Running virtualized native drivers in User Mode Linux

V. Guffens, G. Bastin

UCL/CESAME (Belgium)

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Outline

- Overview of User Mode Linux (UML)
- A wifi layer for UML
  - Principle
  - Architecture
- Applications
  - wireless setup emulator
  - Teaching tool

PART I

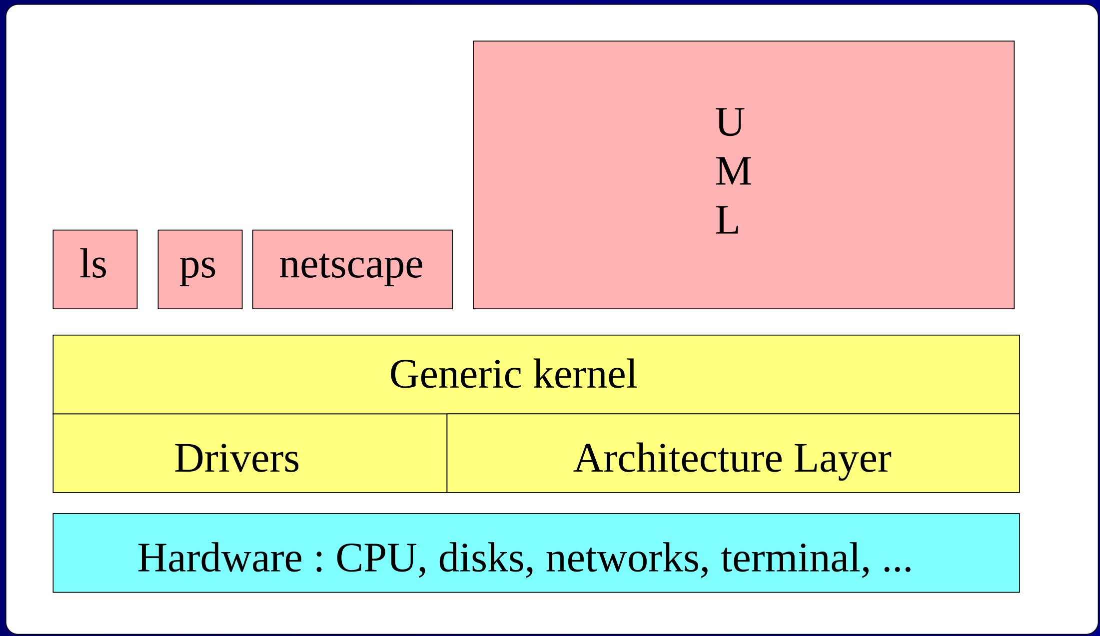
Overview of User Mode Linux

User Mode Linux

- Mainly developed by Jeff Dike
- Started in February 1999 (Registered at sourceforge in November 1999)
- UML architecture is described in papers found on the UML kernel home page (OLS’01, OLS’02)
- Integrated in the official Linux 2.6.9 tree

