



WAF: An Adaptive Protocol Framework for Multihop Wireless Networks

Authors:

Christos Koulamas, George Orphanos
Intracom S.A.

Fabrice Lucas, Sylvie Colin
AQL SILICOMP Grp.



MANET Requirements

- **Routing**

Mainly based on shortest-path metric, but other approaches have been also proposed (link-level quality, path congestion).

- **Appropriate coupling of protocol layers**

Independent operation of layered protocol state machines leads to non-optimal behaviour.

- **Interoperability**

Seamless handling of heterogeneous wireless technologies (802.11 a/b/g, Bluetooth PAN)

- **Link layer robustness**

Wireless links exhibit large variations in packet loss rates, latency and throughput



Objective

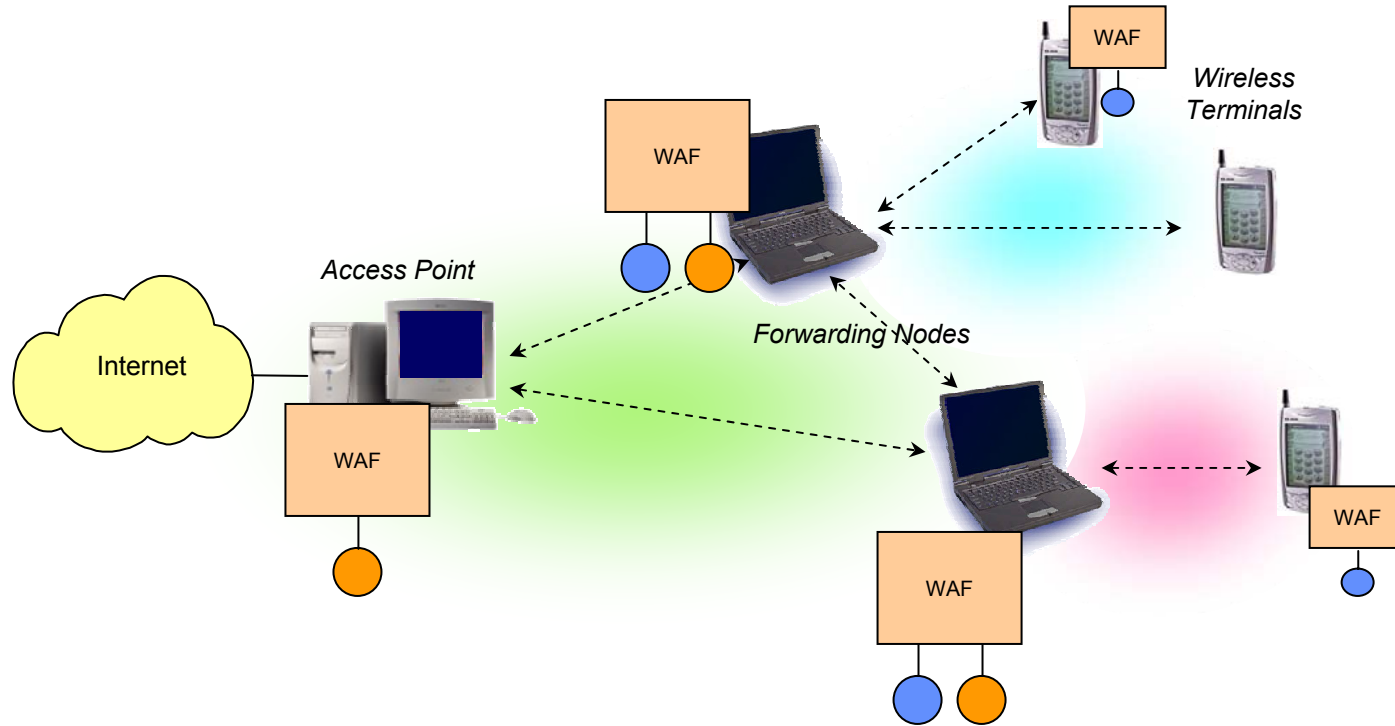
Define a cross-layer design environment (framework) in order to facilitate:

- Adaptive solutions in multi-hop routing or other networking protocols
- Link-layer robustness and end-to-end performance enhancements
- A uniform and extensible way of tuning different parameter spaces of any underlying components by hiding particularities of heterogeneous technologies and performance enhancing approaches



