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Dependability and Performance Analysis of a Protocol for Efficient Real-time Group Communication

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The development of distributed applications has already reached a good success both based on the Internet and the Web and on mobile networks that allow a very high connectivity. There is a clear need to define new computational and structural models to allow users, programmers and designers of such applications to reason at the proper abstraction level. Another very important problem consists in guaranteeing the proper quality of service (QoS) as required by applications. QoS can be defined as a set of qualitative and quantitative characteristics of a distributed system which are necessary for obtaining the required functionality of an application. Therefore the term QoS encompasses many aspects such as reliability, availability, fault tolerance and also properties such as reliable or atomic broadcast/multicast.

To achieve a real-time reliable group communication in wireless local area networks is a hard task. The mobility of the system components has a direct effect on the definition of a co-operative group and the hostility of the environment produces a great loss of messages. In this context, a protocol able to tolerate erroneous and uncooperative behaviour of the system components is required. In order to plan future co-operating actions, the protocol must dynamically detect which of the mobile autonomous systems currently form a co-operative group, and it must provide the group with a consistent view of its state.

A proposal to achieve these goals is represented by the protocol defined in [1], which is based on an extension of the IEEE 802.11 standard for wireless local area networks. The standard provides the basic means for the implementation of a real-time communication protocol via a centralised medium arbitration. It is obtained with a central co-ordinator that regulates the accesses of all the system units thus avoiding the problem of contentions. In order to account for the high number of message losses in such environment, the standard has been extended according to some specific fault assumptions (like the maximum number of consecutive message losses), so to achieve an atomic delivery of broadcasted messages. Another interesting feature of this protocol is the possibility to have a trade-off between different aspects of the QoS offered such as performances, delay time, formal properties of the broadcast and reliability properties. Actually, according to the different assumptions that can be made on the environment and on the protocol characteristics a family of protocols can be devised, with different quality of service offered.

It is clear that the usefulness and practical utilisation of such group communication protocol depend on the possibility to provide a QoS analysis of the protocol properties, in terms of proper defined dependability and performability related measures. This is a necessary step for the early verification and validation of an appropriate design, and for taking design decisions about the choice of the most rewarding protocol to employ when building a system, in relation with the user requirements.

Our approach for contributing towards this objective is through analytical modeling and evaluation of the protocol (family) and of the environment, focusing our attention on performance and dependability attributes. This approach to quantitative analysis provides a fast, cost-effective, and formally sound way to further analyse and understand the protocol behaviour and its environment. The performance analysis is intended to determine the technical limitations imposed by the communication system and the way the

protocol behaves according to them. Representative figures to evaluate will be: throughput, the average number of lost messages, and the average number of retransmission of the same message. The dependability analysis will be mainly directed to assess the coverage of the assumptions at the basis of the protocol (i.e., the maximum allowed number of omission faults that may affect a message). This way, the performance of the selected protocol and the coverage of the assumptions can be evaluated for different environmental envelopes.

[1] M. Mock, E. Nett, and S. Schemmer. *Efficient Reliable Real-Time Group Communication for Wireless Local Area Networks*. In Proc. of the 3rd European Dependable Computimg Conference, Prague, Czech Republic, 1999.