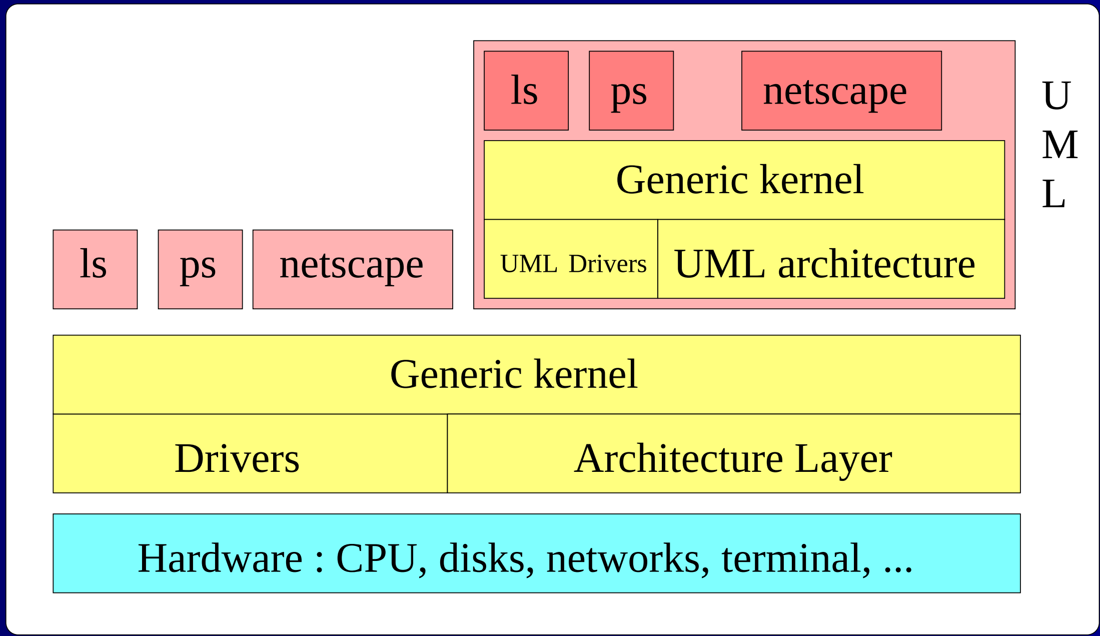
Overview of User Mode Linux

- UML runs as a process



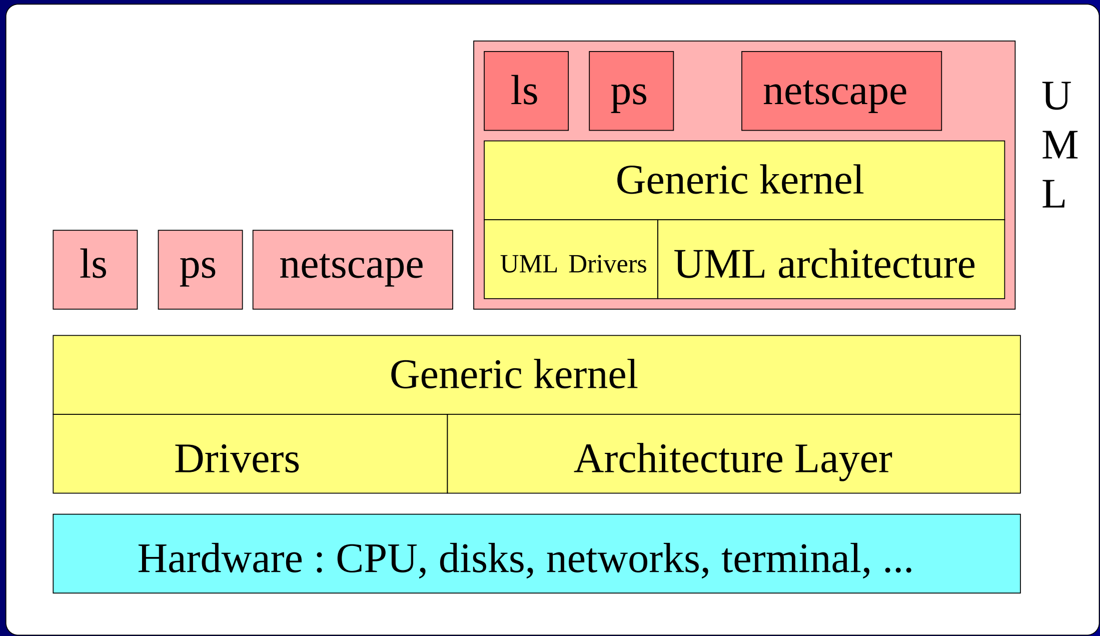
Overview of User Mode Linux

- Virtualised kernel, new Linux architecture



Overview of User Mode Linux

- No attempt to run an unmodified OS



Achieving virtualization

- System calls : 2 modes
  - Tracing thread mode (tt)
  - Separate Kernel Address Space (skas), requires a patch on the host
- Hardware is emulated
  - UML block devices associated with a file on the host which contains a filesystem
  - Interrupts are replaced by signals
  - network devices use a hub daemon on the host OR ethertap, . . .