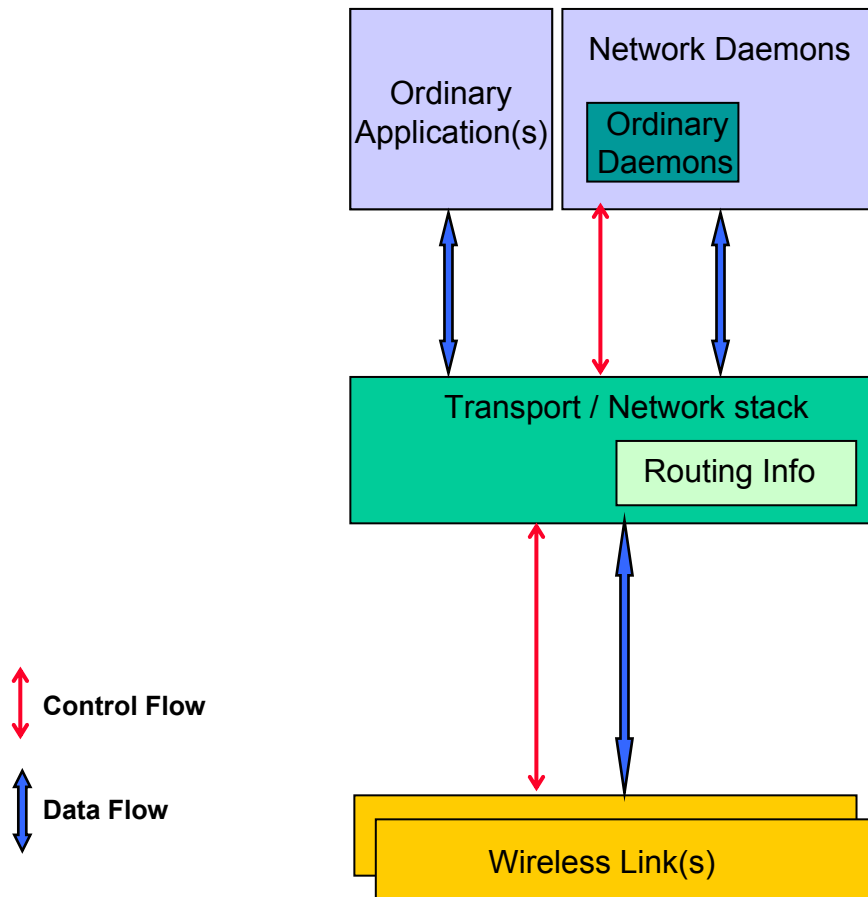
Wireless Adaptation Framework

A software architecture for heterogeneous multi-hop networking, to be used either in production devices or to facilitate analysis in evaluation setups.



