

Introduction to IPv6 Simulation

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Outline

Introduction

- Outline
- Why Simulate?

What is IPv6Suite?

Simple Walk-through

Screenshots

Conclusion

- IPv6Suite is an Open Source IPv6 simulation system running in OMNeT++.
- Outline of Presentation:
 - Why Simulate?
 - What is IPv6Suite?
 - Simple Walk-through
 - Screenshots of other Examples
 - Conclusion

Why Simulate?

- Protocol interactions inherently too complex to analyse
- Scalability of protocols too expensive to test on large testbeds
- Quicker to simulate than to assemble and configure network
- Conditions are *more* controlled especially for wireless

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A collection of protocols for OMNeT++

Introduction

What is IPv6Suite?

- Protocols
- Medium-sized program
- OMNeT++
- History

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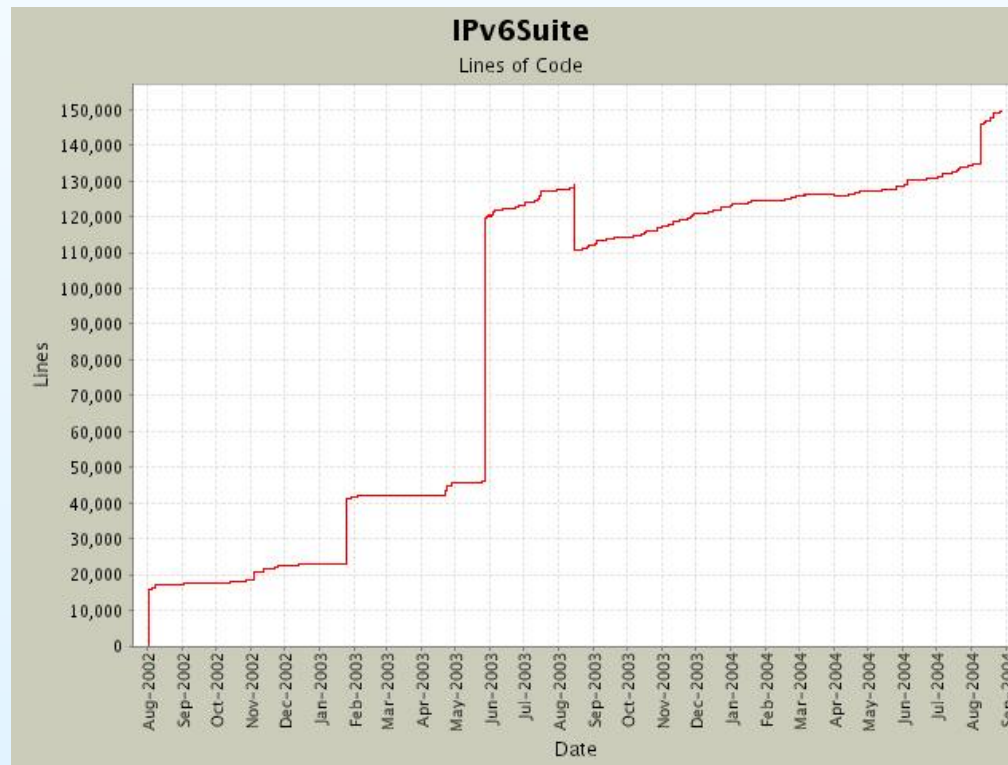
Conclusion

- Our simulation suite implements the functionality of the following RFCs:
 - RFC 2373 IP Version 6 Addressing Architecture
 - RFC 2374 An IPv6 Aggregatable Global Unicast Address Format
 - RFC 2460 Internet Protocol, Version 6 (IPv6) Specification
 - RFC 2461 Neighbour Discovery for IP Version 6 (IPv6)
 - RFC 2462 IPv6 Stateless Address Autoconfiguration
 - RFC 2463 Internet Control Message Protocol (ICMPv6) for the
 - RFC 2464 Transmission of IPv6 Packets over Ethernet Networks
 - RFC 2472 IP Version 6 over PPP
 - RFC 2473 Generic Packet Tunneling in IPv6
 - RFC 3775 Mobility Support in IPv6 (no security)
- and the following Internet Drafts:
 - Hierarchical Mobile IPv6 Mobility Management (HMIPv6) mipshop-2
 - Optimistic Duplicate Address Detection Revision 0
 - Fast Solicited Router Advertisements Revision 4
- and also the following standards:
 - IEEE 802.3
 - IEEE 802.11b