System calls

- tt mode
  - One process on the host per process on UML + tracing thread process
  - use *ptrace* syscall to intercept the UML syscall, nullify it run the syscall handler in UML kernel
- skas mode
  - Only 4 process/UML on the host
  - use a */proc/mm* interface on the host to change address space

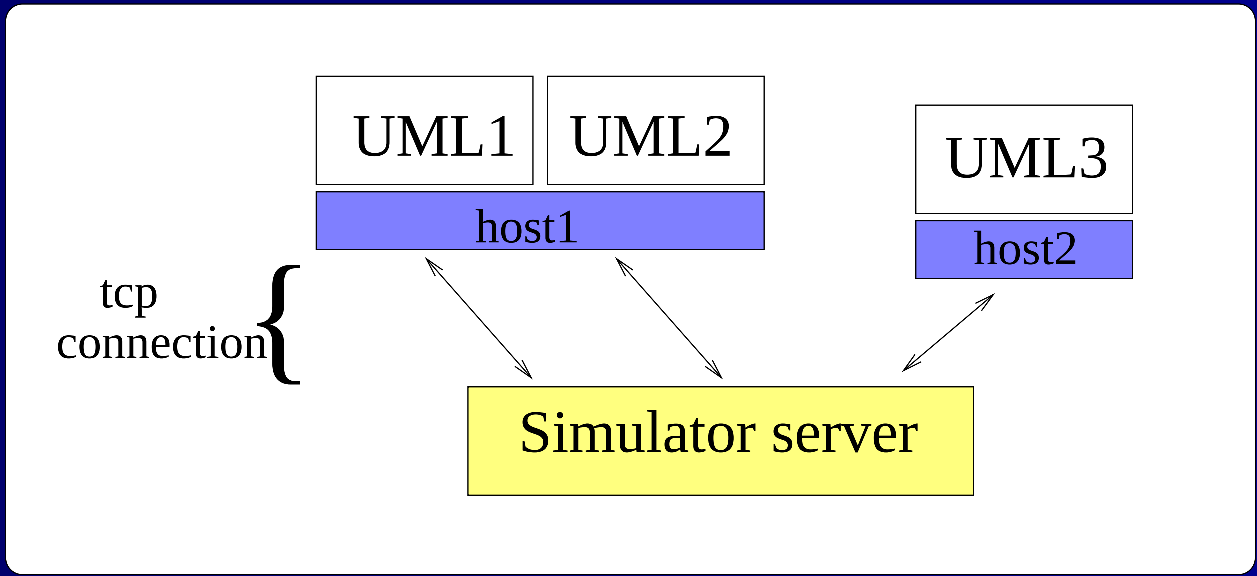
Hardware emulation, example

```
uml-gw:~# cat /proc/interrupts
           CPU0
  0:       2147       SIGVTALRM  timer
  2:         40           SIGIO  console
  3:          0           SIGIO  console-write
  4:       4906           SIGIO  ubd
  9:          0           SIGIO  mconsole
 10:          0           SIGIO  winch, winch
 11:         38           SIGIO  write sigio
```

PART II

A wifi layer for UML

UML-wifi Principle



- UML is used to create virtual machines
- Machines are interconnected through a simulator server

Needed components 1/2

Wireless Network interface with wireless extension in UML

- Write a specific UML driver similar to what exists now in UML
- Use an existing wireless driver and virtualize it

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Use hostap driver

Needed components 2/2

Physical layer

- Forward the packets from nodes to nodes
- Drops the packets when needed (probability loss model)
- graphical display
  - Visualise what happens in the network
  - Easily create an arbitrary topology

The hostap driver (Jouni Malinen)

- Supports multiple hardware type
  - PCI, PCMCIA $\longrightarrow$ Add a UML layer
- Supports a host AP mode in software

Inserting the hostap driver in UML

- unresolved PCI related symbols in hostap_pci

```
$ nm hostap_pci.o | grep pci | grep U
         U pci_disable_device
         U pci_enable_device
         U pci_register_driver
         U pci_restore_state
         U pci_save_state
         U pci_set_power_state
         U pci_unregister_driver
+ writew and readw
```

