Optimizing Component-Oriented Systems: A Case Study in Wireless Sensor Networks

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ABSTRACT

In this demonstration we describe a systematic design process and a corresponding software system for automated planning, optimization and configuration of wireless networks according to user-specified scenarios and requirements. As an example we consider wireless sensor networks, but this methodology is also applicable to other kinds of networks. Using service-oriented approach the framework automatically "wires" components to generate a stack of components chosen from a wide variety of available software modules in order to maximally fulfill the user requirements. To reach a decision the system utilizes rule-based knowledge base reasoning, utility-based optimization, meta-heuristics and self-learning. After the network deployment the performance is further fine-tuned using a simplified version of the mechanisms employed at the pre-deployment stage. The run-time optimization includes both component-level parameter adjustment and cross-component manipulations. The presented system can be extended to optimize the performance of the network not only by choosing and configuring software modules, but also by altering the network topology.

Categories and Subject Descriptors: C.2.1 [Computer-Communication Networks]: Network Architecture and Design – *Wireless communication, Distributed networks*

General Terms: Algorithms, Design, Management

Keywords: service-oriented, run-time optimization, pre-deployment configuration, wireless sensor networks

1. DESCRIPTION

The advent of service and component-oriented architectures with capabilities for dynamic reconfiguration is enabling new levels of flexibility in both wireless and wired environments [1]. We describe a systematic design process and a corresponding tool for autonomous network composition, configuration and optimization. The developed *extensible component-oriented* software system is capable of initial off-line *pre-deployment configuration* and further *runtime optimization* of a wireless network according to *quantifiable* performance metrics.

First, a pre-deployment configuration tool is used to find and deploy the most promising services and related software components on network nodes. Later, at runtime, the network is further fine-tuned to operate more optimally in the changing network conditions. The tool does not rely on static pre-defined evaluation of network components, rather the components are evaluated at runtime and the evaluation data is fetched back to the tool enabling self-learning. Analytical performance estimates can be used to bootstrap the process. We use wireless sensors networks as an example of a component-oriented network. The tool is implemented and runs using Visual Studio (C#), Microsoft SQL Server, TinyOS 2.x and UDAE [3].

Both parts of the system evaluate user satisfaction using a *utility/objective function* that directly depends on major network *attributes*, like delay, reliability and lifetime, which are influenced by all the components forming the stack [4]. The attributes are in turn dependent on *parameters* which are directly adjustable module variables, like the maximum packet size. The value of the utility function also depends of the network configuration and topology. The user specifies the desired services, the initial network topology, as well as the hardware and software platforms, the constraints on the basic network attributes and the form of utility functions. Additionally a list of considered software modules, their detailed description in form of metadata [2], and data on their performance has to be stated. A set of allowable component wirings can be defined as well.

The present implementation of the software supports only uniform configuration of nodes and currently we are working on the support of heterogeneous network environments. We plan to extend our software to support software defined radios (gnuRadio) development and do a open source release of the software.

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2. REFERENCES

[1] V. Bahl *et al.* Towards highly reliable enterprise network services via inference of multi-level dependencies. *SIGCOMM Comput. Commun. Rev.*, 37(4):13–24, 2007.

[2] E. Meshkova *et al.* An Extendible Meta-Data Specification for Component-Oriented Networks with Applications to WSN Configuration and Optimization. In *Proc. of IEEE PIRMC*, Cannes, France, September 2008.

[3] K. Rerkrai *et al.* UDAE: Universal Data Access Engine for Sensor Networks. In *Proc. of IEEE SECON*, San Francisco, USA, June 2008.

[4] S. Shenker. Fundamental design issues for the future Internet. *IEEE JSAC*, 13(7):1176–1188, 1995.