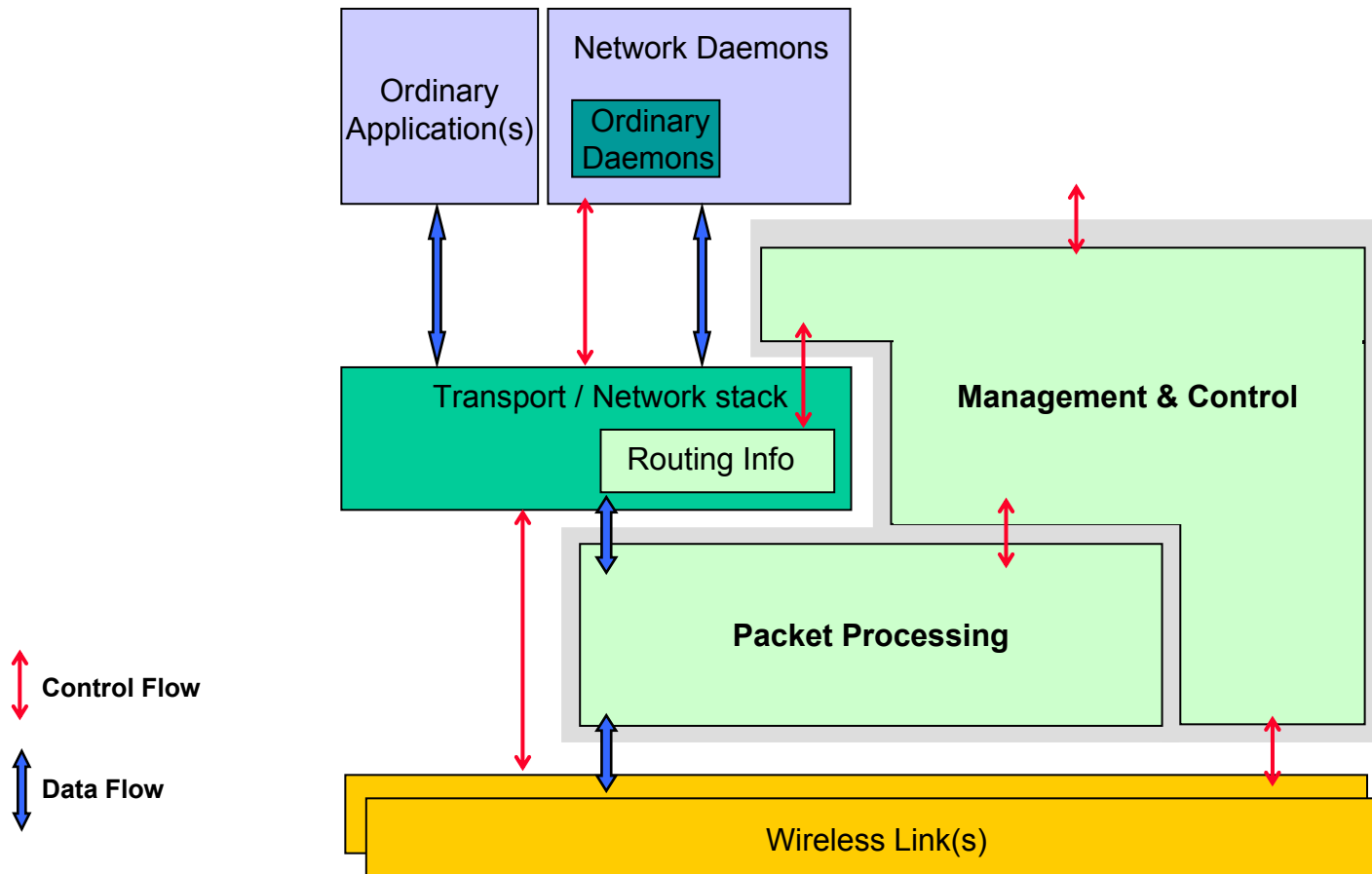


Standard Node Architecture



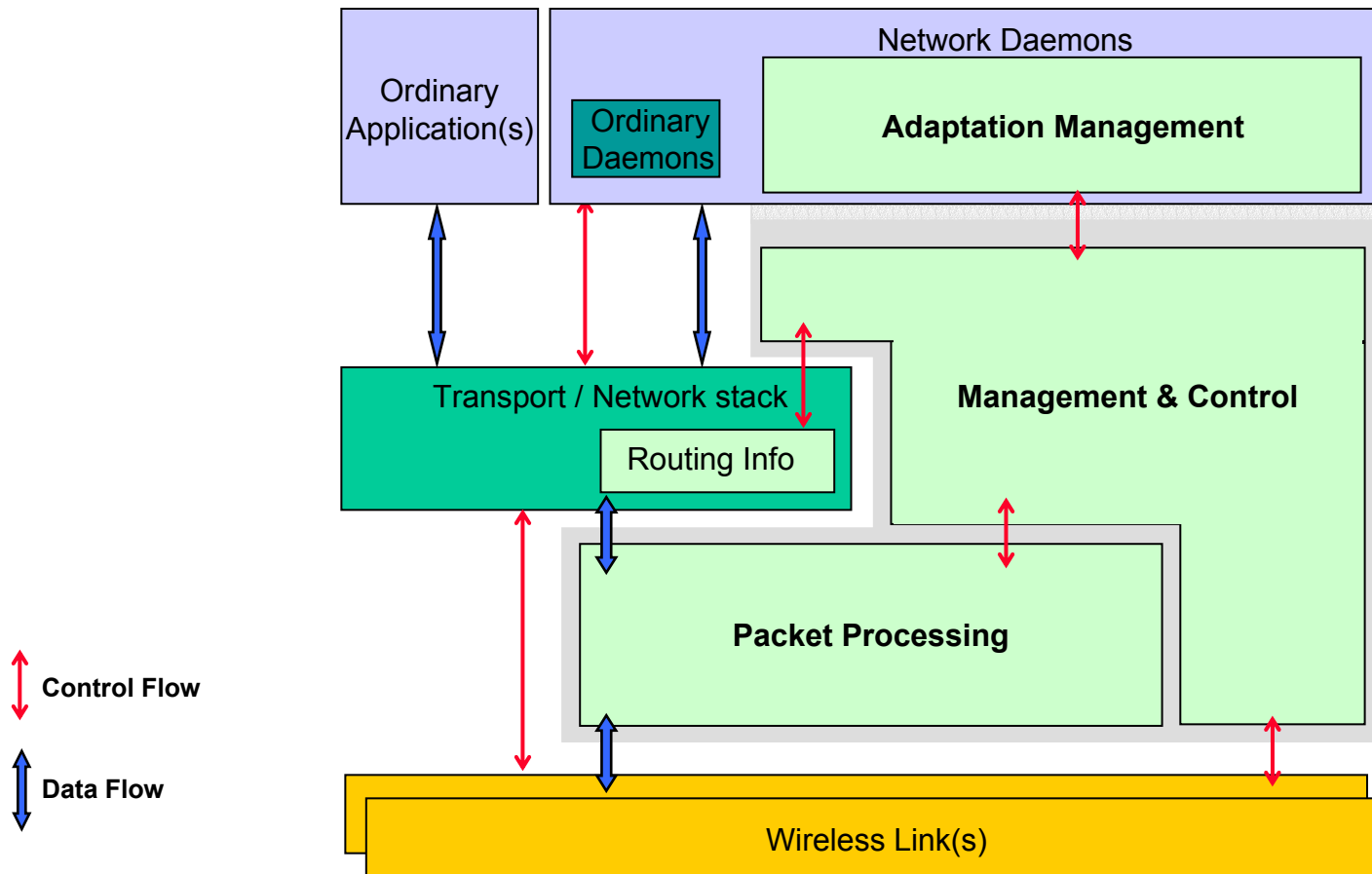


WAF-Enabled Node Architecture



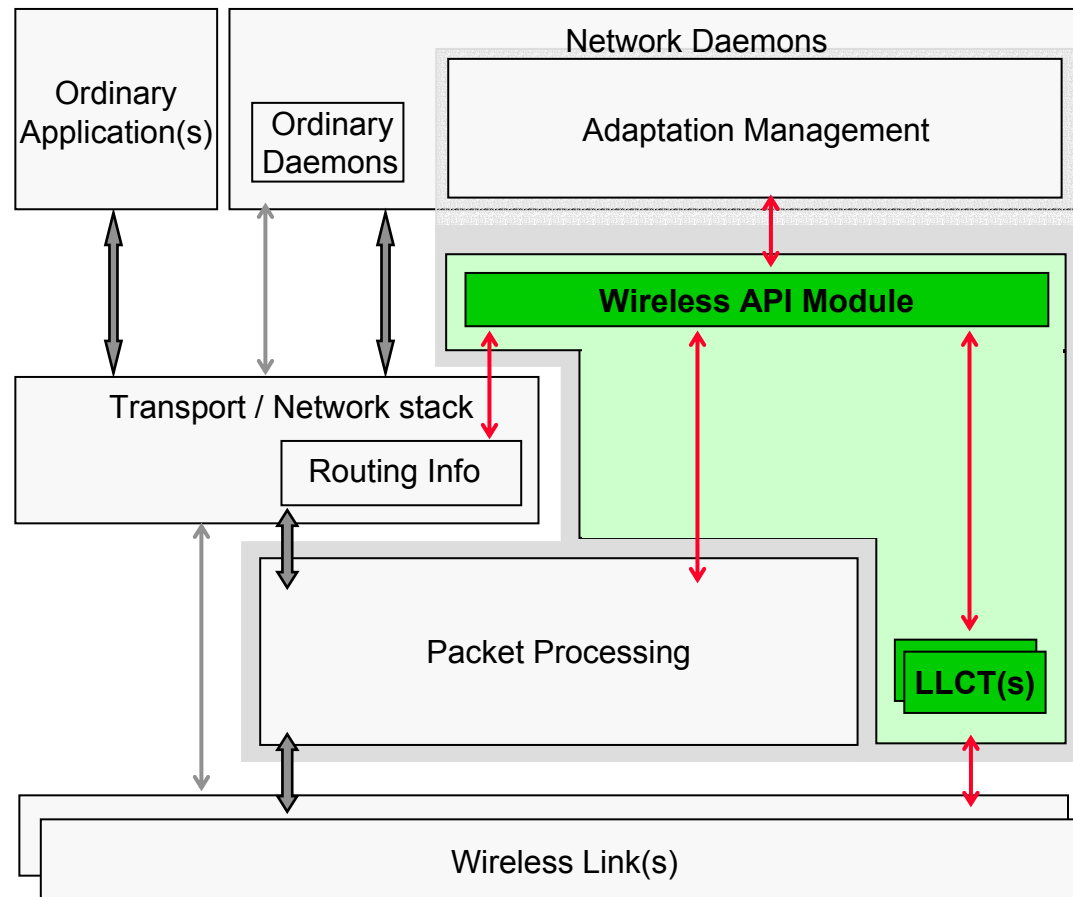


WAF-Enabled Node Architecture





WAF Management & Control Part





Logical Link Control Translators (LLCT)

- Each **LLCT** is aware of one technology (e.g. 802.11, Bluetooth), exporting one or more services (e.g. PAN or LAN for Bluetooth, ESS or Ad-Hoc for 802.11)
- It masks the OS and some wireless technology peculiarities of the specific driver interfaces, providing a uniform way to manipulate the functions exposed to the Wireless API module.