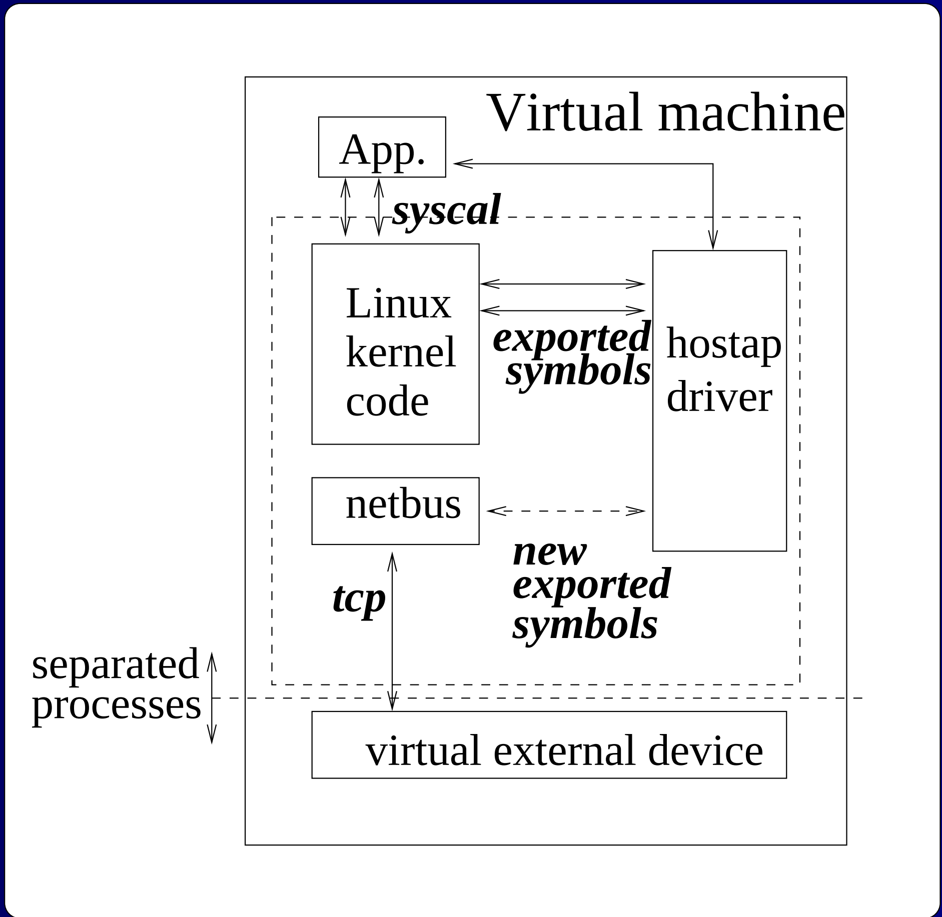
Inserting the hostap driver in UML

- No PCI bus in UML
- Add a new virtual bus in UML : netbus
- Replace the PCI-dependent code of the hostap driver

Inserting the hostap driver in UML

```
$ nm hostap_uml.o | grep netbus | grep U
         U netbus_finish_interrupt
         U netbus_read_interrupt
         U netbus_readw
         U netbus_recv
         U netbus_register_device
         U netbus_request_irq
         U netbus_send
         U netbus_unregister_device
         U netbus_writew
```

