Chapter 7
Architecturing Resource Aware Sensor Grid Middleware:
Avoiding Common Errors in Design, Simulation, Test and Measurement

Philipp M. Glatz
Graz University of Technology, Austria

Reinhold Weiss
Graz University of Technology, Austria

ABSTRACT

Resource aware sensor grid middleware is subject to optimization of services and performance on one side and has to deal with non-functional requirements and hardware constraints on the other side. Implementing different applications and systems on different types of hardware and architectures demands for sophisticated techniques for modeling and testing. This chapter highlights common misconceptions in design, simulation, test and measurement that need to be overcome or at least be considered for successfully building a system. Rules of thumb are given for how to design sensor grids such that they can easily be simulated and tested. Errors that are to be expected are highlighted. Several practical issues will be discussed using real world examples. A sensor grid utilizing network coding and duty cycling services serves as an example as well as a multi-application middleware and a localization system. The approach shows how to implement performance optimizations and resource awareness with a minimum of negative impact from mutual side effects. This type of view on system development of sensor grids has not been looked at before in detail. Therefore the reader will get valuable insights to state of the art and novel techniques of networking and energy management for sensor grids, power profile optimization, simulation and measurement and on how to translate designs from one stage to another.

DOI: 10.4018/978-1-61350-113-9.ch007

INTRODUCING THE COMBINATION OF GRID MIDDLEWARE AND WIRELESS SENSOR NETWORKS FOR PERVASIVE SERVICES

Computing anything, anywhere at any time as envisioned by Weiser (1991) gives a good specification for what is targeted by ambient computing technologies. The challenge when setting up such ubiquitous systems is twofold. First, functional constraints need to be satisfied for providing services at a given Quality-of-Service (QoS) or for achieving a given end-user performance in terms of throughput or sampling rate. Second, a suitable technology needs to be selected and integrated for setting up the system satisfying non-functional constraints like ambient integration or low power operation.

For achieving a cost efficient solution one needs to apply suitable modeling techniques, simulation environments and pre-deployment characterization using modeling, simulation and testbeds for the chosen technology. Yick et al. (2008) and Akyildiz et al. (2002) have presented surveys on Wireless Sensor Network (WSN) technology. Using WSNs as an enabling technology for Pervasive Computing, services can be provided by means of sensor grids (Lim H.B. et al., 2005). Tham and Buyya (2005) give an example of a hierarchically organized sensor grid using Mica2 motes. These motes have been introduced by Hill and Culler (2001) and will serve as target technology in this chapter as well. Though novel platforms have been introduced like TelosB and others Mica2 motes provide a valid platform for planning and implementing development and deployment techniques and different kind of optimization. An example for how to implement the technique called low power listening on the different platforms has been shown by Moon et al. (2007).

Similar to the twofold structure of the challenge, the approach presented in this chapter will take two perspectives as well. On one side, functional constraints for sensor grid services will be discussed. A middleware layer will be presented considering two often used communication paradigms. It will be designed and optimized suitable for worst case assumptions in the middleware, the networking and the Media Access Control (MAC) layer. Functionality will be tested using modeling and simulation-based approaches.

On the other side WSN hardware will be discussed. Its implications for the maximum end-user performance that can be achieved will be related to the MAC layer and Power State Models (PSM) as well as higher level protocols' impact on the energy balance. Instead of only running simulations, the main aspect will be on how measurement systems and testbeds can be set up.

Chapter Objectives

Both ways mentioned need to be combined for arriving at a complete analysis of a sensor grid prior to deployment. Apart from introducing and discussing novel and state of the art solutions for different levels of abstraction a main focus will be given on modeling, simulation, measurement and test errors. Functional and non-functional properties of the system may experience different kinds of errors. We give a novel description of how to avoid or at least recognize these errors and compare different errors' impacts.

Especially for WSNs the modeling of the wireless channel is a tough challenge. Usually, accurate characterization of wireless scenarios can only be done using in-network measures when the system has been deployed. We will introduce and discuss means of modeling scale dependent issues in laboratory sized environment and discuss its implications on errors when profiling testbeds compared to online characterization of deployments. Figure 1 gives an overview of different levels of abstraction that are used in the chapter. Environmental conditions will be considered as far as energy harvesting is considered. Power supply issues are the main issue then as are how the energy reservoirs are impacted by power dissipa-