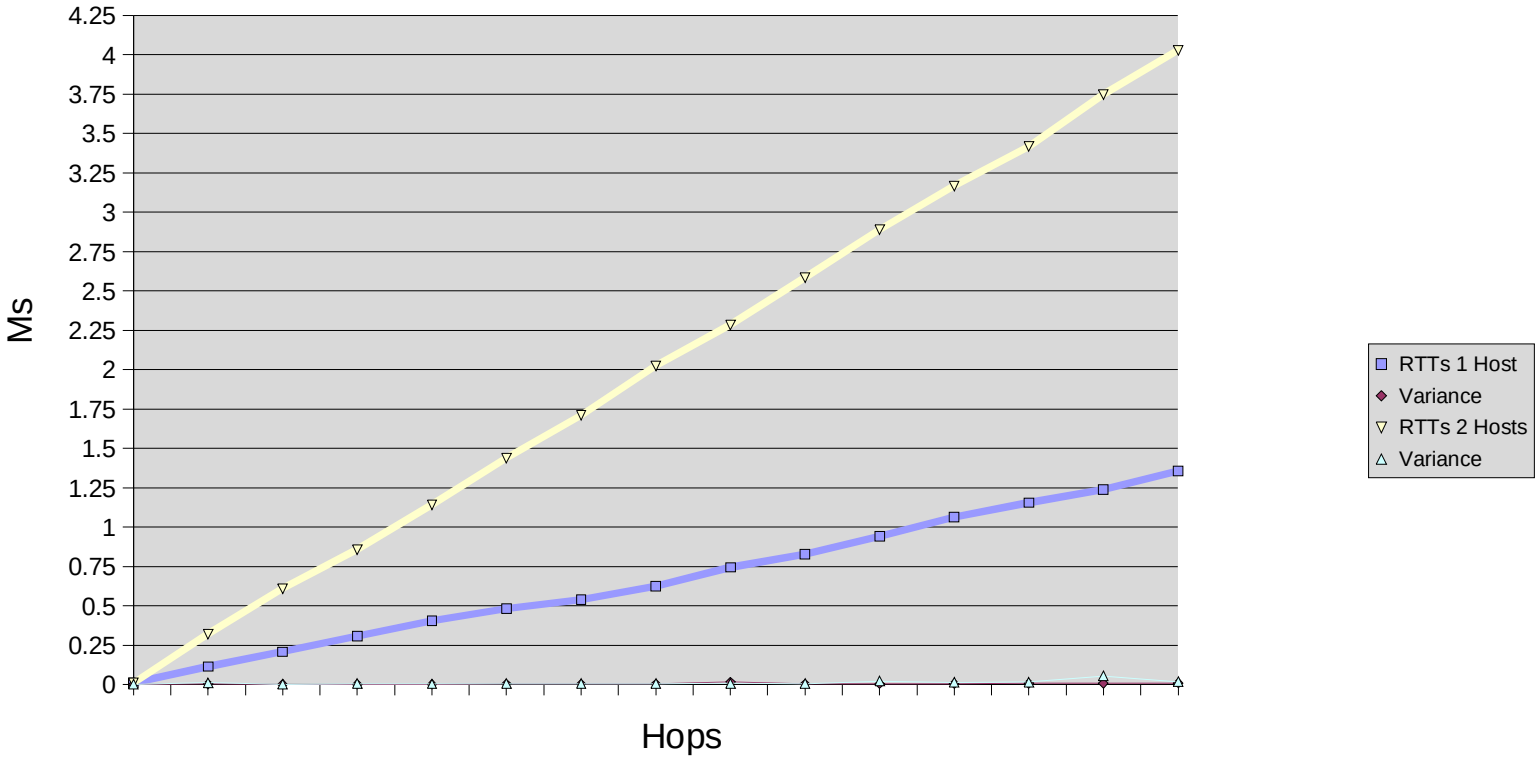


Virtual Router
Evaluation of Packet Delays

- Measurement of Round Trip Times
- Impact of multiple VRs per computer
- Impact of VR distribution
  - Identical topology
  - Distribution to multiple computers.
  - Different numbers of VRs



