The 4th Workshop of COST Action IC0902
Cognitive Radio and Networking for Cooperative
Coexistence of Heterogeneous Wireless Networks
October 9–11, 2013
Rome, Italy

Insert here "Contribution to WG2/SIG3"

On the development of a Cognitive Radio Network Simulator based on OMNeT++/MiXiM

Giuseppe Caso, Luca De Nardis – Sapienza University of Rome

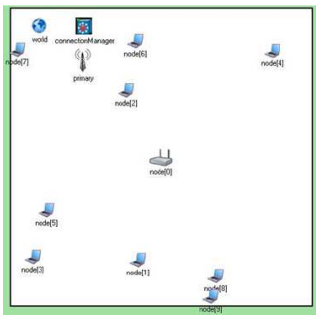
Giuseppe Caso – Sapienza University of Rome

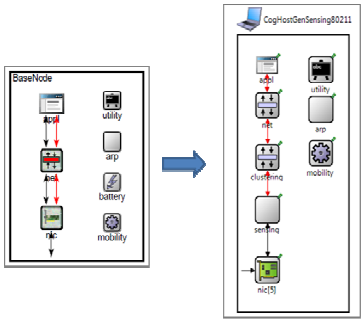
The broad term Cognitive Radio (CR) is often used as a synonym for Dynamic Spectrum Access (DSA) and it refers to a different way of thinking and researching about wireless communications, by improving via cognition many aspects of them. CR, built upon a Software Defined Radio (SDR), is a context-aware intelligent radio capable of autonomous reconfiguration by learning from and adapting to the communication environment, and it represents a very appealing concept in the wireless world. The final goal remains to form networks that (cooperatively) coexist with other systems and devices, in order to fulfill the need for intelligent and high-performance communication, taking care of the efficiency of overall spectrum utilization.
A widespread methodology for performance analysis and evaluation in communication systems engineering is network simulation. It is widely used for the development of new architectures and protocols. Network simulators allow to model a system by specifying both the behavior of the network nodes and the communication channels and CR-related research activities have been often validated and evaluated through simulation too. Following this approach, this work presents the ongoing efforts in our research in the development of a CR simulation framework, useful for the design and the evaluation of protocols and algorithms. OMNeT++/MiXiM was chosen as the developing platform, thanks to its open source nature, its modular architecture, the existing documentation, and the provided IDE. OMNeT++ (Objective Modular Network Testbed in C++) is a quite known tool for discrete event simulations, widely used, as examples, for traffic, protocols and complex communication scenarios modeling. Specific application areas are catered by various simulation frameworks. MiXiM (MIXed sIMulator) is a merger of several OMNeT++ frameworks for mobile and wireless simulations. It provides detailed models of the wireless channel and connectivity, mobility and obstacles models, and many communication protocols, especially at the MAC level. Furthermore, it provides a user-friendly graphical representation for the definition of complex scenarios. MiXiM allows every module in the simulation to be replaced by another modules, adding or overriding functionalities to the base implementation. The wide choice of available protocols provides, in terms of MAC layer, standard protocols for wireless LANs and PANs (IEEE 802.11b/g family and IEEE 802.15.4 standard, as examples). Moreover, for channel propagation models, Net Layer and Mobility, MiXiM already presents a rich library of useful modules. In general, the simulation environment describes a communication system with a variable number of hosts in a playground. Each host is an OMNeT++ compound module of simple modules representing, substantially, the layers defined in the generic ISO/OSI stack. While retaining the advantage of modularity of the chosen software platform, the ongoing work is focusing on the

development of the CR framework in terms of its most relevant characteristics. Concretely, some of the most important and peculiar CR functionalities were modeled and preliminary comparisons between analytical and simulation results confirm the reliability of the simulator. The design of the CR scenarios has started from a generic MiXiM scenario added with fundamental functionalities simulating peculiarities of the Primary Users (PUs) vs. Secondary and Cognitive Users (SUs) case of study:

- Introduction of particular hosts simulating the PUs;
- Introduction of the SUs, with cognitive functionalities in the OSI stack (particularly, the Spectrum Sensing capabilities and the Cognitive Engine for learning and decision making);
- Introduction of Multi-Channel possibility (if the scenario requires it);
- Introduction of network organization modalities (exchange and management of control information for the SUs, clustering capabilities, mobility management and so on).

In light of these requirements, the main design activities until now were focused on the introduction of OMNeT++ modules compliant with the required functionalities, as depicted in the following Figures:





The simulator was already used in network organization algorithms design and performance evaluation, since it is possible to define different scenarios by adjusting key parameters as PUs behavior, cognitive network features (number of SUs, Energy Detector-based Spectrum Sensing modes, mobility models), operating frequencies (also DVB-T), medium access modalities, propagation channel models, network types and topologies, and so on. Comparative analysis and the so-far obtained results regarding, in particular, 1) spectrum sensing performance (both local and centralized cooperative with different hard decision fusion rules, 2) the impact of mobility, 3) the impact of spatio-temporal correlation, 4) the introduction of cluster-based solutions for the network organization and nodes selection, 5) the effective achievable data throughput of the cognitive network in particular contention scenarios seem to confirm the reliability of the simulator and call for further efforts in the improvement of it by refining the existing characteristics and expanding possibilities and functionalities.