XIAN: Cross-Layer Interface for wireless Ad hoc Networks

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Lipari - Italy
Summary

- 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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Technical background

- 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 \textbf{\textit{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
XIAN implementation

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
Thales Architecture Framework

XIAN software architecture

Examples of combined metric use

User/Kernel Space Information Exchange

Same XIAN interface

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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.
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
  ```c
  u_int32_t 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
  ```c
  u_int32_t get_metric_name(
      char * dev_name,            /* Interface name */
      unsigned int * code_err);  /* Error code */
  ```
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A use case: QoS routing

Background basis

- The use of hop count may lead to poor quality routes that follow 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-W MAG cards with Atheros chipset
- TCP and UDP performances measured by iperf software

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
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<tbody>
<tr>
<td>$\delta$</td>
<td>10ms</td>
</tr>
<tr>
<td>N</td>
<td>60</td>
</tr>
<tr>
<td>UDP sending rate</td>
<td>100 KBytes/s</td>
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<tr>
<td>Packet size</td>
<td>100 bits</td>
</tr>
<tr>
<td>Interval between iperf reports</td>
<td>0.5s</td>
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<tr>
<td>802.11 bitrate</td>
<td>11Mbits</td>
</tr>
<tr>
<td>RTS/CTS</td>
<td>off</td>
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How can XIAN help in routing decision?

In this case, it can help routing to make better decisions...
Radio Signal Strength measured by XIAN

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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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