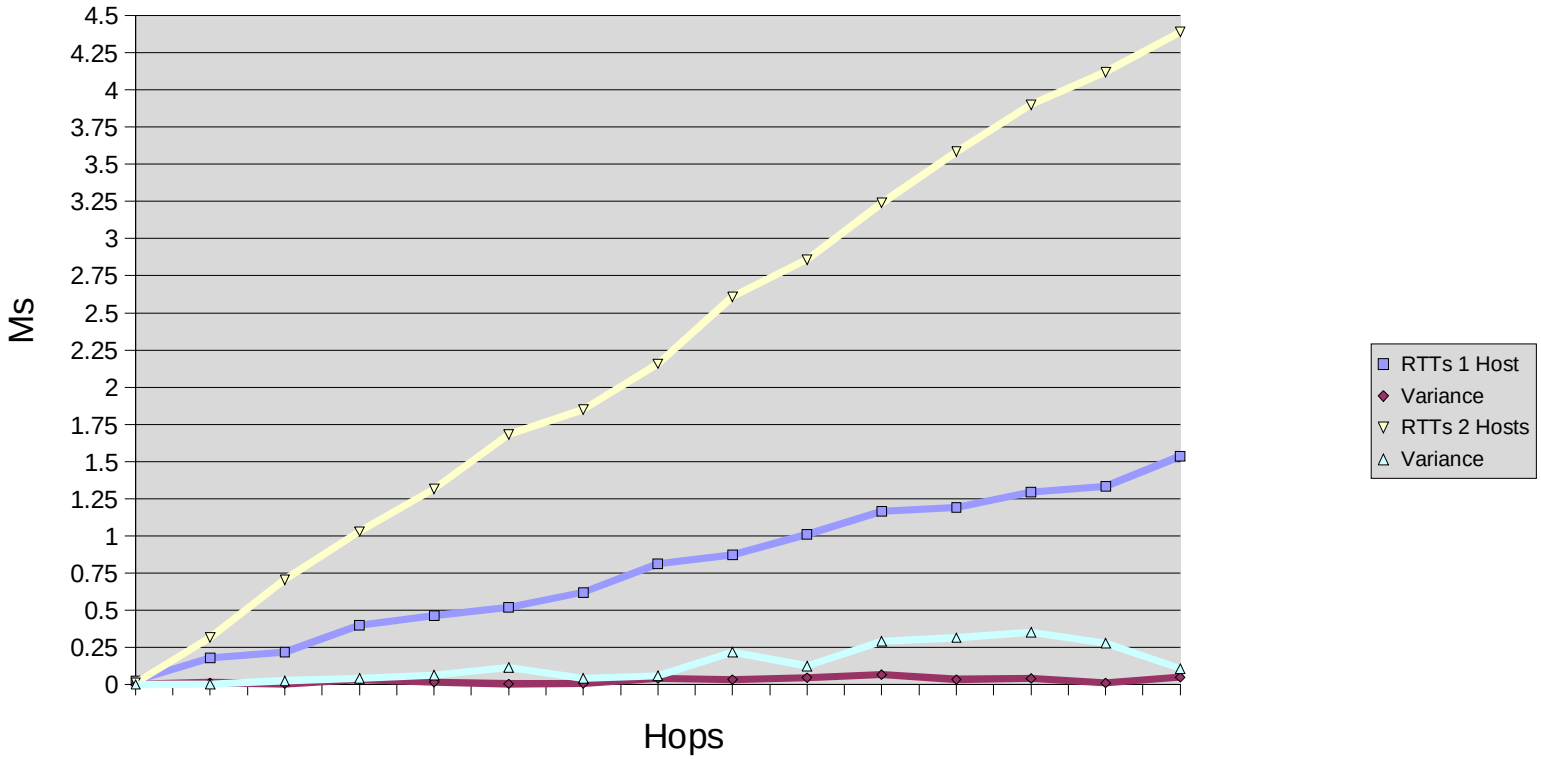
Packet Delay
Impact of Distribution



- Distribution to multiple computers increases the delay.
- Linear increase with the number of hops