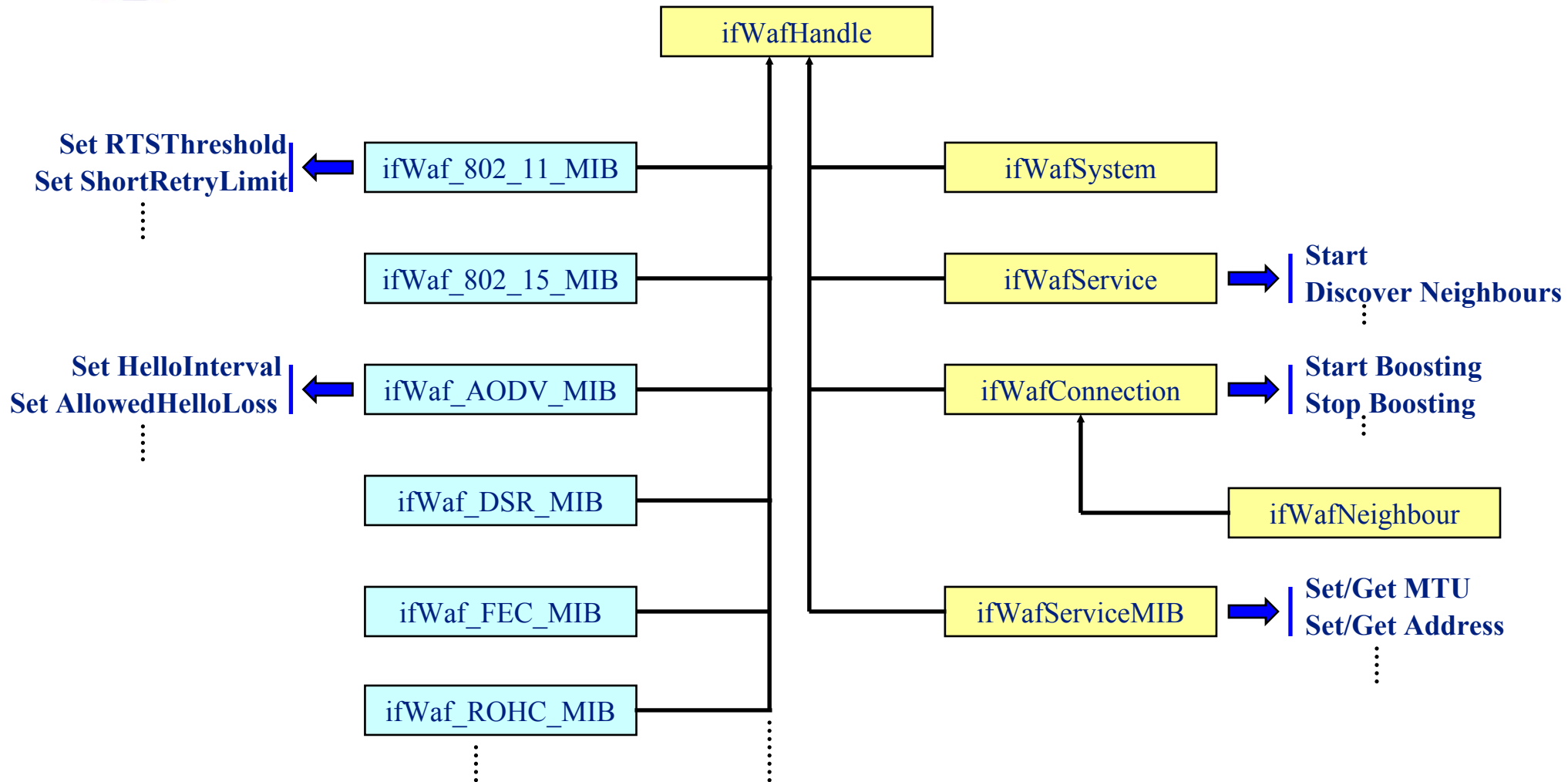
Wireless API

Abstracts access to networking mechanisms and implementations of different operating systems, and to interfaces of different wireless technologies and services, in order to provide a uniform and extensible interface between higher level WAF entities or other WAF-aware applications and lower level WAF functionality, as:

- OS specific protocol stack implementations and routing protocol specific structures and tunable parameters
- Packet processing, performance enhancing policies and booster specific parameters
- Link level configuration parameters, quality measurements and statistics (through the technology specific LLCT modules)

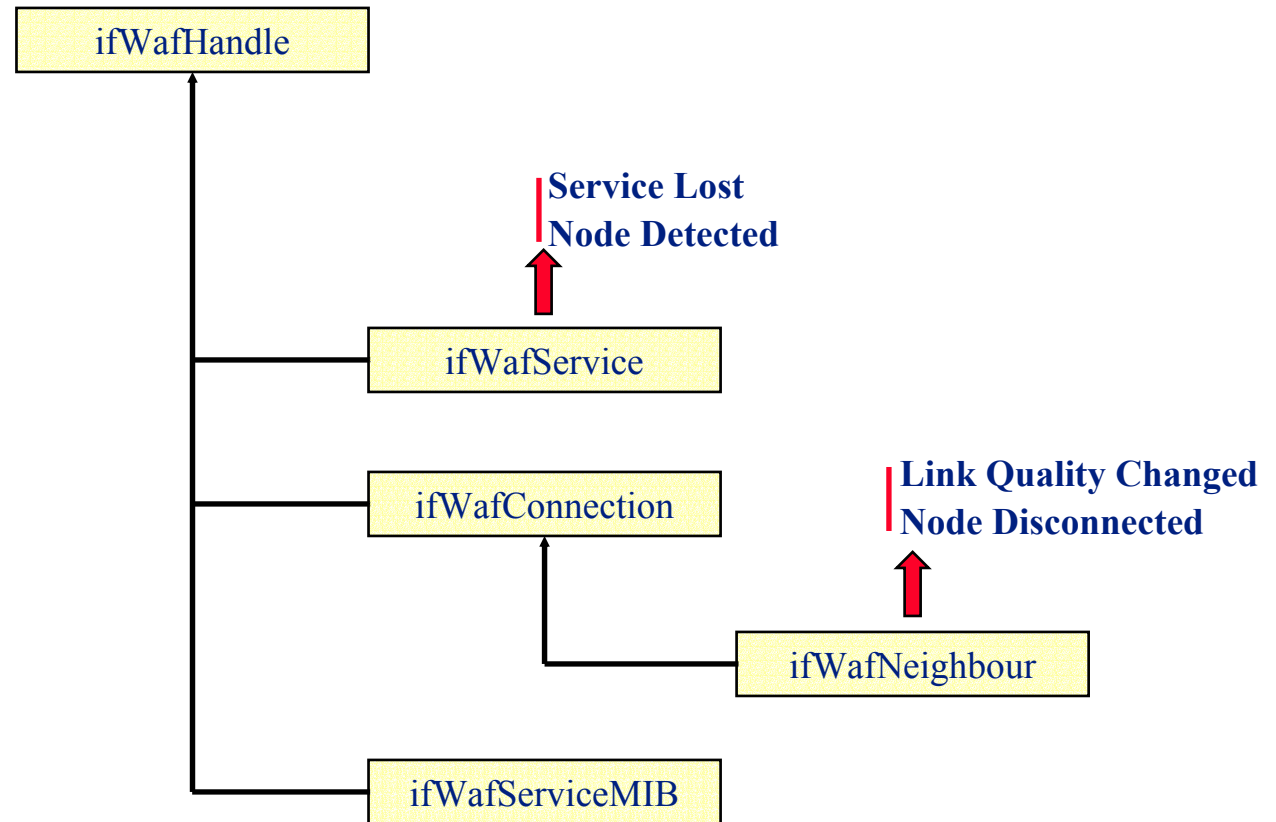


Wireless API : A set of Control Interfaces





Wireless API : Event delivery



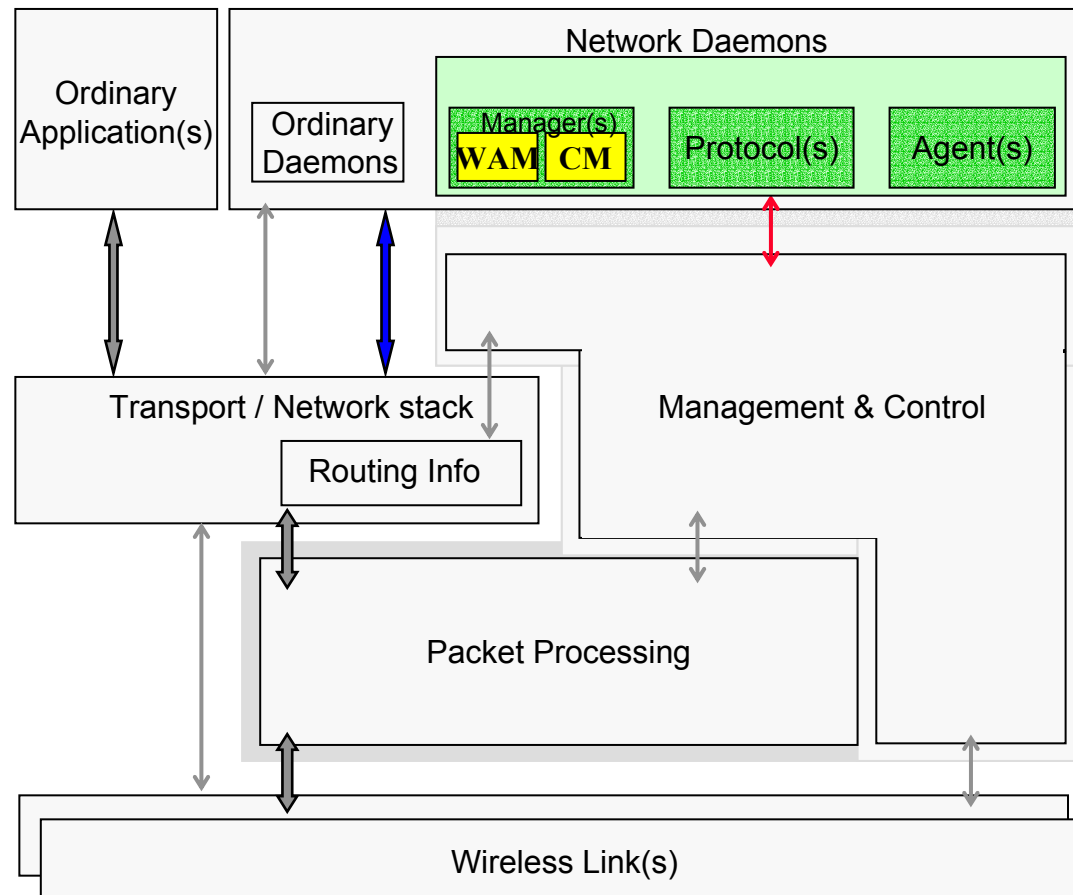


Protocol Boosters Framework (PBF)

- **Packets Filter** module :
Provides the interface with the network layers stack; it processes all the incoming and outgoing packets, calling the required protocol boosters.
- **Boosters Policy** module :
Maintains tables of the traffic classes and of the current links boosting policies; provides classification for the outgoing packets according to these policies.
- **Boosters Support** module :
Acts as the controller / manager of the overall packet processing functionality and its parameters, providing an interface to the higher level parts through which configuration of the boosters policy and the boosters themselves is made possible.



