Composite Simulations for B3G Service and Network Management Platform

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Abstract

Assuming that different wireless technologies will be cooperating components of the future heterogeneous context, there is a need for designing new management platform in order to handle efficiently the use of the various access systems. This paper provides a high level description of such a management platform, validated by a prototype. This prototype includes two types of the simulation tools that were developed first for palliating the lack of real networks and secondly for being used within the optimisation process. The first simulator is dedicated to the simulation of the IP core network and is based on the well-known Network Simulator (NS) that have been modified. The second simulator represents the various radio access systems (UMTS, DVB, Hiperlan) and was developed over a radio planning software. Means to interconnect these two simulators between them as well as with the B3G management platform were provided.

Key Words: Simulation, NS, Heterogeneous systems, B3G.

1 INTRODUCTION

The wireless world is witnessing the convergence of different radio access networks around the IP technology. This convergence, often called “Beyond 3G” (B3G), is oriented towards the user for whom the access to different and novel services should be easy and transparent.

However, for properly allocating the radio and core network resources, the network operator should take into account several parameters. Because of the heterogeneity of the wireless technologies, management actions should be properly assessed before their real application into the networks. For that purpose, advanced management platforms should be developed. These platforms will necessarily include simulators engines in order to help finding the most appropriate management actions.

This paper presents a management platform prototype developed within the framework of the European project MONASIDRE [1], with an emphasis given on its simulation tools. Two different tools were considered and bridged together: one specific to the radio aspects and another adapted to the core network. It was possible to reuse existing tools, such as the Network Simulator (NS) [2], after modifications, leading to a considerable gain in terms of development and validation time.

The paper is organized as follows. The first section draws the context of the management platform. Then requirements on the simulations of the prototype are given followed by a description of the simulation components. Finally, the last section provides an example with the results that could be obtained with this platform.

2 A MANAGEMENT PLATFORM ADAPTED TO B3G SYSTEMS

Wireless communications continue to attract immense research and development effort. From a technology perspective, the main evolutions are the enhancement of mobile cellular infrastructures towards the 2.5G/3G, the introduction of Broadband Radio Access Networks through the development of mobile computing and Wireless LAN, and the advent of Digital Video Broadcasting (DVB). Instead of making these standards compete, the B3G convergence trend encompasses all the wireless standards and leverages on their differences. A B3G system coordinates different radio access techniques to offer advanced experience for users. Through this composite infrastructure, a network operator is able to provide to final users a more efficient wireless access to broadband IP-based services.

This convergence trend leads to an evolution of the requirements from the different wireless world actors: the users, the service providers and the network operators. These requirements have been identified and collected [1] and were the starting point of the development of the service and network management platform described here. A summary of the high level requirements is given below:

- *Final user*. Transparent and easy access to services and content. QoS and availability enhancement.
- *Service provider*. Unified interface with network operators, so as to ease the management of Service Level Agreements. Possibility to adapt the content accordingly to available resources.
- *Network operator*. Simple and efficient exploitation of its heterogeneous infrastructure. Scalability and easy evolution of the platform. Possibility to plug new radio interface.

From these requirements the management platform specifications were derived. Two layers were defined. The first one is independent of a specific radio access technology

(RAT); it allows for instance interaction with the service provider, as well as communication between different platforms. It also acts as a resource broker to offer the possibility to accept or move traffic from/to another network operator. The second layer is technology-dependent and the components have been derived into Cellular, WLAN, DVB-T, and Core IP versions.

In addition, there is two kinds of functions needed in the management platform: the first one is related to communication, i.e. gathering data, enforcing management action, answering to requests, communicating with other platforms. The second kind of function is obviously dedicated to optimisation, providing the most appropriate management configuration in order to serve the services taken into account the current and forecast networks status.

As a result, a B3G management platform should comprise the following elements:

- Inter-platform communication and service provider interworking: MASPI-RATIP (Monitoring and Service Provider Interworking, RAT Independent),
- Communication with network elements: MASPI-RATD (RAT Dependent),
- Optimisation and resource partitioning: RMS-RATIP (Resource Management Strategies),
- Optimisation to find the appropriate configuration of a specific RAT: RMS-RATD.

It is noted that this architecture allows the possibility to introduce later new resource management strategies. The proposed management platform can be seen as an open platform, providing a skeleton from which any network operator can plug its own management strategy. Figure 1 represents the architectural decomposition showing only the functions directly linked to the management

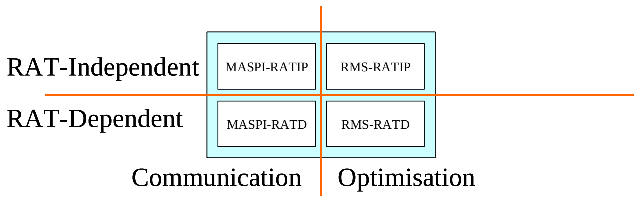

Figure 1. Management platform architecture

3 Platform Prototype

For the prototype development, all these blocks have been developed separately. Of course, for the dependent part, a block per radio technology has been developed, plus one for the IP part. These blocks could be located anywhere in the network operator domain to form a B3G management platform. In fact, these blocks are interconnected thanks to a CORBA bus while the communication between a platform and the outside world uses only standard protocols: HTTP for the communication between the platform and the service provider and COPS for the communication between the platform and the managed network elements, for the configuration flows. Regarding the monitoring, instead of using a real SMNP agent for gathering information coming from the simulators, simple sockets or direct requests to the databases storing the simulated events are used. Figure 2 details the communication flows within a B3G management platform, depicting the CORBA, COPS, SQL requests and sockets as well as the main interactions.