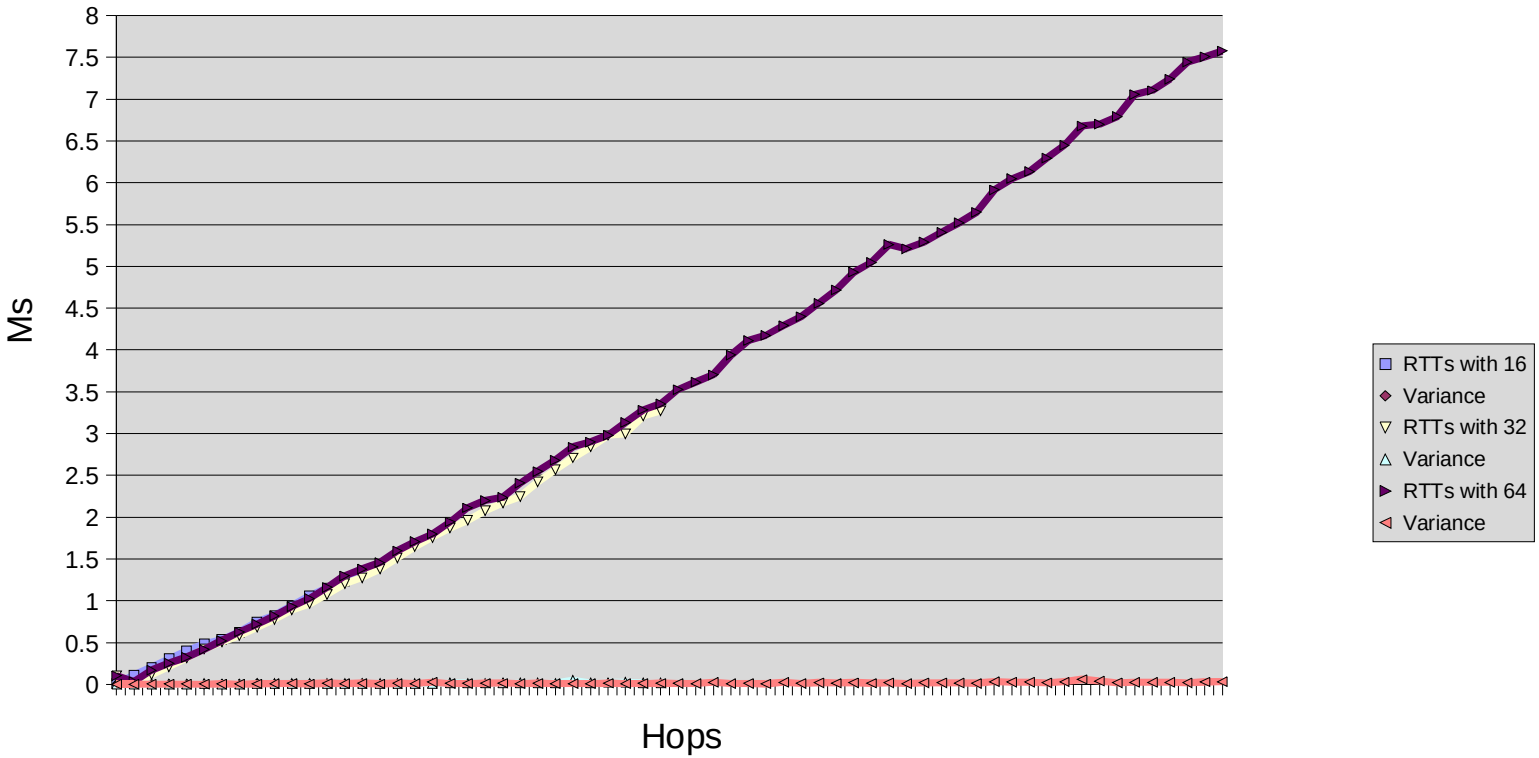
Packet Delay

Impact of Distribution (+ additional traffic)



- Additional load mainly increased the variance of the RTTs.