Medium-sized C++ program

- Currently 40,000 Source Lines of Code (SLOC) as defined by sloccount. But our web page says 53,000
- Over 400 classes see code metrics
- Other interesting statistics available on CVS activity

Figure 1: Lines of Code over Time



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What is IPv6Suite?

- Protocols
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- OMNeT++
- History

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OMNeT++

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- IPv6Suite is built on top of OMNeT++.
- OMNeT++ is a discrete event simulation tool that inherently supports modularity.
- Open Source and *free* for academic research
- Unlimited levels of granularity via composition
- Object-oriented
- Well documented
- Vibrant and active user community

History

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- Started in August 2001 based on IPSuite
- Ahmet Şekercioğlu acquired a grant and used it for developing IPv6 simulation for VPAC supercomputers
- We managed to port to DEC alpha but in the end too much of a maintenance headache.
- Tried to add MPI but realised task was too onerous for time available
- IPv6 components built from the ground up
- Some reference to the Linux IPv6 code

Single Router

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What is IPv6Suite?

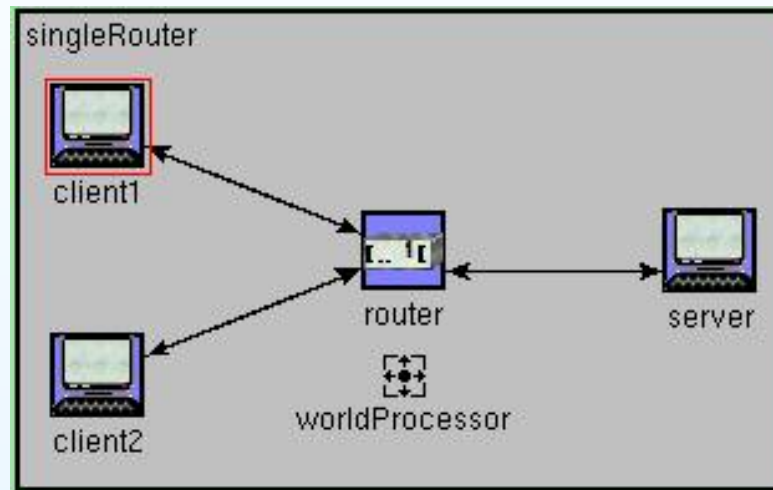
Simple Walk-through

- Single Router
- Configuration

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Figure 4: singleRouter available in **MyNetworks/SingleRouter**



- All nodes are connected to router by Ethernet links
- Client 1 pings server starting at 30s into simulation

[Parameters]

```
singleRouter.client1.ping6App.startTime=30
singleRouter.client1.ping6App.deadline=100
singleRouter.client1.ping6App.destination = "AAAA:0:0:3333:127b:c0ff:fe2e:7212"
singleRouter.client1.ping6App.interval=1
```


Single Router Configuration

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- The topology is described in the ned file.
- The ini file **omnetpp.ini** contains assignments to ned parameters and general OMNeT++ configuration.
- We have added an XML configuration file to assign other parameters, because variable length array like variables with complex elements cannot be assigned in ini files.
- By adding the following line into the ini file

```
*.client1.networkLayer.proc.forwarding.core.routingInfoDisplay  
= true
```

- Lines like the one below are output to the console of the running simulation.

```
client1 <-- 94.0004 src=fec0:0:0:abcd:260:97ff:0:4 dest=fec0:0:0:abcd:260:97ff:0:1  
len=49
```

- Name of the node that “captured” this datagram
- Direction of the datagram (→for egress and ← for ingress)
- Simulation time when datagram was “captured”