Interconnection with UML



- Hostap driver can be inserted in UML
- Need to act on an emulated device

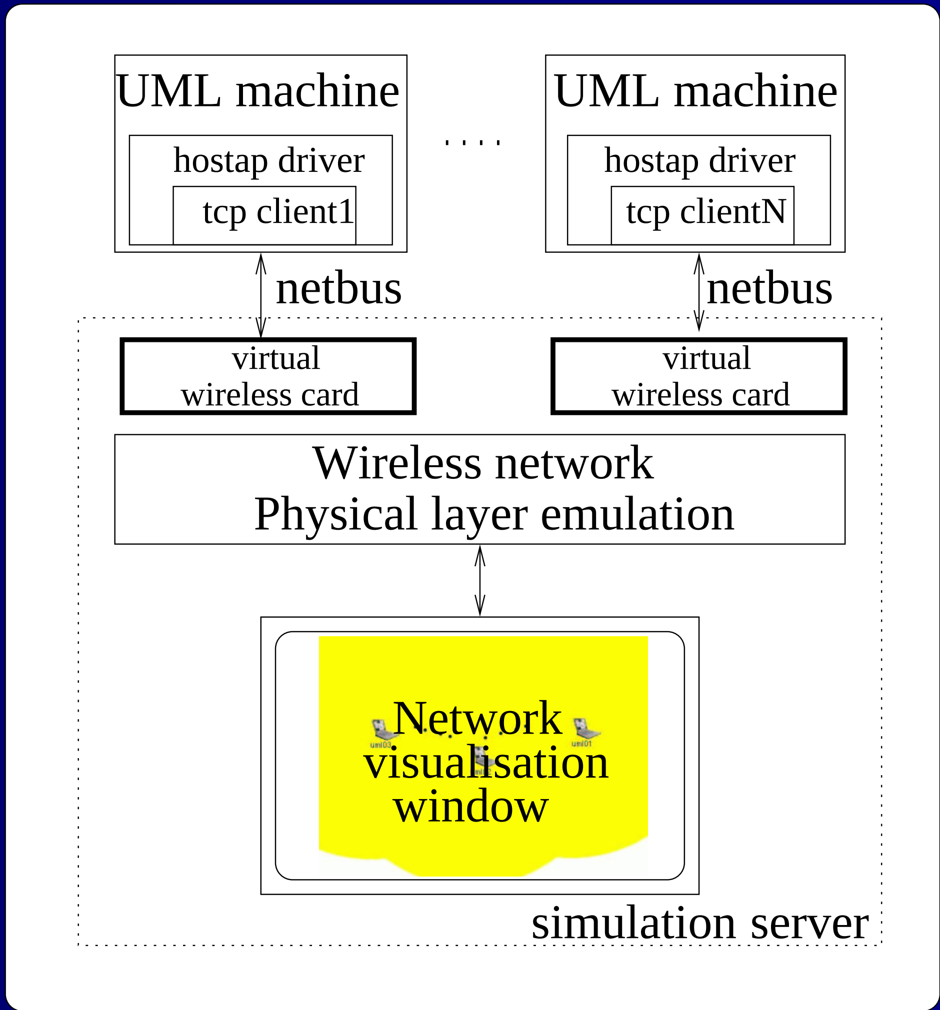
Device emulation

- Simulator server written as a tcp server in QT/C++
- Each device is and object instantiated when a connection is established
- driver may read and write word in device memory, status register is emulated
- A second tcp connection is used to send interrupt requests

Physical layer emulator

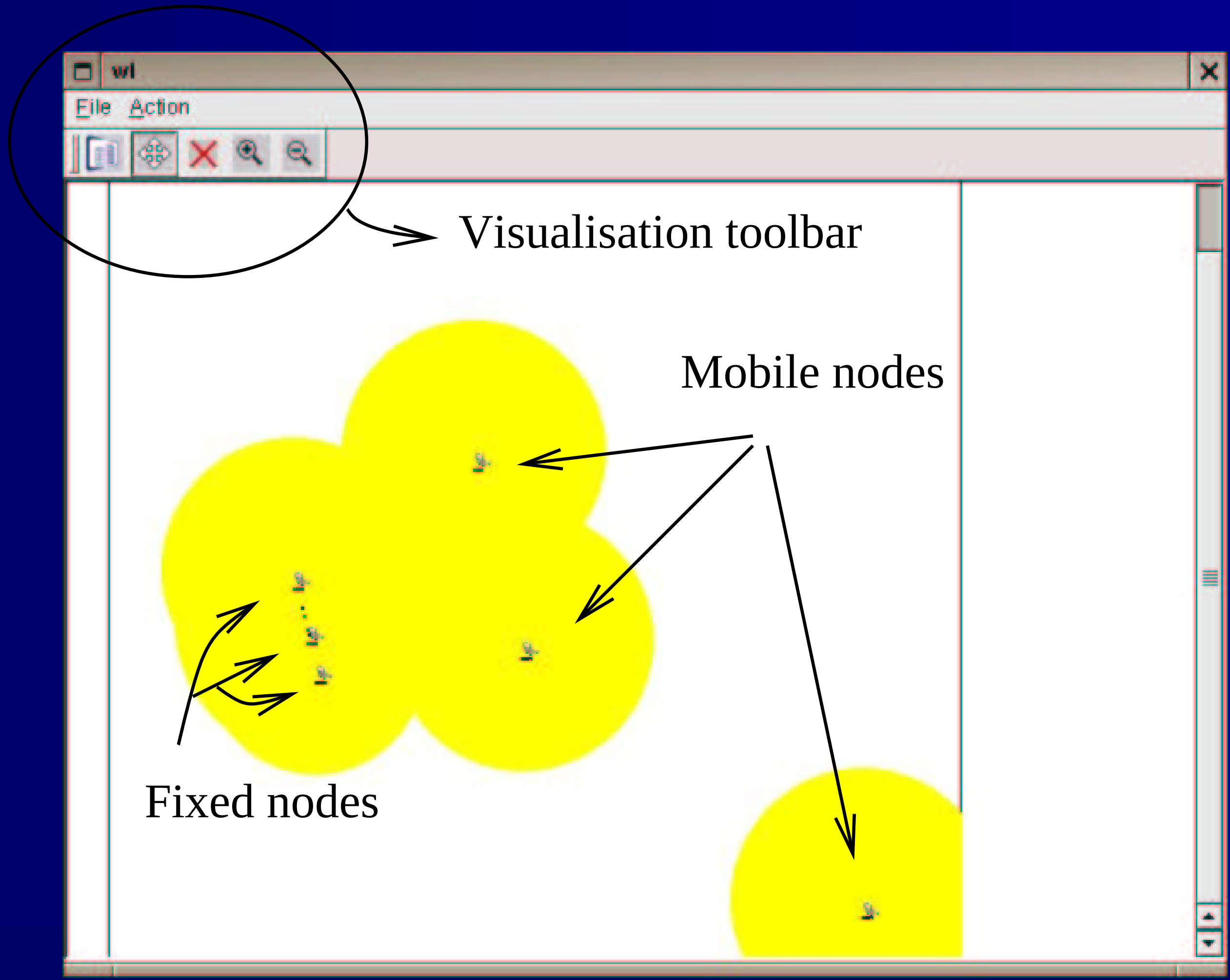
- Each device has a 2D physical position (x, y)
- Empirical and theoretical models are available for path lost against distance
- Packet error rate may be calculated with Signal-to-Noise ratio depending on the digital modulation
- Include a mobility model

