THALES

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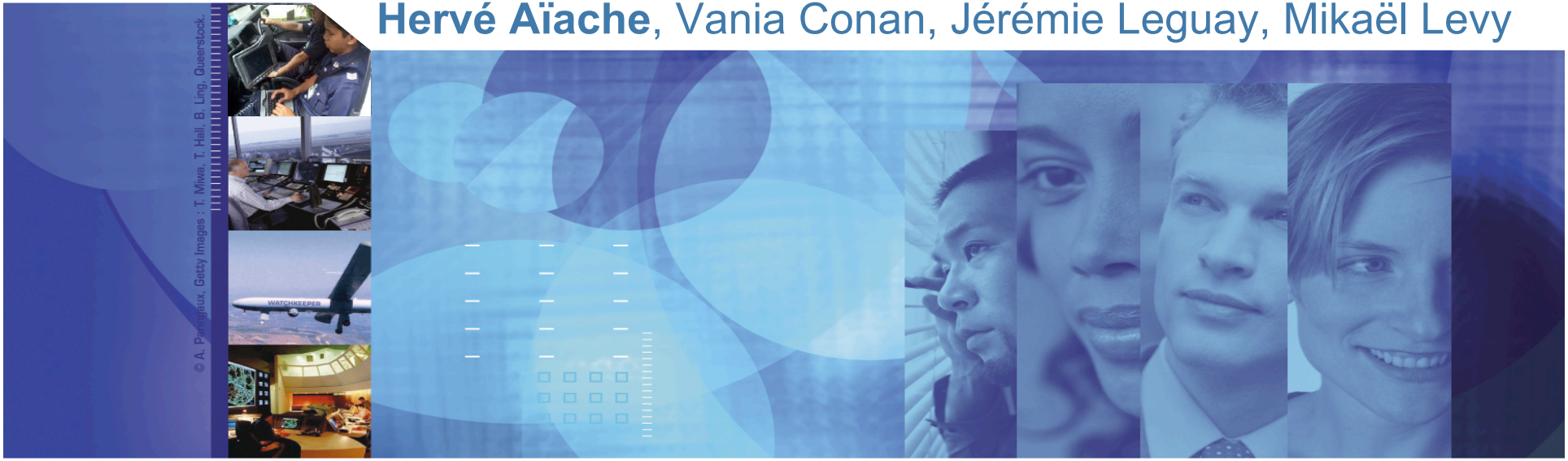

XIAN: Cross-Layer Interface for wireless Ad hoc Networks

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Lipari - Italy

- Why XIAN?
  - Technical background
  - XIAN Motivations
- XIAN design
  - XIAN software architecture and implementation
  - *Madwifi* 802.11 metrics
  - XIAN interfaces
- QoS routing: a use case
  - Experimentation description
  - How can XIAN help routing decision?
  - Radio Signal Strength measured by XIAN
- Conclusion and future work

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- Well known issues of Mobile ad hoc networks (MANETs)
  - Spontaneous set up of wireless communication system
  - Set of mobile nodes sharing one or more wireless channels
  - No centralized control
  - Network topology and resources subject to variations with time
  - Dynamic and unpredictable distributed environment

- In such a context, traditional network system conception is challenged
  - Recent research work and studies explore new promising and more flexible designs ➔ ***Cross-Layer approaches***
    - More flexible exchange of status or control information between the different components of the communication system
    - System expected to be more reactive to the wireless environment and more responsive to quality required by applicative-oriented elements

Why XIAN?

- When compared to usual layer model
  - Different Cross-Layer models have been investigated
  - A wide spectrum of options have been proposed
  - Can be classified depending on their impacts or differences
    - Global exchange of information between components [Conti et al., 2004]
    - Limitation to adjacent layers interactions [Kawadia et al., 2003]

- Cross-Layering calls for a software architecture that allows access to wireless air interface parameters and status
  - Need for a software implementation supporting more flexible sharing of information and status exchanges
  - But experimenting cross-layer design for MANETs remains difficult
  - Most of ad hoc testbeds based on 802.11 cards lacking appropriate API support

- XIAN implementation aims at enabling and facilitating cross-layer studies and experimentations over MANETs testbeds