MIPv6 Example

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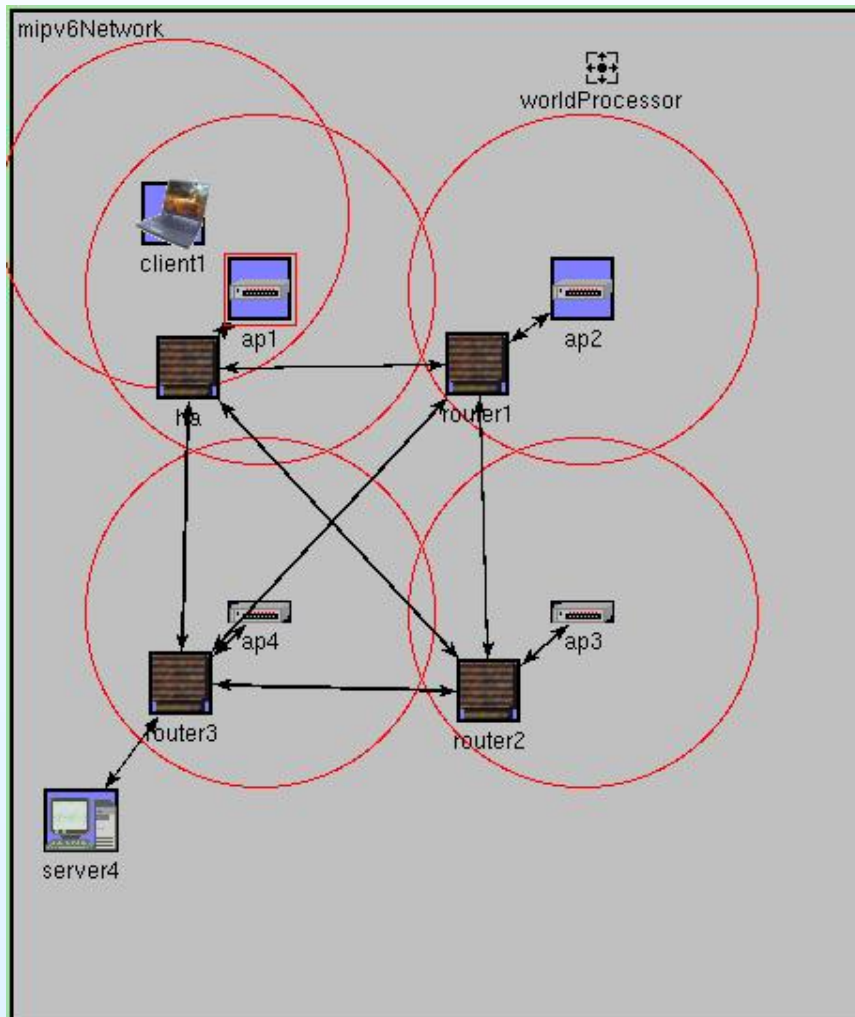
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- MIPv6 Example
- HMIPv6 Example
- Simultaneous MIPv6 Handovers
- Layer Two Handovers Only

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Figure 5: `MIPv6Network -f MIPv6Network.xml -r 1`
in **Examples/MIPv6Network**



