Poster Abstract: A declarative approach for Hierarchical-organized Wireless Sensor/Actor Network

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Abstract *– The paper is focused on the convergence of WSN and Artificial Intelligence provided by complex infrastructures and related information model. Main goal is the increasing of abstraction level during both design and implementation steps and the increasing of efficient self-management ability for systems in accordance with a certain policy (eventually adaptive) typically oriented to resource optimization.*

Index Terms - Wireless Sensor/Actor Network, Network design, Context–Aware Systems, Artificial Intelligence.

I. Introduction

A WSN model provided with a certain level of Artificial Intelligence is sure a very attractive research issue that could improve, in determinant way, some central aspects of WSN directly or directly related to self-management/organization in function of certain central/local control logic, eventually adaptive. Actually, the main limitation in this sense is represented by sensor hardware: even if very advanced by all point of views [5], actually low cost sensor nodes can be considered as inadequate to work directly using a PROLOG-like interpreter. Advanced systems [1], based on WSN, typically supply hardware limitations partitioning networks into cluster and integrating WSAN with complex and advanced infrastructure able to improve the great part of issues related with managing, configuration and organization. Moreover, this class of system (typically SOA) can be easily integrated into internet context and so can be efficiently enabled for high level interaction into Virtual Organization. The ideal complement for this class of architecture could be a central or distributed control system based on an intelligence model that guarantees high expressivity and abstraction level both with the ideal support for efficient run-time complex query systems on logic/physic sensors and for advanced structure and mechanisms oriented to the increasing of the level of self-management/organization of systems.

II. Related Work

Current models [3] oriented to the design and implementation of declarative WSNs [4] propose an interesting point of view in terms of design abstraction, system feasibility and extensibility, interoperability and portability considering fundamental limitations of limited resource context. We propose a model more oriented to Artificial Intelligence, with the main goal of further increasing the efficiency of self-management of systems in complex hierarchical organized network [1], than an approach oriented to NesC code mapping/generation [4].

III. Multi-level Declarative Specification

Reference network is showed in Figure 1 and fully described in [1]; a large scale WSAN is hierarchical-organized in clusters, each one headed by local Base Station; Base Stations are organized into Areas; each local Area has just one Base Station with the special role of Gateway; Gateway "represents" its area and its main function is the interaction with central control system.

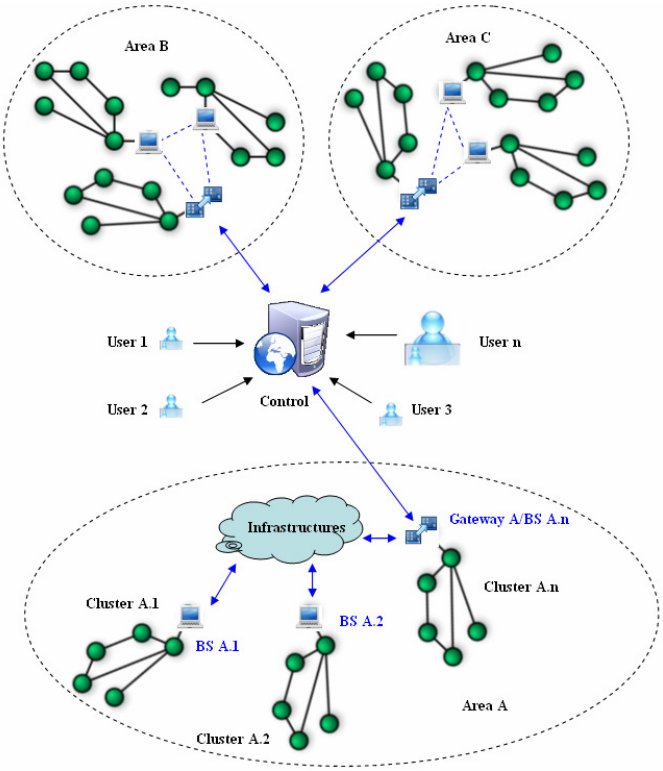

Figure 1: Reference Network.

System specification is articulated on three different levels (Figure 2):

- *Run-time Machine*: it concretely represents the lower (by logic point of view) architecture, including both WSAN

cluster-based architecture and related infrastructures [1]. Its main goal is capturing and interchanging information, typically directed to infrastructures (convergent communication). Related data is efficiently organized in accordance with a logic paradigm that maps hierarchical organization of system. By logic point of view, a Run-time machine is considered advanced independence of its ability of deducing information.