The components run over Linux or Windows indifferently. The motivation of the technology choices for building the prototype (CORBA, COPS, SQL, etc…) are not in the scope of this paper, an interested reader could further consult [1].

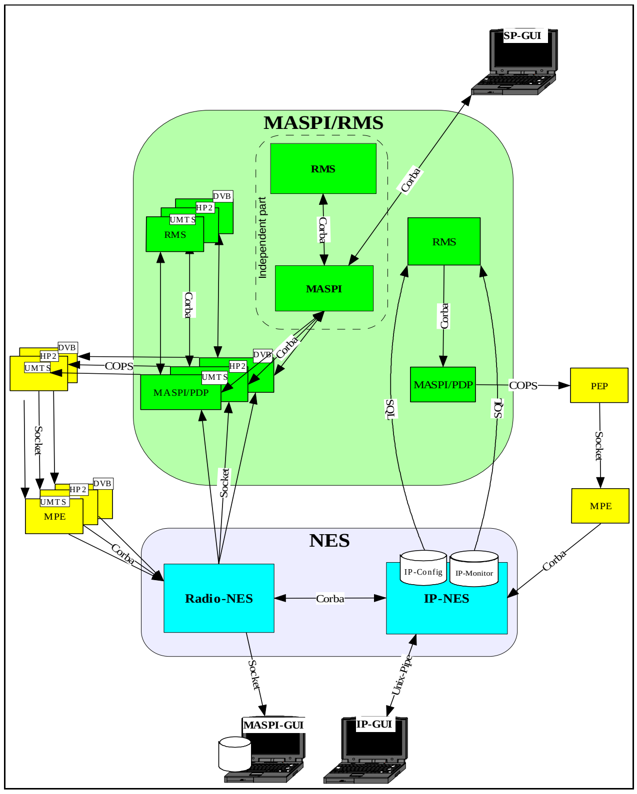

Figure 2. Prototype platform

4 Simulations in the B3G Management Platform

The role of the Network and Environment Simulator (NES) component is:

- To palliate the lack of large-scale experimental testbeds. When the prototype was developed, there were little even no commercial 3G or digital broadcast systems covering a same area. It was necessary to emulate such networks for validating and demonstrating the prototype,
- To allow network operator to simulate the effect of management actions prior to their application to the real networks. The simulators could help the platform finding the most appropriate set of management actions in the context of composite radio systems.

For both applications, the NES must interact with the rest of the platform as close as possible to the way the platform will interact with real networks. This requirement has lead to the use of standard protocols for communication between the management platform and the NES.

Moreover, the NES should be able to represent the various aspects of the considered radio systems: UMTS, DVB and WLAN, as well as the core networks. It is assumed that all these radio systems have a similar core network based on traditional IP networks or are directly connected to a public IP network.

Consequently, four kinds of simulation must be developed: one dedicated to the IP segment and three others simulating the radio part of the cellular, broadcast and WLAN systems. Even if these three systems are different, they could be based on a similar core simulation engine. The IP simulator is more classical and should allow emulating the router management, following different QoS strategies.

Thus, two basic simulator engines were considered: one dedicated to the radio systems (Radio-NES) and the other for the IP network (IP-NES). The radio simulators were based on the same engine, with different parameters and ran as different processes. On the other hand, there was only one simulation process for the various core networks, but with separate management domains.

At last, instead of developing from scratch the engines, some existing software was adapted. NS was considered for the IP part, and radio-planning software inherited from other projects [4] was a starting point. Modifications were necessary to adapt the softwares to the specific needs of the platform. The issue was to make the two discrete event simulators communicating together without loosing their internal time/event representation. Moreover, any simulated data communication must be derived in the two simulators, generating linked events.

For that purpose, a master/slave concept with a pseudo-time synchronization of the two simulators was considered. The IP-NES was the slave of the Radio-NES: the calls were generated/terminated by the Radio-NES, leading to the creation of the corresponding event in the IP-NES, for uplink and downlink calls.

The Figure 3 represents the NES overall architecture, showing the basic components: the IP-NES and the 3 types of Radio-NES, each one corresponding to a particular RAT.

To allow the IP-NES executing on demand request from the Radio-NES and/or the B3G platform, it was mandatory to modify NS that is originally script-based: the simulation to be executed is theoretically described in advance in a script file. Then, the outcome of the simulation is written in another file that can be played back in a visualization software, Network Animator (NAM) [3]. This way of running the simulation implies that the simulator user knows in advance the lists of events to simulate. It also implies that neither modification of the network topology, management action or unscheduled traffic is allowed during the simulation. In order to overcome this limitation, NS was modified to allow external interactions when simulation is running. Several “input pipes” have been added in which commands can be inserted during the simulation, as depicted in the Figure 4.