HMIPv6 Example

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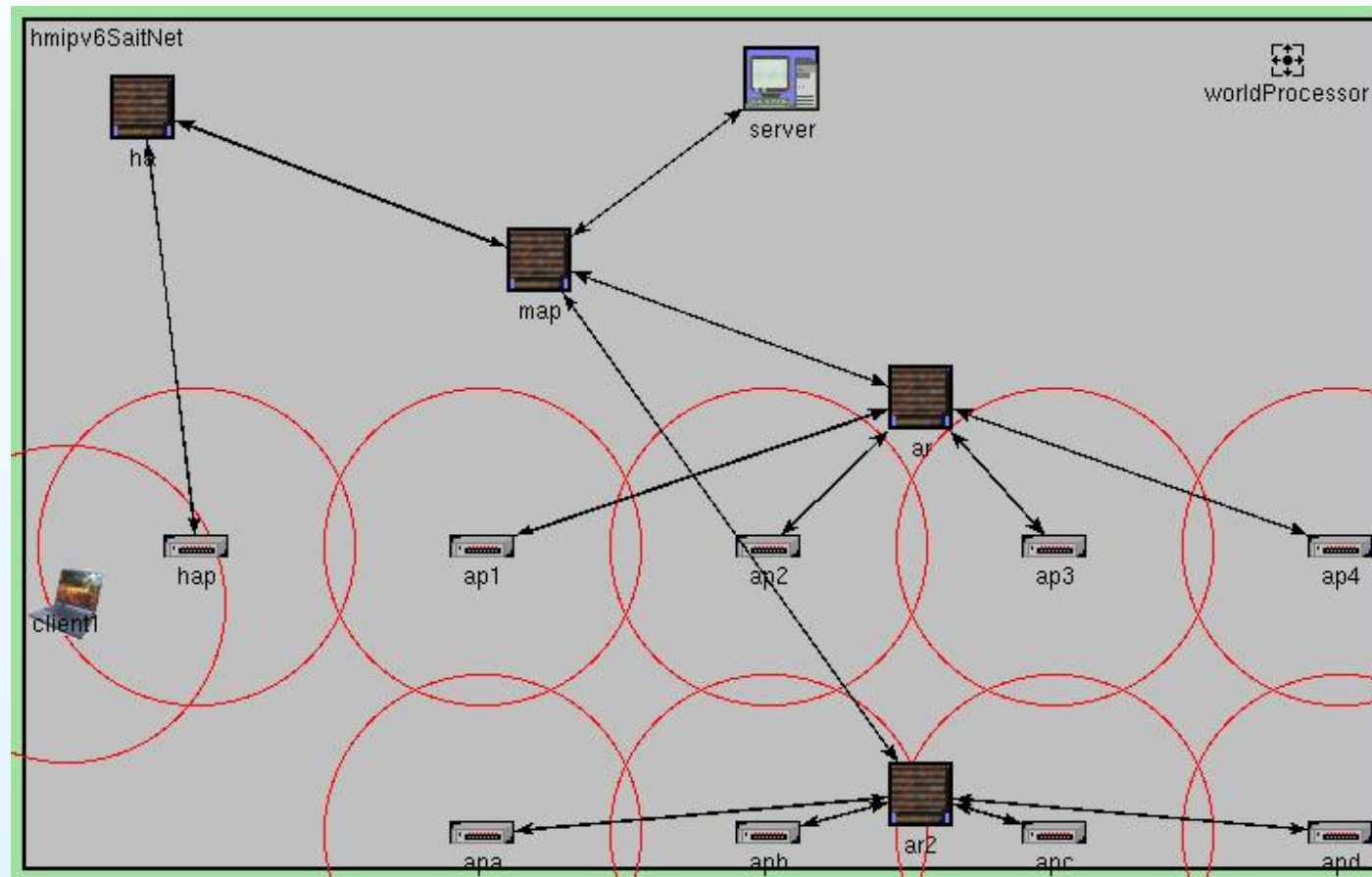
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- **HMIPv6 Example**
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Figure 6: HMIPv6Network -f HMIPv6Sait.xml -r 1 in Examples/HMIPv6Network