WAF Adaptation Management Part





WAF Adaptation Management Part

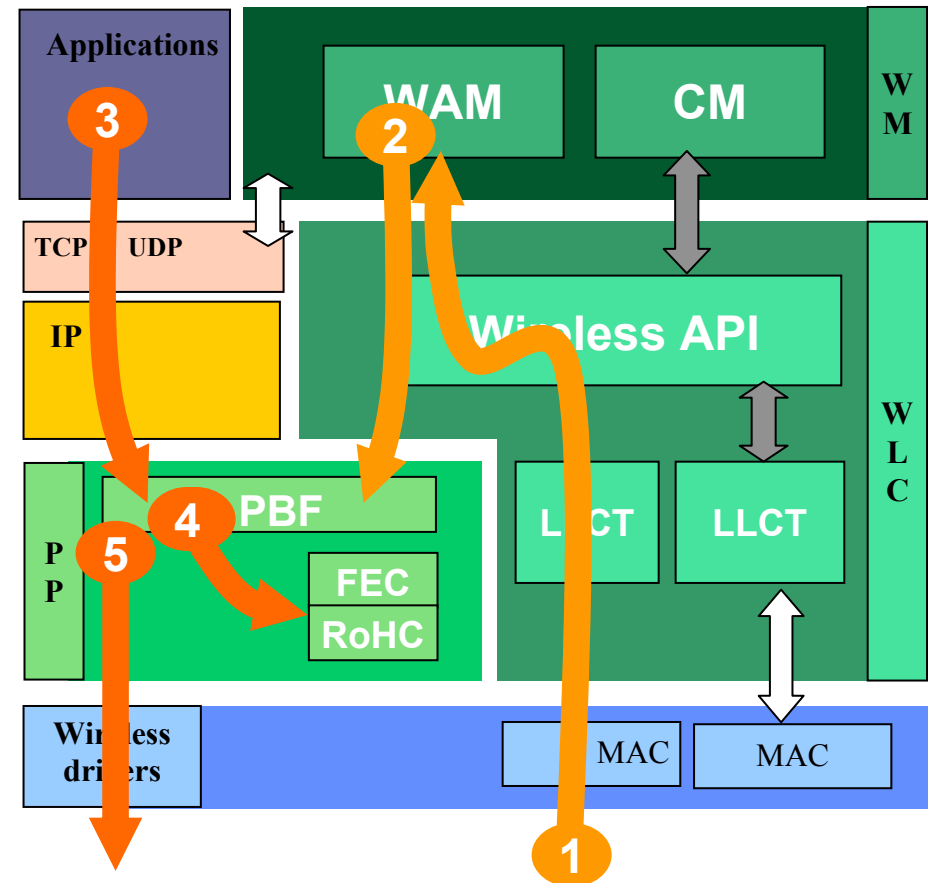
- **Manager(s):** Perform particular control functions and adaptations on other existing components or protocols. Such functions are configuration, statistics retrieval, event handling, neighbour capability discovery, connection management (e.g. vertical handover), power management, external routing protocol adaptations.
- **Protocol(s):** Complete implementations of networking protocols, as routing and mobility management protocols, which use the WAF extensions in order to adapt their operation according to the local or network status at any moment.
- **Agent(s):** Network management agents, with main purpose to extend the accessibility of existing network management protocols (e.g., SNMP) to the new parameters and statistics “namespace” introduced by WAF.



Adaptation to link conditions

- Detection of lost connections
- Periodical measurement of link quality

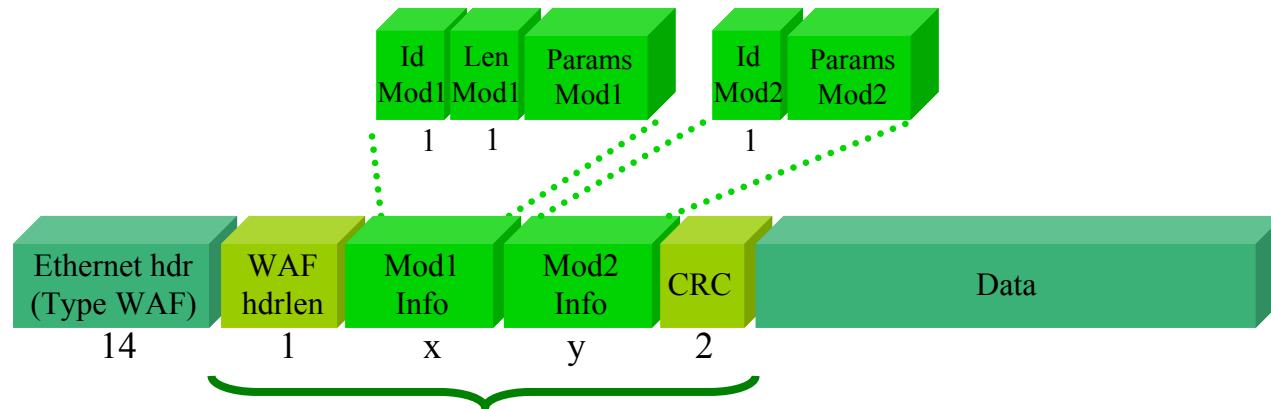
- 1 • According to SNR/Rate, adaptation of parameters for boosters (WAM)
- 2 • Update of boosting policy in the PBF
- 3 • Downstream traffic
- 4 • Call of the suitable boosters with their relevant parameters
- 5 • Transmission





Boosting process

- WAF header, embedded on each Ethernet packet
- Carry the list of boosters and their parameters
- Protected by a CRC
- Extensible scheme
- Lightweight overhead (few bytes)





Conclusions

- **Introduction of the *Wireless Adaptation Framework (WAF)* as enabling technology that allows optimizations in multihop environments, by supporting:**
 - cross-layer protocol interactions
 - adaptation of routing and application protocols to link and network conditions
 - dynamic protocol boosting activation / deactivation
 - uniform control interface to underlying wireless interfaces and protocol machinery



Thank you