Similarly, NAM has been modified to allow "real-time" visualisation of the IP-NES. For that purpose, a pipe mechanism has been added to NAM that feed the visualisation tool with the events to be shown.

Regarding the visualization of the Radio-NES part, a specific GUI written in Java was developed, showing in "real-time" what happened in Radio-NES. The synchronization between the visualization interfaces was ensured by the intrinsic synchronization between IP-NES and Radio-NES.

5 Example of Use

The following scenario illustrates how the B3G management platform could work: a service provider (SP) has a commercial agreement with a cellular operator, and this network operator owns WLAN access points in some dense areas of its cellular coverage and made a cooperation agreement with a DVB-T operator.

This sample scenario has been validated with the prototype, leading to capacity improvement when the different radio systems cooperate. Detailed information on the B3G management platform could be found in [5] while performance results are captured in [6].

The prototype, including the simulation tools demonstrated its ability to handle SP requests as well as to react dynamically to congestion events that could occur in any wireless systems. The simulation tools embedded in the platform allows reaction time in average below five minutes. Such reaction time is largely compatible with the objective of semi-dynamic performance management of the B3G platform.

6 Conclusion

Current trend of wireless systems is convergence, or at least cooperation between complementary types of access. As a result, WLAN access is used in urban dense areas to reduce the load of cellular systems. Similarly, digital broadcast is foreseen to provide efficiently broadcast/multicast IP services. In order to manage efficiently the use of these various radio access systems, new management platforms should be designed. This paper provides a high level description of such a platform, validated by a prototype and using simulation tools first for palliating the lack of real networks and secondly for being used within the optimisation process. Instead of developing a proprietary unique tool, the paper presents the interconnection of two simulators, one dedicated to radio environment that could be derived for representing the various radio access systems. The second simulator is dedicated to simulation of IP networks and was built on the public NS software. Our approach leads to efficient simulations that allow dynamic response of the B3G management platform prototype when facing congestion event or simple requests from service provider.

7 REFERENCES

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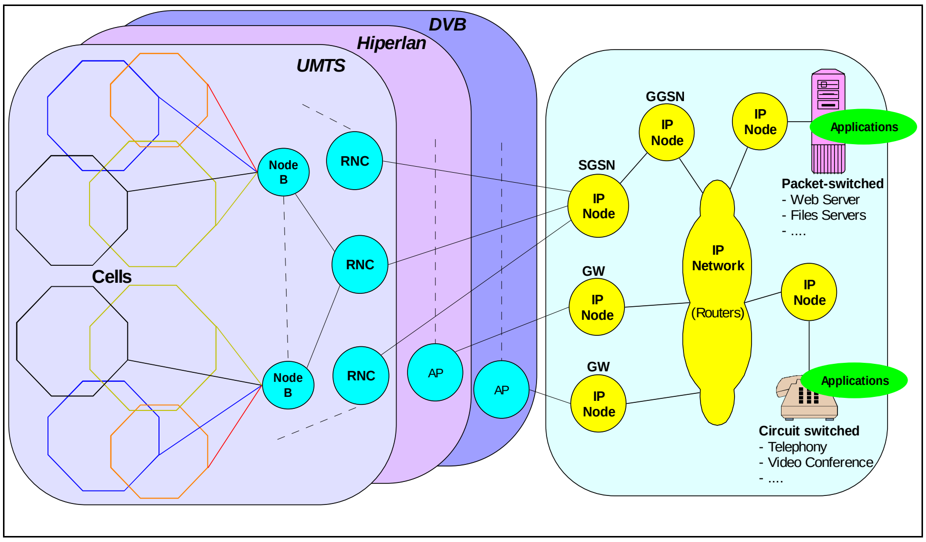

Figure 3. NES overall architecture

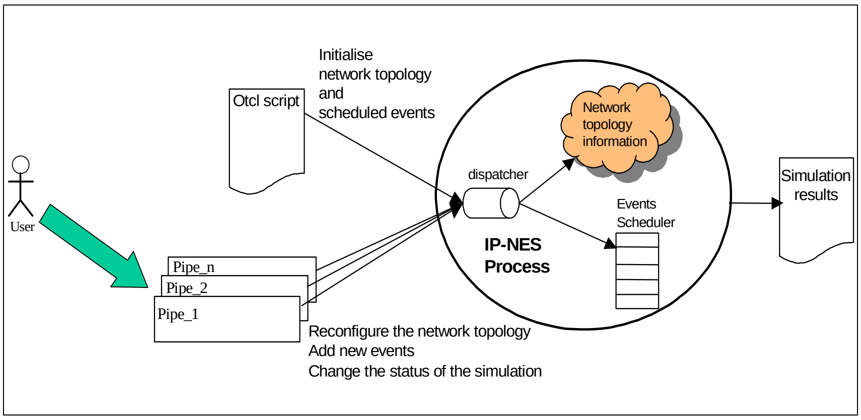

Figure 4. Modified NS architecture