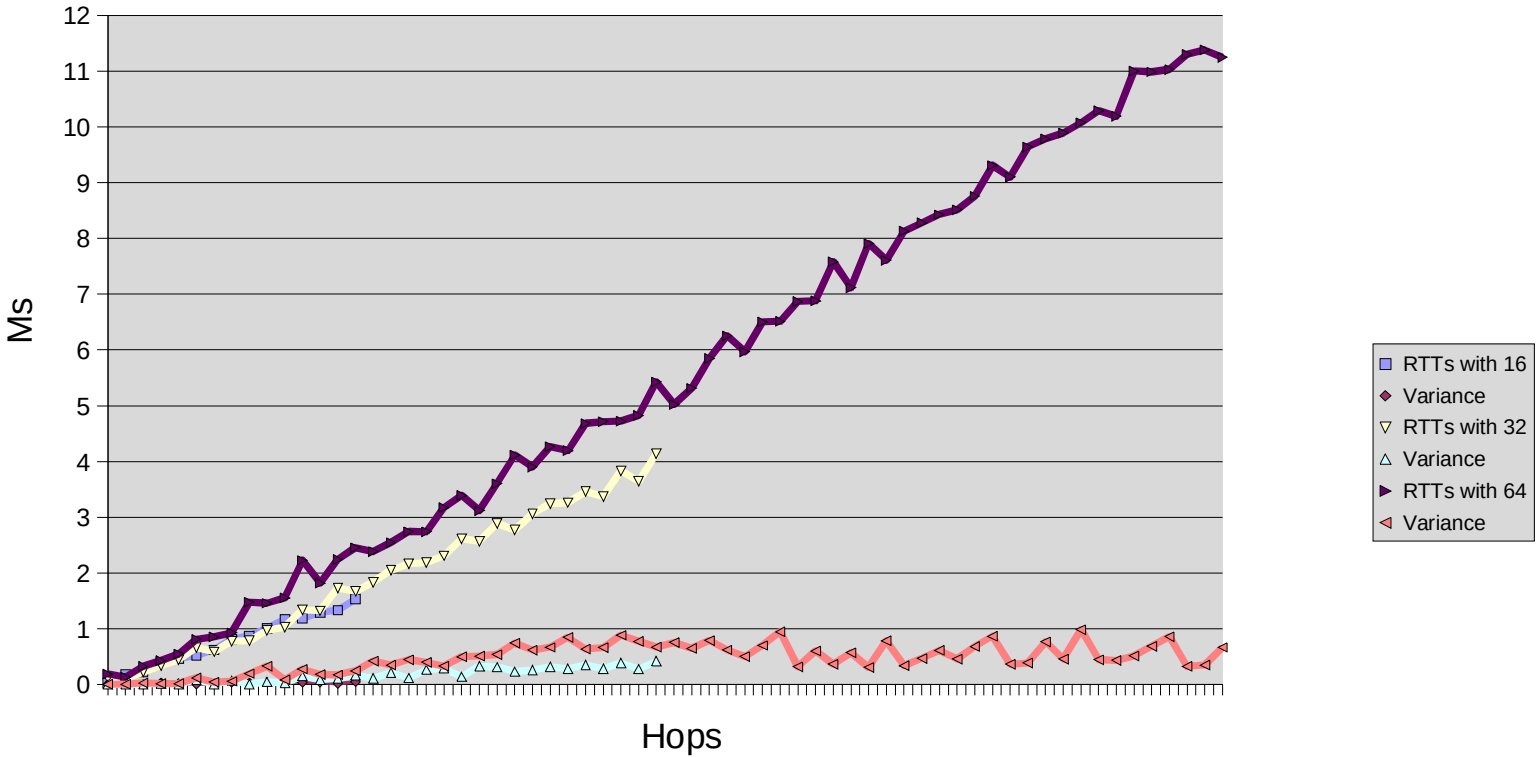
Packet Delay
Impact of VR Instances



- Linear increase of RTTs.
- No impact of number of VR instances on delay for 16, 32 and 64 VRs.

Packet Delay

Impact of VR Instances (+additional traffic)