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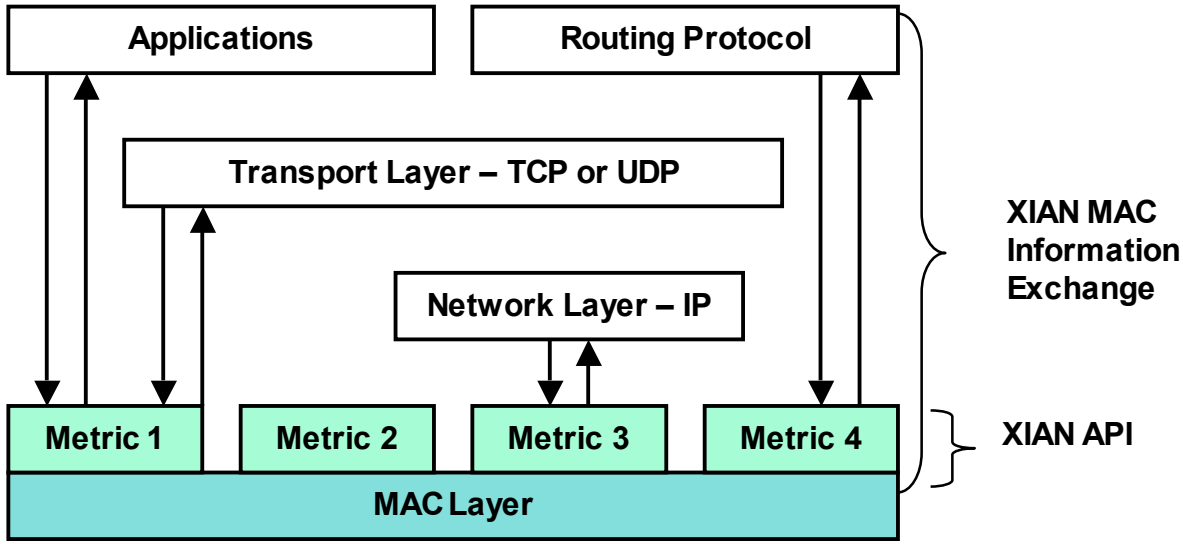
- XIAN objectives
  - Specify, implement and validate a Cross-Layer Design only based on standard 802.11 driver and network interface
  - Study relevant Cross-Layer information available in standard network drivers in view of QoS Routing/MAC interactions

