Dependability Provisions for a Network Management Platform

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1 Introduction

Wireless communication systems are moving towards a new era, where information technology and communications are approaching the same goal. This goal can be summarized as communication *anytime*, *anywhere*, and "*anymedia*" where new applications demand for higher and higher data rate.

The recently started European IST project CAUTION++ [1] aims to build a capacity and network management platform for increased utilization of present and future wireless systems. The challenge of resource management and mobility support in multiple radio environments, pursued by CAUTION++, unavoidably results in a higher system complexity that deserves special attention. The implication is that issues concerning the dependability of the subsystems composing the CAUTION++ environment need to be explicitely addressed. In fact, behavior correctness, reasonably attained when dealing with simple system components, becomes hard to achieve when complex functionalities are introduced, which have to cope with a variety of external and internal system behaviors.

Work is currently in progress on the identification of relevant dependability requirements for CAUTION++ architecture, and in initial setting up of appropriate architectural solutions for the CAUTION++ most critical components. In Section 2 the logical architecture of CAUTION++ is presented, while the related dependability issues are discussed in Section 3.

2 CAUTION++ Project Framework

The main objective of CAUTION++ is the smooth transition from existing wireless systems to new generation ones. This is pursued by designing and developing a novel, low cost, flexible, highly efficient and scalable system able to be utilized by mobile operators to increase the performance of all network segments. Different segments can use different technologies and radio access. CAUTION++ exploits the available system resources in that way to enable real-time monitoring, alarming, immediate adaptive application of RRM (Radio Resource Management) techniques, vertical handover to other systems (possibly of other operators) having as a major goal to optimize the systems increasing operators' revenue and users' satisfaction.

CAUTION++ will exploit knowledge and system platform developed under the framework of CAUTION project [2] and extend this to UMTS (Universal Mobile Telecommunication System), WLAN and systems beyond. In CAUTION, an architecture which is based on the concept "monitor and manage" is developed to support systems of present generation. All resources at the air-interface are monitored and a centralized resource management subsystem receives alarms from the distributed monitoring components, so that a set of management techniques is selected and applied where needed. In CAUTION++ this is extended to include next generation wireless systems. The decisions-making process is performed at two levels: a local resource management in charge of managing the capacity of a each single network and a global resource management, which is in charge of inter-network coordination for the sake of the overall optimization of network capacity.

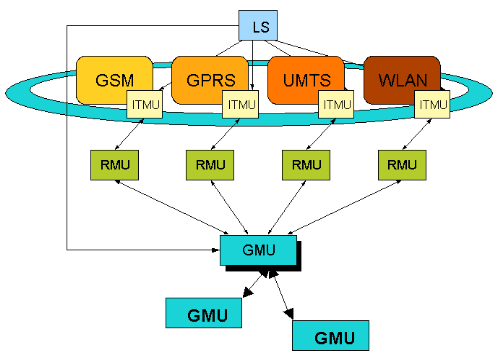

Figure 1: CAUTION++ architecture

Figure 1 shows the main components of the CAUTION++ architecture. Each network segment (i.e. GSM, GPRS, UMTS, WLAN) has its own ITMU (Interface Traffic Monitoring Unit) and RMU (Resource

Management unit) which allow to monitor and manage the attached network, respectively, as in the CAUTION project. Within each operator network, a GMU (Global Management unit) can perform a global optimization. Different GMUs cooperate to extends the optimization opportunity among different operators. A Location Server (LS) can be used to track users' mobility and location: such information can be exploited by GMU for a global optimization.

3 Dependability Issues in Caution++

The main goal of Caution++ is to design and implement a scalable system that will monitor all available resources from a set of wireless communication networks for the sake of systems' management and interworking. Caution++ is superimposed over existing wireless networks, which have already their own telecom-grade dependability requirements, and proper means in place to comply with them. It is reasonable to expect that the dependability of the whole interconnected system created by Caution++ would be not worse than that of component networks, for otherwise the goal of better service would be missed.

Therefore, the most important and challenging dependability requirements on the CAUTION++ architecture is to prevent RMU and/or GMU from carrying out a reconfiguration action wrongly or when is not necessary (as consequence of some fault). Indeed, a FMEA analysis [3] helped to understand the connections among the possible kind and severity of faults affecting the system and its failure modes. Particularly, omission failure can be tolerated while emission failure can lead the system to act worse than doing nothing. In accordance with the desired final dependability figures, several design solutions seem appropriate to fulfill such general dependability requirement, spanning from applying error detection mechanisms coping with incremental sets of relevant fault types, to the enforcement of full self-checking behavior, e.g. through full replication and comparison.

The achievement of the overall dependability is a combination of two main aspects of Caution++ system. At one side we are concentrating on the dependability issues concerning the capabilities of the Resource Management Techniques (RMT) which are built on top of the distributed Caution++ architecture. At the other side, we consider the architectural aspects of Caution++ which should allow supporting such capabilities.

3.1 Model-based evaluation for design

The Caution++ architecture should allow putting in place correctly the identified RMT, hopefully despite the occurrence of faults. Thus, the design of the CAUTION++ architecture necessitates verification activities to be performed as soon as possible since the early phases of the design process, in order to justifiably trust the identified solutions and to make appropriate choices among several possible alternatives. Model-based validation is promoted inside the CAUTION++ framework to this purpose. Both analytical and simulative models will be pursued, as a support to the verification of the adequacy of the envisaged solutions with respect to the imposed requirements, and to guide the refinement process necessary to improve on deficient choices.

3.2 Model based evaluation for decisions making

Besides its usage as a support to the design activities, the model-based evaluation technique will be profitably employed as a support to the decision-making process performed by the RMU or GMU subsystems. In fact, in order to properly calibrate the reaction to the specific alarm situation signaled by the ITMU and to optimize resource assignment, quantitative assessments of the benefits deriving from applying a certain answer is very important. Particular emphasis is placed on the transient period following a decision. During this period, performance can be temporarily worse than before the reconfiguration, but it should be better when the system reaches the new steady state. However, it is an important issue to evaluate pointwise performance to prevent that it degrades under a given acceptable level and to measure the time to reach the expected steady-state effect. Indeed, these are key factors which should be taken into account in the decision making process.

Such evaluation activities could be performed both off-line, with the obtained results stored in the system database to be retrieved when necessary, and, to some extent, on-line, e.g. to better cope with unforeseen situations, for which adequate solutions have not been yet completely identified. Of course, on-line evaluation is possible to analyze reasonably simple behaviors (for real-time reasons), and provided that spare resources are available in the system. Actually, such on-line activity could be supported by both dedicated resources, and resources not specifically devoted to it when under-utilized for their main purpose (e.g., during time intervals when the network is less used, as during the night).

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