Simultaneous MIPv6 Handovers

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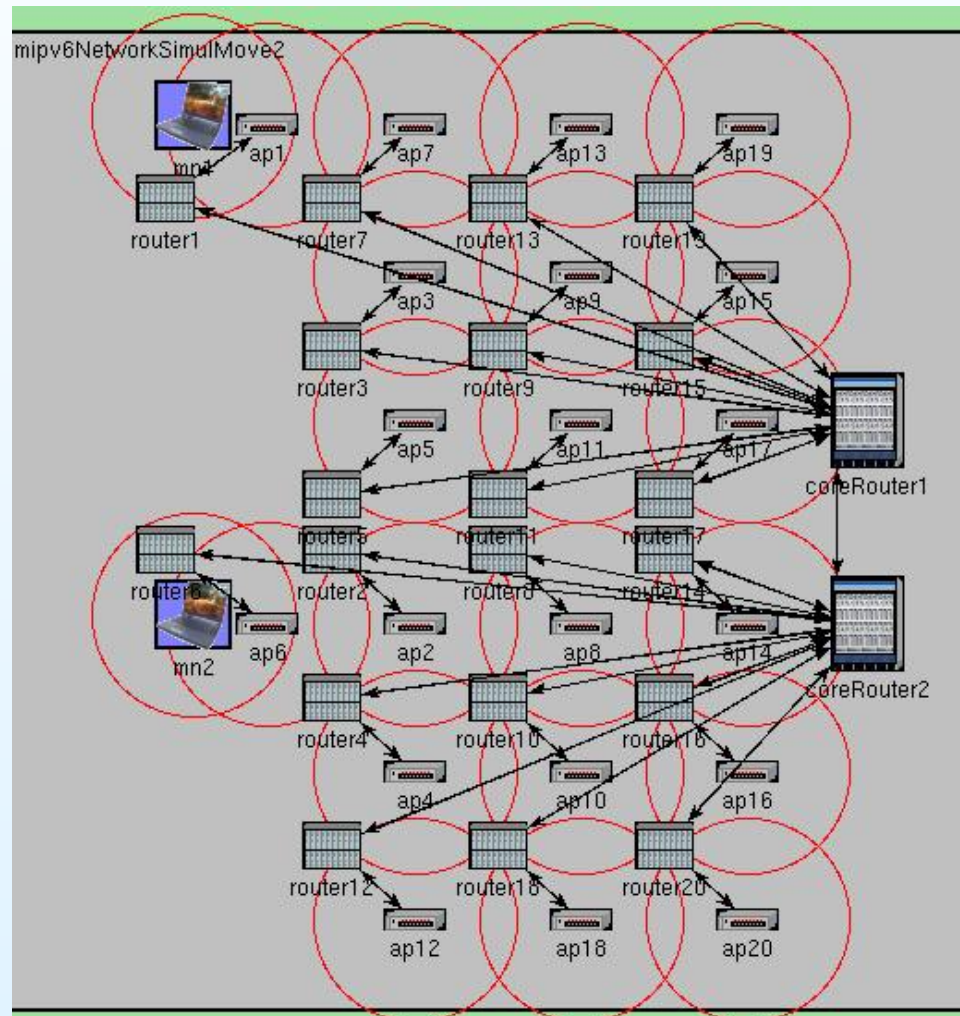
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