Cognitive Wireless Networks: Your Network Just Became a Teenager

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Contents

- Motivation
- Towards cognitive wireless networking technologies
- The Cognitive Resource Manager (CRM) architecture
- Tools for “cognition”
- Functions, APIs and enabling technologies
- Summary and the future work

Motivation I

- We witness a constant increase of the number of wireless devices operating in the unlicensed 2.4 GHz band.
- Not only the number but also the diversity of the devices is large.
- Severe competition of the different technologies for the same spectrum.
- Serious interference problems and decrease of the communication performance.

Need for “smart” and self-learning methods to more optimally utilize the spectrum

Motivation II

- Alternative method for cross-layer optimization for more efficient use of available communication capacity in the wireless systems.
- Better matching between the needs of the applications and the available resources in the wireless devices.
- Transparent flow and utilization of information through the protocol stack over well defined interfaces.

Need for advanced multi-dimensional optimization and reinforced learning

Towards cognitive networking

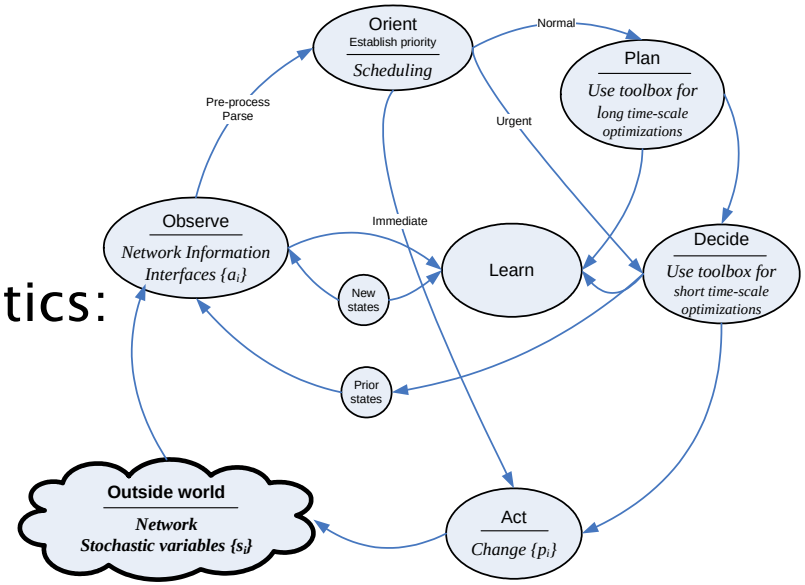
- More than just a “cognitive radio” concept.
- Extending the scope towards more holistic approach.
- Introducing a framework Cognitive Resource Manager (CRM) for automatic optimization of the communication stack as a whole beyond the traditional RRMs by using machine learning and pattern recognition approaches:

- Optimal management of spectrum resources
  - Scheduling
  - Management of link parameters
  - Scalability and self-organisation
  - Cooperation between the applications and the system

- CRM tries to dynamically learn the environment, find out, for example, the capacity bounds and then optimize system performance to reach the best possible state.