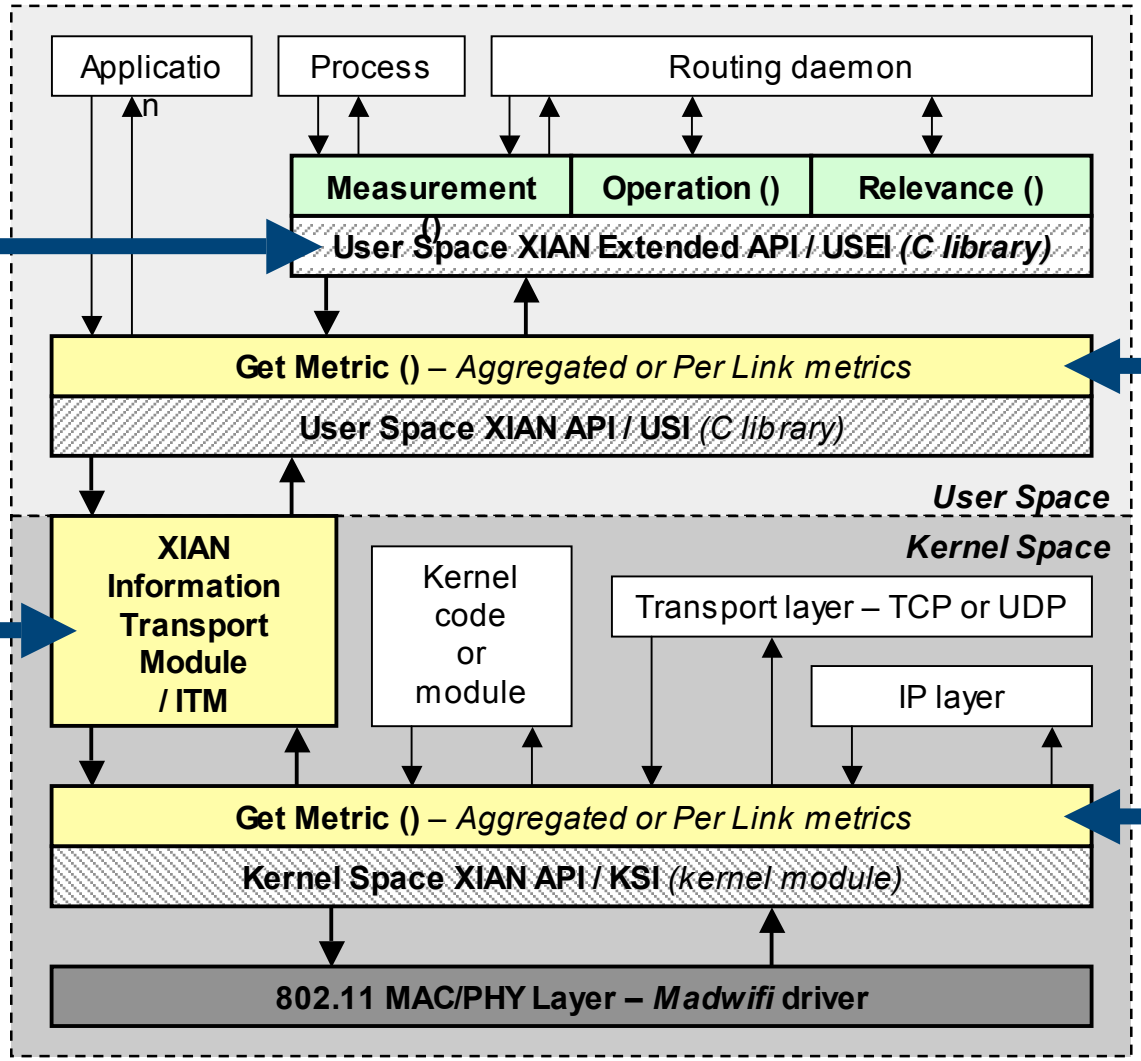


- Hands-on approach
  - To go beyond simulation and support experimental test beds
  - To study what is really available in existing drivers
  - To feed simulation studies with experimental results

- First XIAN implementation
  - Implemented for a Linux kernel 2.4.X
  - Experimented with a *Madwifi* driver
- 802.11 *Madwifi* drivers
  - Open source project
    - Multiband Atheros Driver for Wireless Fidelity
  - Very active community and open/modular architecture design
  - Driver versions supported by Linux
    - BSD branch (Good support of ad hoc mode and monitor mode)
    - WDS branch (Roaming and bridging between access points)
    - WPA branch (Focused on 802.1x for RADIUS-based authentications)
- 802.11 driver selected: *Madwifi* BSD branch
  - 180 states/information/statistics
  - About 40 per-neighbor measurements