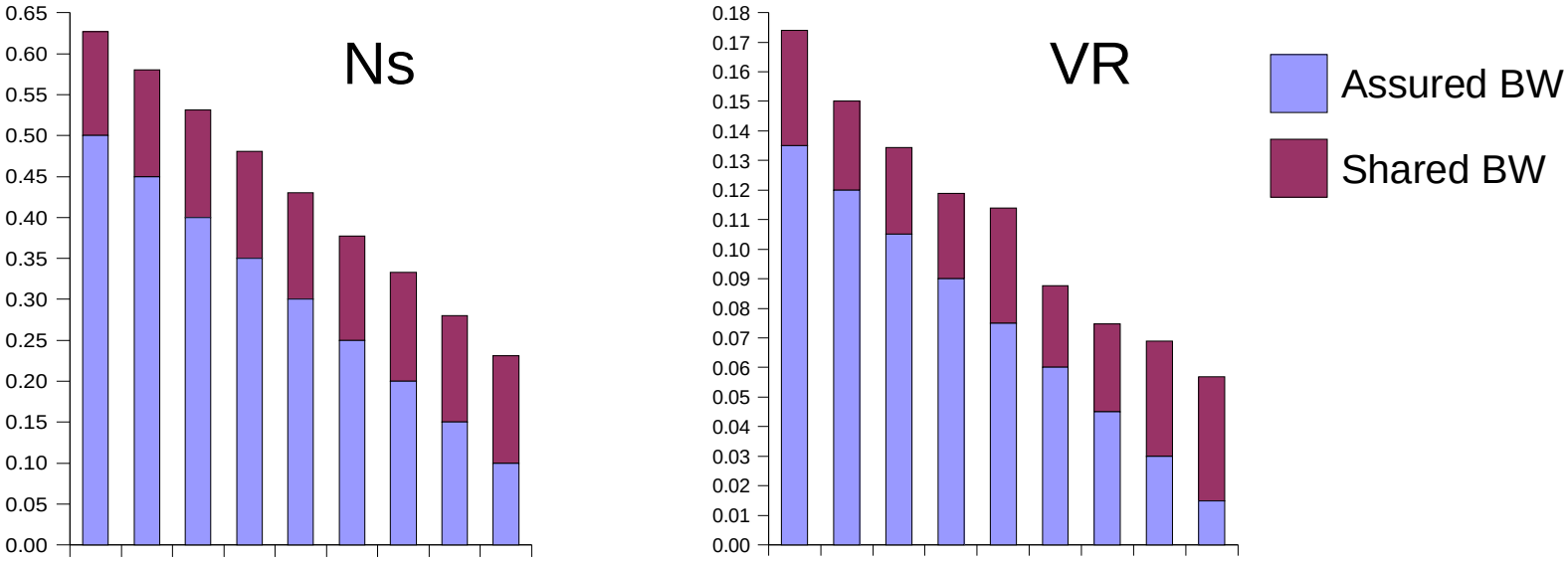


- Linear increase of RTTs, but different numbers of VRs cause different per hop delays
- Additional traffic causes higher variances.

Differentiated Services with VRs and ns

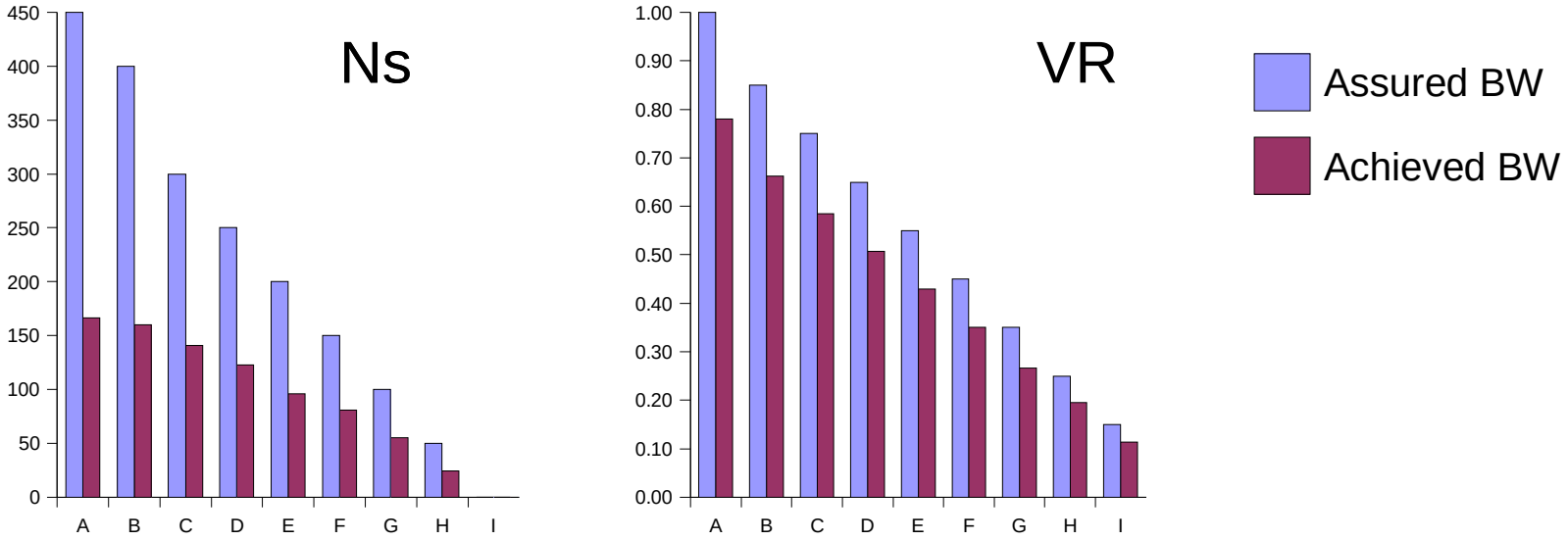
- Comparison of ns simulations with VR experiments.
- Focus is on Assured Forwarding, since Expedited Forwarding is more “robust”.
- AF with two drop precedences only (Assured Service).
- Virtual Router setup on a single computer.
- Simple bottleneck topology.
- Evaluation of Virtual Routers using standard measurement tools (e.g. ttcp).

