RVS Seminar
VirtualMesh: An Emulation Framework for Wireless Mesh Networks with OMNeT++

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VirtualMesh: An Emulation Framework for Wireless Mesh Networks with OMNeT++

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Motivation

> Mesh networks require distributed applications (monitoring, software distribution, streaming)

> Testbed for application/protocol development, debugging, functional evaluation, benchmarking, presentation

> Real-world wireless testbeds are error prone and expensive (radio interferences, high hardware costs, mobility)

> Simulations too abstract to test real software (do not consider real software stacks, simplified protocol behavior)
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**VirtualMesh: Overview (1)**

- Wireless emulation with help of real-time simulation
- Virtualized Linux mesh nodes
VirtualMesh: Overview (2)

> Transparent emulation of OSI layer 1 and 2 (MAC/PHY)
> Distributed setup of wireless emulation
Client Tools: vifctl/libvif

> vifctl: create/delete virtual wireless interfaces (VIF)

Usage: vifctl [-cdhlr] VIFNAME

- c VIFNAME  Create virtual wireless interface
- r VIFNAME  Remove virtual wireless interface
- l          List virtual wireless interface(s)

> libvif: handles wireless parameter states (channel, transmit power, retry limit, RTS threshold, …)
  — allows access to VIF via public API
  — implements ioctl() syscall for kernel compatibility

> Wireless tools (iwconfig, iwlist, iwpriv)
  — patched (+2 lines) to use libvif
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Client Tools: iwconnect

> Handles communication between wireless node and simulation

Usage: iwconnect WLANMODEL [-p PORT][-i INTERFACE][-6][-n][-d]

Parameters:

WLANMODEL IP Address/Hostname of wireless model
-p PORT Destination port (default: 2424)
-i INTERFACE Infrastructure network interface (def: eth0)
-6 Use IPv6 protocol
-n Enable node-to-node communication

> Registers the host at the simulation server
> Forwards/injects the “wireless” traffic on the node
> Propagates VIF configuration modifications to wireless emulation
Wireless Emulation: WlanModel

> Emulates the physical and MAC layer of the WLAN

> Implemented with OMNeT++/INET

> Based on the IEEE 802.11b Ad-hoc stack (replaceable)

> Keeps track of participating wireless nodes and creates a virtual representation inside the simulation

> Can profit from sophisticated OMNeT++ mobility models
  — LinearMobility, (random) MassMobility, Bonnmotion, ANSim
ADAM Integration

> Capable to run an ADAM network with up to a dozen nodes

> ADAM enhancements
   — added node type 'xen' including the required Xen kernel config
   — additional packages for VirtualMesh
      (vifctl, libvif, iwconnect, wireless-tools, netperf)
   — enhanced 'image-tool' to create a virtual disk image for Xen

> Node image distribution/update possible with Xen
Evaluation: Test Setup

> Two servers connected via 1Gbit cross-link

> Simulation server
  — Dual-core Pentium D, 3.2GHz, 1GB RAM
  — Gentoo Linux (x86_64)
  — OMNeT++ 4.0p1, INET-2010-01-10 (git snapshot)
  — No running services during benchmarks!

> Virtualization server
  — 4x Xeon 3.6GHz, 12GB RAM
  — CentOS 5.4, kernel 2.6.18, Xen 3.3.1

> Wireless nodes
  — 32 MB Memory
  — ADAM Linux image, kernel 2.6.26.4, olsrd 0.5.6
RTT related to Packet Size

![RTT vs Packet Size Graph](image)

- **OMNeT++ Simulation**
- **VirtualMesh Emulation**

26. Mai 2010
Emulation Scalability

![Graph showing Emulation Scalability](chart.png)
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RTT of Multi-hop Scenarios

OMNeT++ Simulation
VirtualMesh Emulation

RTT [ms]
Number of hops
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Throughput vs. Parallel Transfers

![Graph showing throughput vs. parallel transfers]

- Simulation Ethernet
- Simulation UDP
- Simulation TCP
- VirtualMesh netperf
- VirtualMesh nc

Throughput [Mbps]

Number of parallel transfers

Throughput [MB/s]
Throughput in Multi-hop Scenario

OMNeT++ UDP Throughput
VirtualMesh netperf
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Live Demo
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Video Streaming

![Graph showing Video Streaming performance with different bit rates (500kbit, 300kbit, 100kbit) for varying number of hops (1 to 4)].

Dropped Frames [%] vs. Number of hops.
Conclusions

> Flexible environment for experiments with distributed applications and real protocol stacks

> Highly configurable wireless stack in emulation setup and during run-time

> Minimal requirements to wireless node OS and thus fully compatible with ADAM

> “Real-time” simulation accuracy depends on network complexity
Future Work

> Synchronization of simulation and virtualization timer

> Feedback from simulation to wireless node (packet loss, channel sniffing, SNR values)

> Generalization:
   — Connect different network stacks:
     IEEE 802.11g/n/s, IEEE 802.16 (WiMAX), IEEE 802.15.4, Bluetooth, IEEE 802.3 (Ethernet)
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More Information

> Master Thesis: Reto Gantenbein, 2010 (out soon)

> Previous RVS Seminar presentations (technical details)


> Download VirtualMesh:

http://www.iam.unibe.ch/~rvs/research/software.html
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Questions
Appendix: Infrastructure Network Overhead

Test setups:
(a): gigabit  (b): phy-to-pv  (c): phy-to-hvm
(d): gigabit-iwconnect  (e): gigabit-pv-iwconnect