ABSTRACT

The simulation technique is of primary importance in the design, implementation and performance evaluation of many real world systems. Many tools used for the simulation of wireless networks have a monolithic design and implementation in a single execution unit manages the evolution of the whole simulation. Mainly due to memory constraints and the excessive amount of time required to complete the simulation runs, the approach based on a single execution unit is unable to fulfill the scalability requirements imposed by the simulation of large-scale wireless networks. An alternative approach is based on Parallel and Distributed Simulation (PADS), in which a set of execution units is in charge of the evolution of the simulation. Research work has been done in the field of synchronization and data distribution management (DDM) to reduce the communication overheads, increasing the PADS speed-up with respect to the monolithic approach. The main advantage of PADS approach is the aggregation of memory and computational resources by an execution architecture composed of many Physical Execution Units (PEU). The availability of many PEUs can reduce the bottleneck due to the computation requirements, but communication in a distributed system is order of magnitude slower with respect to a single execution unit. The main goal of this work is to demonstrate that large scale wireless network can be efficiently simulated following the PADS approach; specifically tailored techniques can improve the communication efficiency and therefore increase the simulation speed. Finally, using appropriate load-balancing schemes it is possible to exploit massively distributed execution architectures composed of low cost hardware for the simulation of very large-scale wireless networks.

The Advanced RTI System (ARTIS) is a middleware for parallel and distributed simulation, specifically designed to support high degree of model scalability and execution architectures composed of a large number of PEUs. The design of the Generic Adaptive Interaction Architecture (GAIA+) load-balancing mechanism is based on a distributed scheme: each Logical Process (LP) in the simulation collects the useful information from other LPs, creates a local representation of the distributed system and reacts in presence of imbalances. Simulation based Performance evaluatoR (SPR) Framework is based on the parallel and distributed simulation approach and provides high scalability in terms of size of simulated networks and number of execution units running the simulation. Their aim is to reduce the communication overhead and to maintain a good level of load-balancing. The framework
dynamically reconfigures the simulation, taking care of the performance of each part of the execution architecture and dealing with unpredictable fluctuations of the available computation power and communication load on the single execution units.

**SPR**, a Wireless Network Simulator model is a new library composed of models and auxiliary functions, specifically designed and implemented to simplify the simulation-based performance evaluation of large scale wireless networks. The Logical architecture of the distributed simulator is the stack-based framework of the wireless network simulator. In the top **SPR** models the wireless network, the middle layer is the GAIA+ framework that provides functionalities to reduce the communication overhead and to manage load-balancing in distributed simulation. The core of the simulator is the Advanced RTI System (ARTIS) middleware, the main goal of the runtime is to provide an efficient and easy to use environment for parallel and distributed simulation. **SPR** contains a new detailed model of the MAC 802.11 DCF protocol that has been used for the performance evaluation. The model has been implemented in JAVA language and has been designed to comply with the GAIA+ migration-based programming paradigm and the PADS requirements. The scope of this work is to evaluate performance and scalability of the distributed simulator. Under the distributed simulation viewpoint this translates to extremely frequent synchronizations and therefore a very high communication overhead.

The simulator is evaluated in presence of different configurations and execution architectures. Initially, the testbed used in the performance evaluation is described. In complex propagation, mobility and application models would have increased the amount of computation required to complete the simulation runs, without significantly increasing the synchronization overhead. Next, the scalability results obtained by the simulator while disabling the GAIA+ framework, by allowing the **SPR** model to interact with the ARTIS middleware is described. It was shown that increasing the number of PEUs consequently increases the heterogeneity of the execution architecture. Then, the GAIA+ framework was turned ON and evaluated the impact of the communication overhead reduction and load-balancing mechanisms on the simulator and proved that dynamically adjusting the number of SMHs allocated in each LP, GAIA+ obtains a more uniform system, in terms of execution speed. Finally, it was concluded that it is possible to build detailed simulations of very large scale wireless networks, using a large number of PEUs. The migration of the simulated entities can reduce the communication requirements of
distributed simulations and concurrently improve the load-balancing in the execution architecture.