Simulator architecture



Demo

See the video

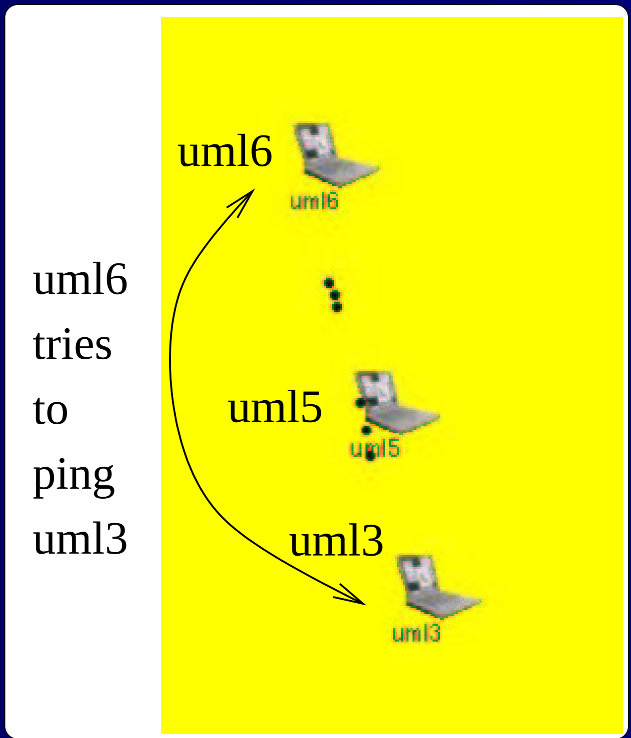


PART III

Applications

A testbed environment 1/4

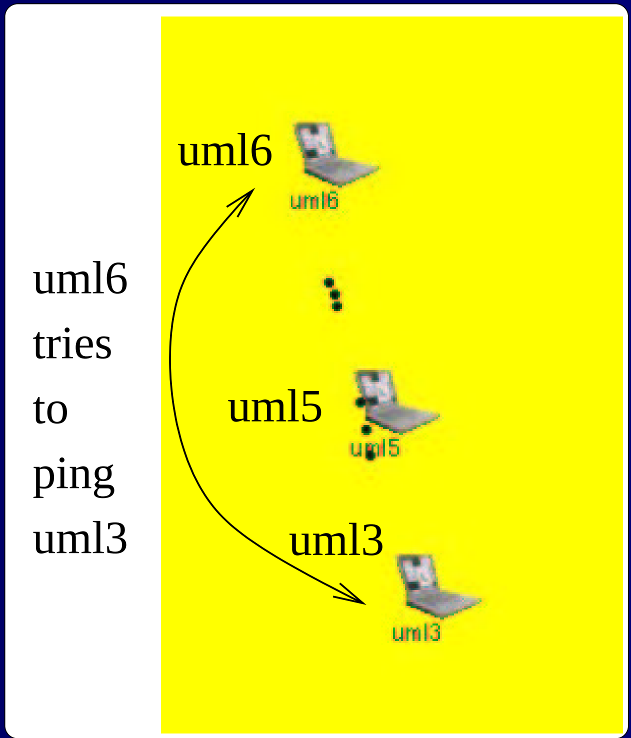
- testing Ad hoc On-Demand Distance Vector Routing