Differentiated Services
UDP Bandwidth Sharing with AF



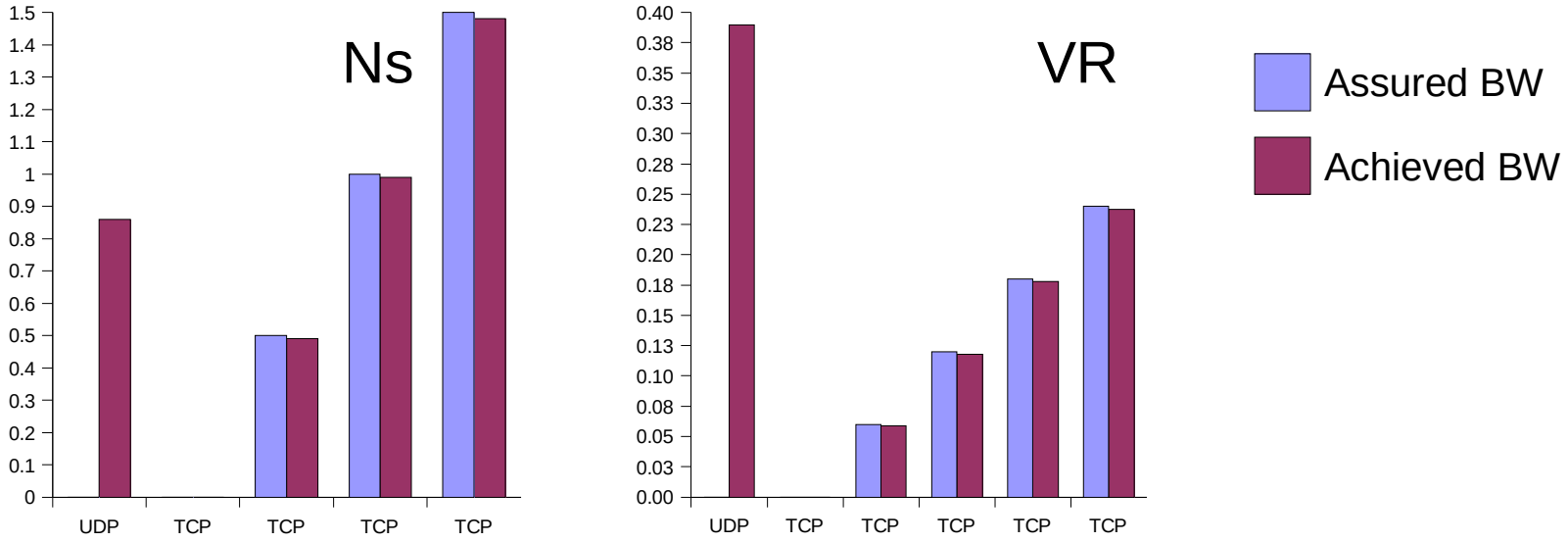
- Remaining bandwith (not used for AF) is shared among flows.

Differentiated Services
UDP in a badly provisioned network



- Bad provisioning disables DS and causes a typical sharing of the available bandwidth.

Differentiated Services
Protection of TCP against UDP traffic



- TCP, protected by AF, can achieve the assured throughputs, while the remaining bandwidth is consumed by UDP.

Summary & Conclusion

- The emulation environment **has** an impact on the results, but the impact is small and predictable.
- Experiments with Virtual Routers show similar results like ns experiments.
- Virtual Routers can be used for realizing test networks for development and small evaluation scenarios.
- Virtual Routers are used within the Swiss Virtual Campus project to provide a platform for remote exercises.