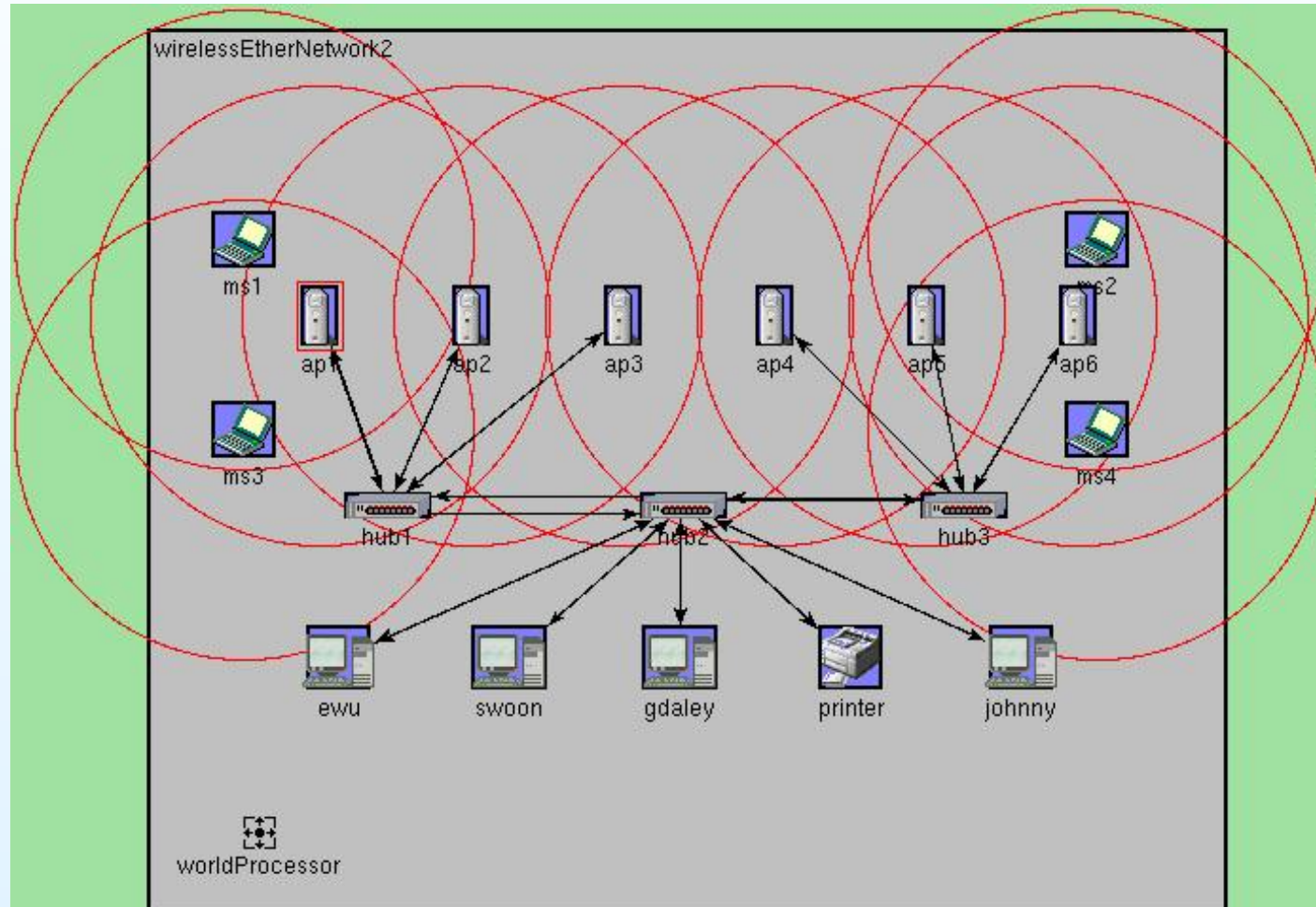
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Figure 7: MIPv6Network -r 5 in Examples/MIPv6Network