- Setup runs for hours (with mobile nodes)
- Connectivity is broken

A testbed environment 2/4

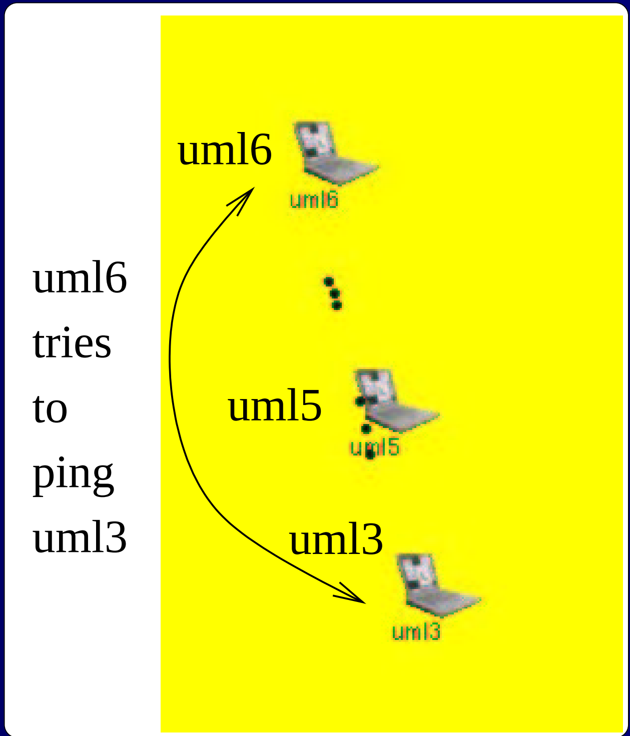
- Troubleshooting




```
Route Table at uml6
----------------------------------------------
IP           |   Seq    |   Hop Count | Next Hop
----------------------------------------------
192.168.0.2    1              1       192.168.0.2
192.168.0.5    1              1       192.168.0.5
192.168.0.6    1              0       192.168.0.6
----------------------------------------------
```

A testbed environment 3/4

- Troubleshooting

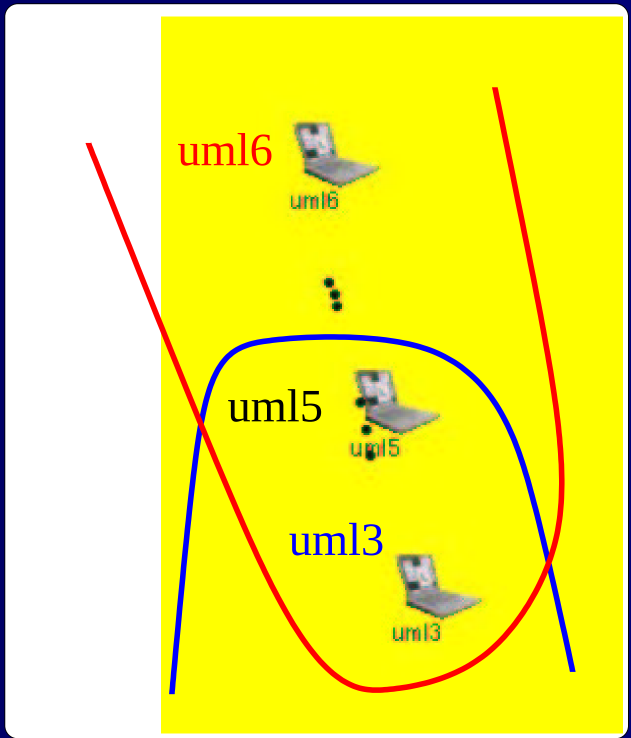


Route Table at uml3

IP	Seq	Hop Count	Next Hop
192.168.0.7	1	1	192.168.0.7
192.168.0.6	1	1	192.168.0.6
192.168.0.5	1	1	192.168.0.5
192.168.0.3	1	0	192.168.0.3