XIAN software architecture

Examples of combined metric use

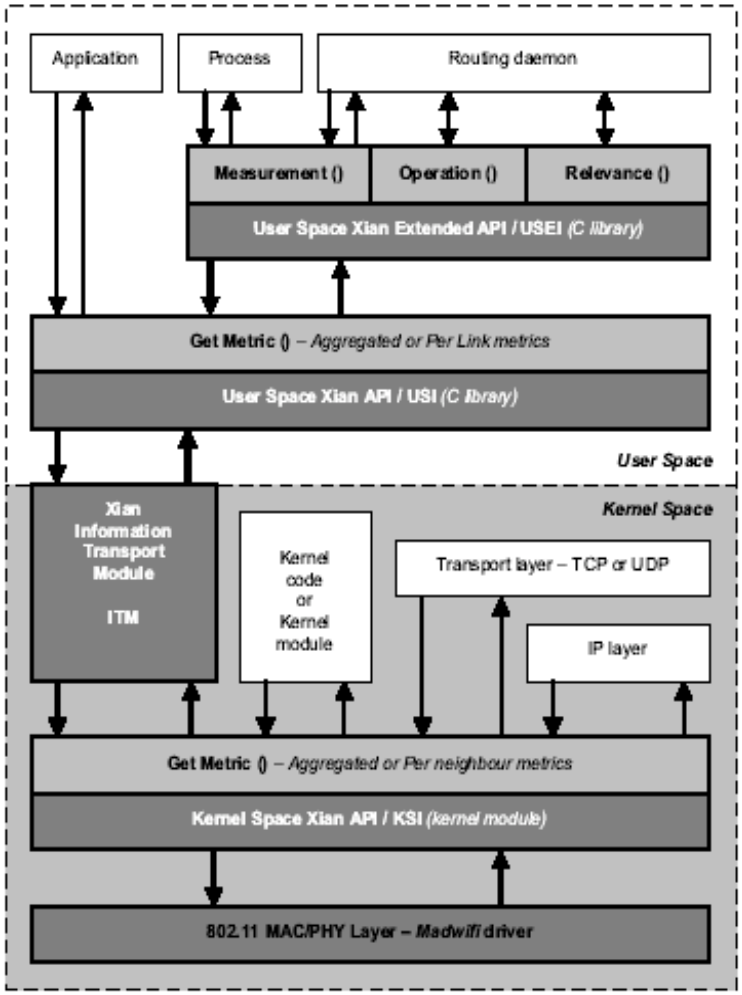


Same XIAN interface

User/Kernel Space Information Exchange

XIAN software components

- Kernel Space Xian Interface (KSI)
  - Dedicated to kernel space components (e.g. TCP or UDP)
  - Linux kernel module
  - Direct interactions with the Madwifi driver to retrieve its internal states and statistics.
- User Space Xian Interface (USI)
  - Kernel Space Xian API but at the user space level
  - An ordinary C library in order to facilitate integration with user space programs (e.g. routing daemons or applications).
- The Xian Information Transport Module (ITM)
  - Allows to pass information from the kernel space to the user space
  - Special character device.



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Madwifi 802.11 metrics

- Configuration states
  - Current configuration parameters of the 802.11 network device
    - Used channel or the number of queues
- Aggregated metrics
  - Global statuses on the use of the 802.11 network interface since it runs first started
    - Number of received frames dropped or with wrong BSSID
    - Number of transmitted frames with CTS or with RTS enabled
    - Relative signal strength (RSSI) of the last ACK on transmission
    - Number of failed receptions (due to queue overrun, bad CRC, PHY errors or decryption problems)
- Per neighbour/link metrics
  - Information related to particular transmission at MAC layer
    - Number of received/transmitted data frames or bytes
    - Relative signal strength (RSSI)
    - Number of transmission retries

- Madwifi 802.11 metrics and XIAN interfaces
  - Aggregated and per-neighbor metrics
  - One function per metric
  - About 180 developed and integrated in XIAN APIs

- Per-neighbor/link metric

```
u_int32_t                       /* returned metric value */
get_node_metric_name(
  u_int8_t * macadd,            /* MAC address of neighbour node */
  char * dev_name,              /* Interface name */
  unsigned int * code_err);     /* Error code */
```

- Aggregated metric

```
u_int32_t                        /* returned metric value */
get_metric_name(
   char * dev_name,              /* Interface name */
   unsigned int * code_err);     /* Error code */
```

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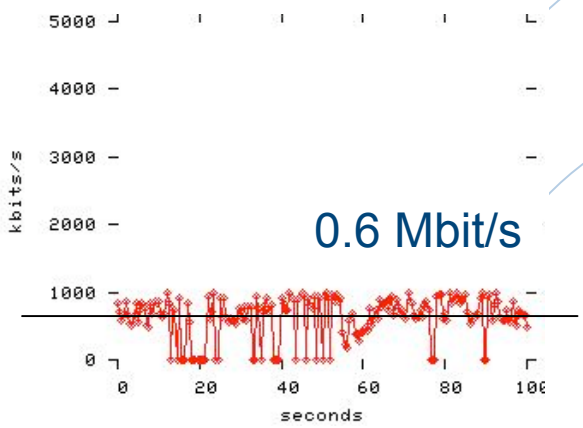
- Background basis
  - The use of hop count may lead to poor quality routes that follows long range links [De Couto et al., 2002]
    - High packet error rate, heavily loaded areas, high level of radio interference, high level of congestion
  - QoS routing uses metrics from other layers to take these parameters into account
    - Expected transmission count [ETX – De Couto et al., 2003]
    - Medium time metric [MTM – Awerbuch et al., 2004]
    - Available bandwidth [Déziel et al., 2005]

