

Cross-Layer Design for Wireless Sensor Networks: Within the Context of the Optimization Agent Framework

I. Introduction:

Recent work in wireless sensor networks (WSNs) has led to increasing utilization across a broad range of applications. For this reason, they are a very active and rich field of research. One of the fundamental concerns is network lifetime, due largely to the fact that each node operates with an extremely limited energy supply. It is imperative that the trade-offs between the purpose of the network – some form of data-gathering and reporting – and its lifetime are balanced carefully.

One of the major roles in each node is the communication protocol, both in terms of the functionality and lifetime/energy consumption of the network. Historically, WSNs were designed with communication systems adhering to the standard OSI model. Researchers quickly discovered that when OSI architectures and the extreme limitations of wireless sensor networks are combined, both the network performance and lifetime are compromised. As a result, researchers have proposed many optimizations to WSN protocols which violate the terms of the OSI model. These proposals and implementations have generally been termed “cross-layer design (CLD)” [1].

II. Statement of the Problem:

As applied to WSNs, once the OSI layer boundaries become unfixed and permeable, there are optimization opportunities between nearly every layer of the model. A number of general approaches to CLD, often called “Cross-Layer Frameworks,” have been proposed, with none gaining widespread acceptance. Some of the proposals go so far as to abandon the OSI model entirely [1]. One more familiar-looking proposal is the optimization agent (OA) approach proposed in [2], which essentially adds intelligence to the OSI model through an agent which has bi-directional links with some or all “standard” OSI layers. The definition of this optimization agent and how to properly design it is unclear and seemingly closely related to the specific application of the WSN.

III. Purpose & Methodology:

Problems associated with each layer can generally be related back to the network lifetime. As an example: nodes providing too much information to the central collector leads to packet collisions, more transmission attempts per packet, and as a result, shorter lifetime. The OA framework offers a clean and potentially flexible baseline for evaluating general CLD techniques. It resembles the familiar OSI model and therefore aligns itself well with many of the current proposals. Within the context of this framework, I plan to conduct a literature review of CLD techniques ranging from application down to physical inter-layer proposals. Some such techniques at various layers are proposed in [3] [4] [5].

For each proposal, I will attempt define the optimization parameters, in terms of the involved layers and the network lifetime considerations and fit them into the OA framework. Defining these careabouts in terms of the framework for each proposal will lead to a clearer understanding of the optimization opportunities for CLD and the effectiveness of the OA framework in describing these CLDs, as well as potential avenues for future research.

Time permitting, I will formulate a specific example of a data-gathering WSN and describe CLD opportunities in terms of the OA optimization framework.

IV. Timeline:

10/23/09	Research Proposal Due
10/23-10/31	Continue Literature Review
11/1-11/16	Draft Definitions within the OA Framework for each proposal, and identify shortcomings of the framework / Create example (time permitting)
11/17-11/24	Write first draft
11/25-12/1	Revise & Complete Research Project
12/04/09	Research Project Report Due

V. References:

- [1] Srivastava, V. and M. Motani. "Cross-layer design: a survey and the road ahead." *Communications Magazine*, IEEE 43 (2005): 112-119.
- [2] Su, W. and T.L. Lim. "Cross-Layer Design and Optimization for Wireless Sensor Networks." *ACIS International Conference on Software Engineering*. 2006.
- [3] Hyun Jung Choe, Preetam Ghosh, Sajal K. Das, "Cross-layer design for adaptive data reporting in wireless sensor networks," *percom*, pp.1-6, 2009 IEEE International Conference on Pervasive Computing and Communications, 2009
- [4] X. Lin, Y. Kwok, and H. Wang, "Cross-layer design for energy efficient communications in wireless sensor networks," *Wireless Communications and Mobile Computing (Wiley)*, February 2008. [Online]. Available: <http://dx.doi.org/10.1002/wcm.608>
- [5] O'Neill, D.; Goldsmith, A.J.; Boyd, S., "Cross-Layer Design with Adaptive Modulation: Delay, Rate, and Energy Tradeoffs," *Global Telecommunications Conference, 2008. IEEE GLOBECOM 2008. IEEE*, vol., no., pp.1-6, Nov. 30 2008-Dec. 4 2008