A testbed environment 4/4

- Troubleshooting



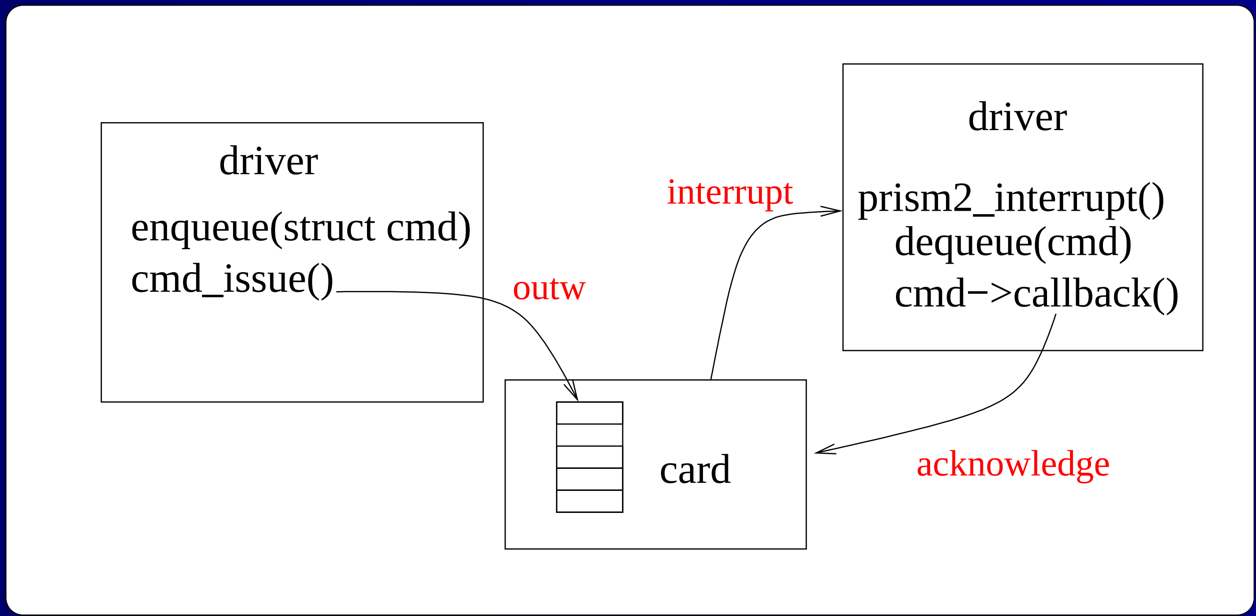
- transmission power of UML3 > UML6
- Classical asymmetric link problem

Development and testing

- All the software available in Linux may be used in a wireless environment
- Easily develop and test new solution
- example: name resolution in MANET (draft-engelstad-manet-name-resolution-01)
- Uses a modified proxy dns server (dnrd)

A teaching tool 1/2

- Study the interactions between a driver and the kernel (ex. sending a command)



A teaching tool 2/2

```
(1) writew(0x10,0x4)                 write param0 in PARAM0_OFF(0x4)
(2) writew(0x0,0x8)                  write parma1 in PARAM1_OFF(0x8)
(3) writew(0x10b,HFA384X_CMD_OFF)    write the command in command
                                     register

  the frame + header previously stored in
  card memory at address param0:param1 (0x1000) is sent

(4) Interrupt evStat=0x18,inten=0xe09f  sent the interrupt to
                                        the processor
(5) readw(0x60)                         read the event status
                                        register
(6) readw(0x64)                         verify if interrupt enable
(7) writew(0x10,HFA384X_EVACK_OFF)      acknowledge cmd
(8) Interrupt evStat=0x8,inten=0xe09f
(9) writew(0x8,HFA384X_EVACK_OFF)       acknowledge alloc
```

Conclusion and future work

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  - Highly realistic simulations
  - Good teaching and development tool

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  - Add more features (AP mode, rate limitation, . . .)
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Thank you !