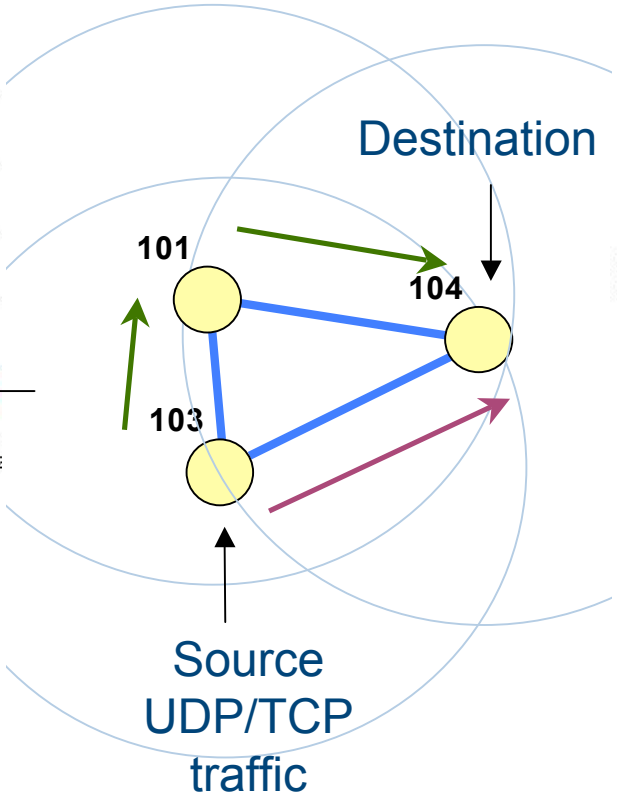
- Experimental ad hoc platform and parameters
  - Gigabyte GN-WMAG cards with Atheros chipset
  - TCP and UDP performances measured by *iperf* software

Parameter	Value
δ	10ms
N	60
UDP sending rate	100 KBytes/s
Packet size	100 bits
Interval between iperf reports	0.5s
802.11 bitrate	11Mbits
RTS/CTS	off

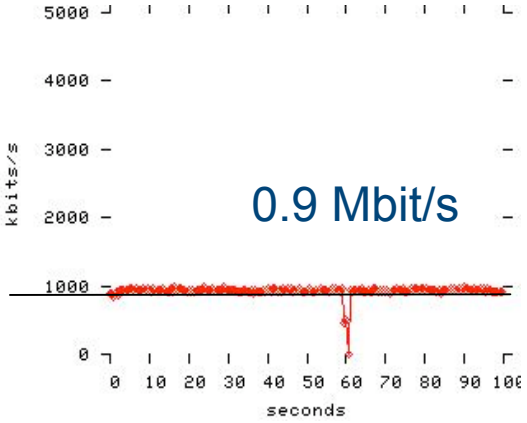
How can XIAN help in routing decision?

Direct route





Indirect route (via 101)