CRM architecture

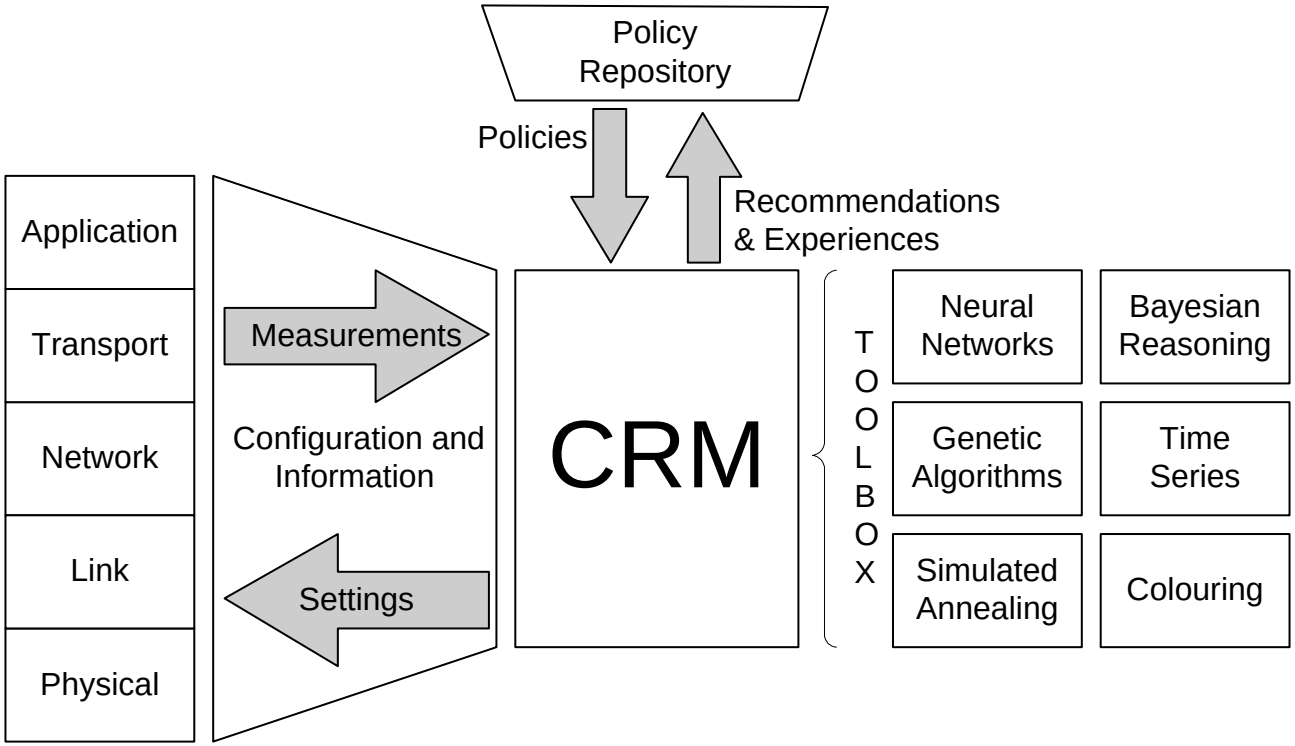
- A multifunctional software entity
- In the optimization process it uses
  - Toolbox of advanced reasoning methods
    - Bayesian reasoning
    - Genetic algorithms
    - Neural networks
    - Time series analysis
    - …
  - Variety of information & statistics:
    - Application
    - Network
    - Link layer
    - Operating system
    - Historical data
    - …



Architectural Challenges

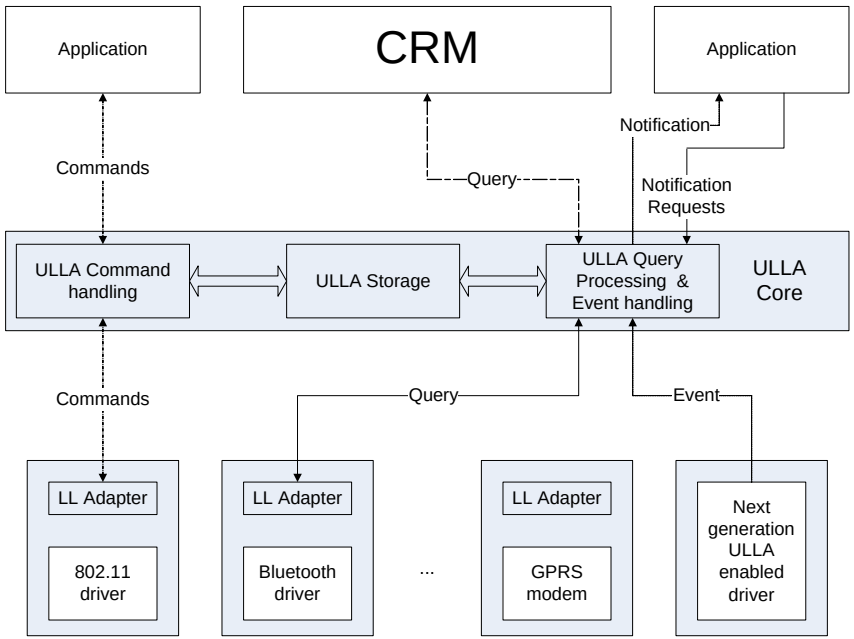
- The dynamic time-scales for different parts of the cross-layer optimization and machine learning are vastly different
  - There can be order of magnitudes differences on characteristic time-scales between Physical and Network layers
  - This includes also need to address scheduling in CRM
- The presentation, semantics and tools of phenomena can differ and need coordination
  - For example describing the policies for spectrum usage (e.g. XG-Policy Language) and radio environment measurements
- Overall handling the complexity in efficient way requires careful and modular architectural design and research for CRM.

CRM is modular



Technology enablers

- Well defined interfaces (APIs) towards the applications and the lower layers in the protocol stack.
- One example is the Universal Link-Layer API being developed by the GOLLUM project (www.ist-gollum.org).



Summary & the Future Work

- The poster discusses early research and directions towards future cognitive networking.
- Focus is put on a multi-dimensional resource optimization in the wireless networks using “cognitive” techniques.
- A high-level architecture of a Cognitive Resource Management framework (CRM) is introduced.
- The introduced work will continue in several directions:
  - Testing & evaluation of the optimization algorithms in the toolbox
  - Development of the required APIs
  - Coping with the large differences in the time-scales for the different processes in the different levels