- *Intelligence*: Run-time machine basically provides a certain amount of organized data; this data has to be interpreted to become knowledge (e.g. fault detection). Assuming the use of PROLOG-like language to define the intelligent machine of the system, this step can be identified with the definition of *facts* in accordance with current *Knowledge Specification.* Facts are typically divided into two main classes: event and data; moreover, they can be associated to *Application Knowledge Specification,* if referred to application, or to *System Knowledge Specification*, if referred to system management issues. A system is considered as "intelligent" in function of its ability of interpreting information.
- *Architecture*: the behavior of system, as reaction to events or as user action, has to be specified as a set of *Architecture Predicates*. Concretely, Architecture Predicates have to work over an extensible set of *Basic Predicates* actually composed by three main classes: *Role* (predicates that define the role of considered actor), *Relationship* (predicates that define the relationships between actors), *Actions* (predicates that define basic actions); they differ respect to Architecture Predicates because they are context-awareness). At the state of art, basic roles are: *SensorNode* (defined by its logic identity [1], its properties, its supported functions [2], its load [2], its state [2], its group and its logic context), *BaseStation* and *Gateway* both characterized by their logic context and by parameters strongly dependent by specific architecture.

An exhaustive description of standards and models for specifications is out of paper goals. Logic entities that calculate Architecture Predicates can be potentially hosted into Base Stations, Gateways and Central Control System (Figure 1) and can be referred to information at cluster, area or system level, independence of application scope. Architecture Predicates should be the ideal support for an efficient *Run-time Logic Query System* for client interactions and a robust infrastructure for adaptive self-management/organization. As related issue, we are actually evaluating possible solutions for models for fully-declarative WSANs: a first solution could be the design of a NesC code generator on the model of [4]; a possible and attractive alternative solution could be the design of an efficient interpreter able to work directly into sensor node implementing just a little subset (eventually with restrictions on the complexity of predicates) of relatively simplified PROLOG-like languages as DataLOG; this last solution, even if hard, could be a little more suitable into nodes based on LINUX platform [5].

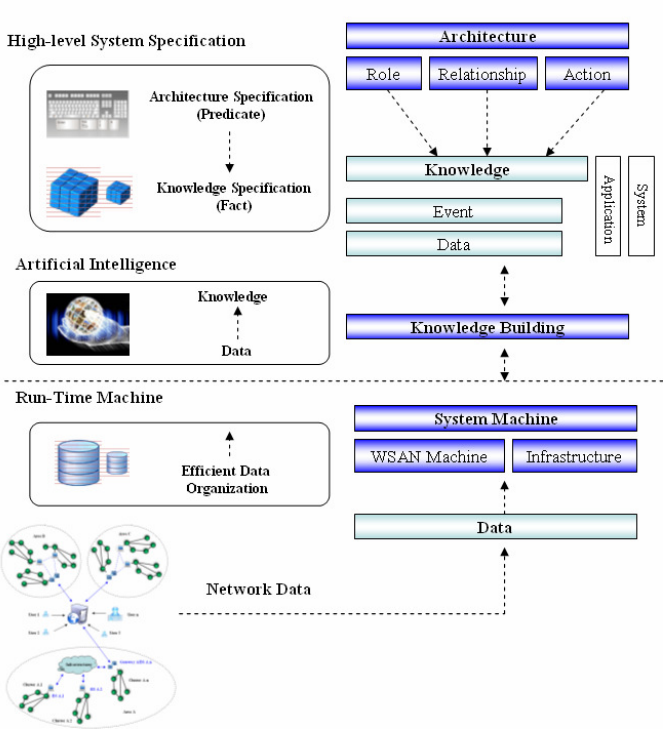

Figure 2: High-level system specification.

IV. Conclusions and Future Work

Providing a complex architecture, based on WSAN, with a layer focused on increasing of system intelligence, results in high-level solution in terms of abstraction level and optimal self-management. Proposed model is absolutely compatible with current hardware/software platforms and can be particularized (or extended) in function of specific architecture or application. Future work will be mainly focused on optimization of components that manage interaction between intelligent components and lower architecture and on design and implementation of applications on the model of proposed architecture.

References

[1] Salvatore F. Pileggi, Carlos E. Palau, Manuel Esteve, *Grid Sensor/Actuator Network Architecture*, Proceedings of International Conference on Wireless and Mobile Communications, ICWMC'06, July 29-31, 2006, Bucharest, Romania.

[2] Salvatore F. Pileggi, Carlos E. Palau, Manuel Esteve, *An adaptive and flexible fault tolerance mechanism designed on multi-behavior agents for Wireless Sensor/Actuator Network*, Proceedings of International Conference on Sensor Technologies and Applications (SENSORCOMM 2007), October 14-20, 2007, Valencia, Spain.

[3] David Chiyuan Chu, Lucian Popa, Arsalan Tavakoli, Joseph M. Hellerstein, Philip Levis, Scott Shenker and Ion Stoica. The Design and Implementation of A Declarative Sensor Network System. The 5th ACM Conference on Embedded networked Sensor Systems (SenSys 2007), Sydney, Australia, 6-9 Nov, 2007. Also see: Technical Report No. EECS-2006-132, EECS Department, University of California, Berkeley, 2006.

[4] Arsalan Tavakoli, David Chu, Joseph Hellerstein, Philip Levis, and Scott Shenker. A Declarative Sensornet Architecture. International Workshop on Wireless Sensor Network Architecture (WWSNA 2007), Cambridge, Massachusetts, April 25-27, 2007.

[5] Crossbow Technology, www.xbow.com.