UDP traffic
avg throughput: 626 kbit/s
Avg delay: 1.5 ms

UDP traffic
avg throughput: 927 kbit/s
Avg delay: 1.1 ms

In this case, it can help routing to make better decisions…

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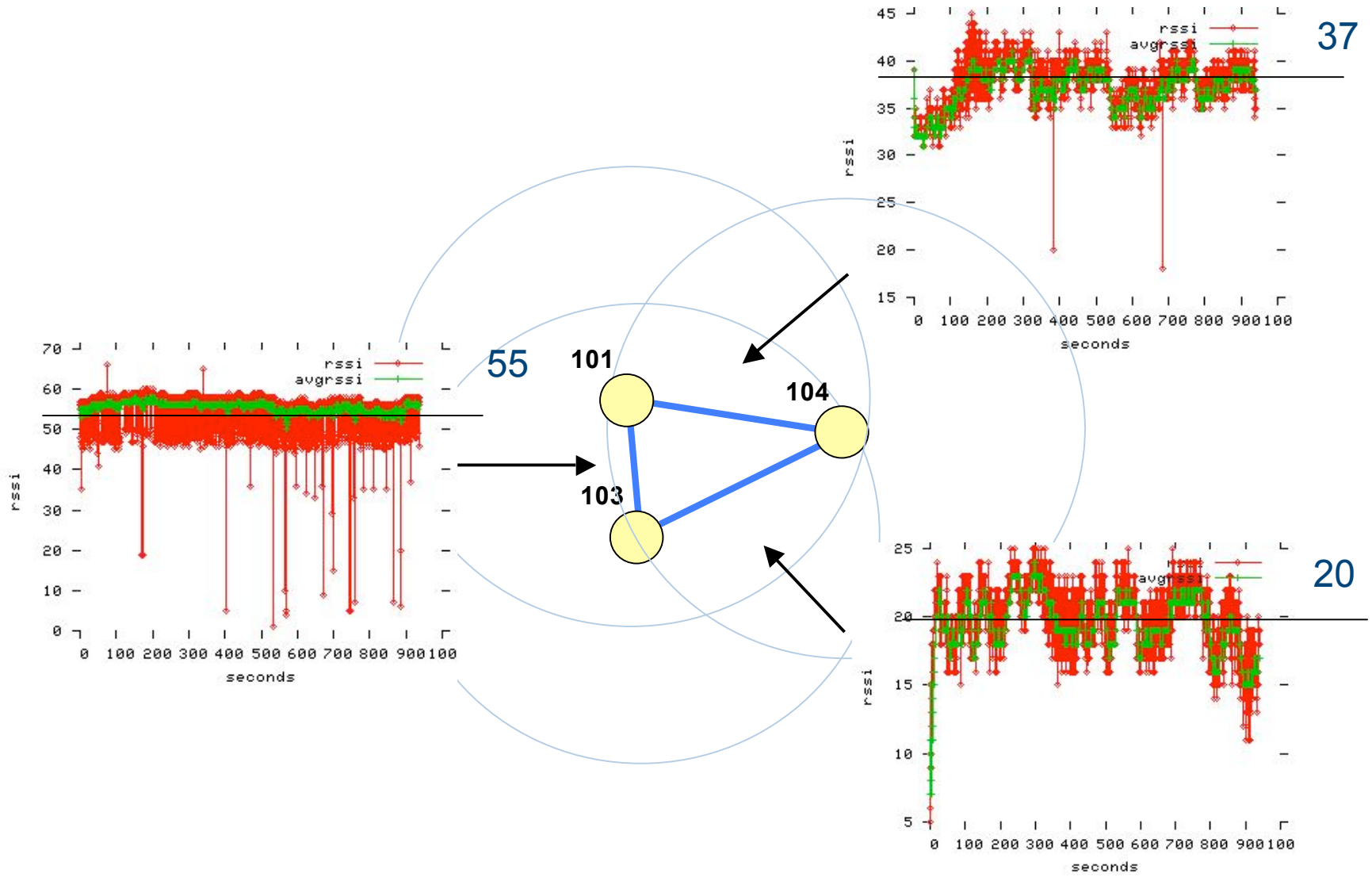
Radio Signal Strength measured by XIAN



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Conclusion and future work

Conclusion

- Description of XIAN approach, design and its interfaces
- Implementation of a cross-layer interface not impacting an existing communication system
- Software enabling experimental set ups and validation of a large variety of use cases for MANETs cross-layering studies
- Presentation of one possible use case through a real deployment highlighting the potential benefit of QoS routing
- First XIAN release available at *http://sourceforge.net/projects/xian*

Future work

- Improvements of XIAN approach
- New interfaces development based on publish/subscribe mechanisms
  - E.g. Enabling link up/down events to react faster to topology changes
- New metrics integration
  - E.g. Weighted average to favour latest measurements, compound of metrics
- Support of other chipsets

Thanks for your attention!

Questions?

Website: http://sourceforge.net/projects/xian

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