Layer Two Handovers Only

Figure 8: WirelessEtherNetwork2 in **Examples/WirelessEtherNetwork2**



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What's Next

- **Fix instability**
- Refactor
- Use OMNeT++ 3.0 new features
- Merge and use new IPSuite and TCP model from Andras
- Automate scenario generation
- Parallel simulation

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- Questions?
- Analysis
- References

Questions?

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Analysis

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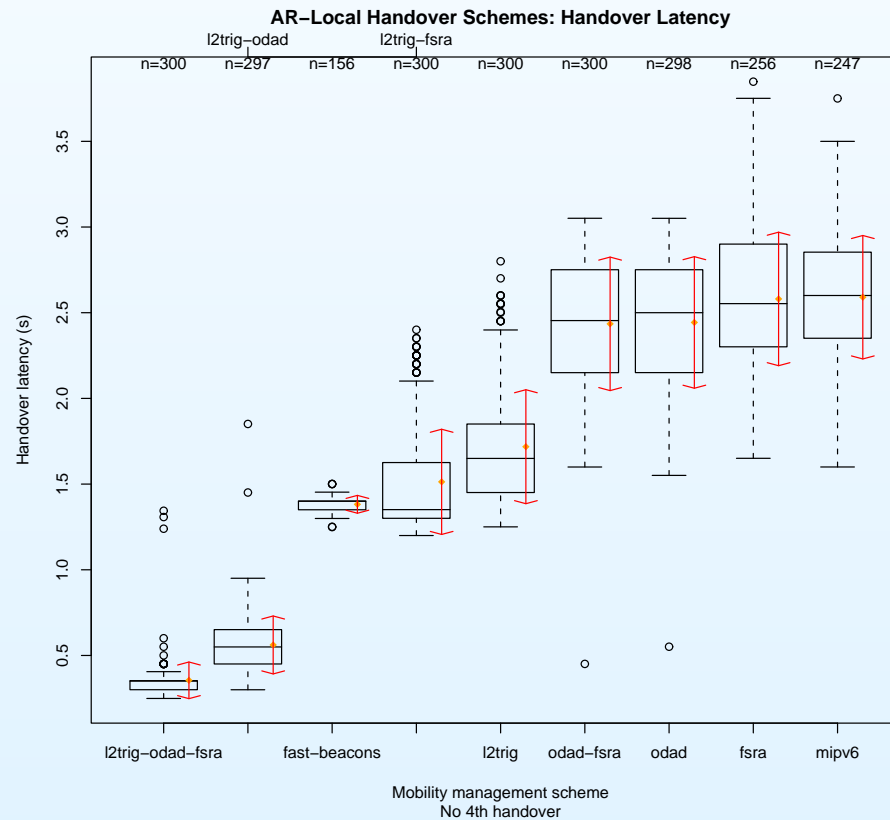
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- I recommend using R [1]. Some R texts I have found useful for copying examples from are [2], [3] and [4]. A good book to introduce or refresh some concepts in statistics is [5].
- Embed the R code in your \LaTeX document directly and generate \LaTeX tables and graphs on the fly.
- Use the Emacs interface [6]



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- [What's Next](#)
- [Questions?](#)
- [Analysis](#)
- [References](#)

- [1] R Development Core Team, *R: A language and environment for statistical computing*, R Foundation for Statistical Computing, Vienna, Austria, 2003, ISBN 3-900051-00-3. [Online]. Available: <http://www.R-project.org>
- [2] W. N. Venables and B. D. Ripley, *Modern Applied Statistics with S. Fourth Edition*. Springer, 2002, ISBN 0-387-95457-0. [Online]. Available: <http://www.stats.ox.ac.uk/pub/MASS4/>
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- [6] R. M. Heiberger, "Emacs speaks statistics: One interface – many programs," in *Proceedings of the 2nd International Workshop on Distributed Statistical Computing (DSC 2001)*, K. Hornik and F. Leisch, Eds. Vienna, Austria: Technische Universitat Wien, 2001. [Online]. Available: <http://www.ci.tuwien.ac.at/Conferences/DSC.html>

XML configuration

```
1 <?xml version="1.0" encoding="iso-8859-1"?>
2 <!DOCTYPE netconf SYSTEM "../../../Etc/netconf2.dtd">
3 <netconf debugChannel="debug.log:rcfile:notice:custom:Ping6:Statistic:IPv6:AddrResln:Forwarding:NeighbourDisc:RouterDisc:Routing:
4   <local node="server">
5     <interface name="eth0">
6     </interface>
7   </local>
8   <local node="client1">
9     <interface name="eth0">
10    </interface>
11  </local>
12  <local node="client2">
13    <interface name="eth0">
14    </interface>
15  </local>
16  <local node="router" routePackets="on">
17    <interface name="eth0" AdvSendAdvertisements="on">
18      <AdvPrefixList>
19        <AdvPrefix AdvOnLinkFlag="on">
20          3333:0:0:4444:0:0:0:0/64</AdvPrefix>
21        </AdvPrefixList>
22    </interface>
23
24    <interface name="eth1" AdvSendAdvertisements="on">
25      <AdvPrefixList>
26        <AdvPrefix AdvOnLinkFlag="on">
27          3333:0:0:1111:0:0:0:0/64</AdvPrefix>
28        </AdvPrefixList>
29    </interface>
30
31    <interface name="eth2" AdvSendAdvertisements="on">
32      <AdvPrefixList>
33        <AdvPrefix AdvOnLinkFlag="on">
```