Chapter 7

Leveraging Context-Awareness in Duty-Cycled Broadcast Wireless Sensor Networks

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ABSTRACT

Operating under duty-cycle mode allows wireless sensor networks to prolong their lifetime. However, this working pattern, with the temporary unavailability of nodes, brings challenges to the network design, mainly for a fundamental service like flooding. The challenging task is to authorize sensors to adopt a duty-cycle mode without inflicting any negative impact on the network performances. Context-awareness offers to sensors the ability to adapt their functional behavior according to many contexts in order to cope with network dynamics. In this context, the authors propose an Enhanced-Efficient Context-Aware Multi-hop Broadcast (E-ECAB) protocol, which relies on multi contextual information to optimize resources usage and satisfy the application requirements in a duty-cycled environment. The authors proved that only one transmission is required to achieve the broadcast operation in almost all situations. Simulation results show that E-ECAB achieves a significant improvement compared to previous work in terms of throughput and end-to-end delay without sacrificing energy efficiency.

INTRODUCTION

The attractive features of wireless sensor networks (WSN) promote their deployment in a large variety of domains, and recently they are increasingly becoming a key building block for realizing the vision of smart cities. In fact, WSNs are infiltrating our daily life through the elaboration of many systems and Internet of Things platforms for smart home monitoring, home automation, assisted living and

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environment monitoring making our life easier and more comfortable. The sensors technology and sensor networking can play a primary role in supporting these Internet of Things (IoT) applications by gathering and delivering raw context information appropriately, according to the constraints imposed by the application and the environment, for further process and analysis. In such fields, heterogeneous applications can coexist within the same remote network resulting to more fluctuations and heterogeneous demands. These contextual and technical requirements may differ significantly considering the diversity and heterogeneity of targeted domains involving WSNs.

To cope with such dynamics and heterogeneity, these resource constrained networks need autonomy to smartly adapt their operations to changing situations while taking into account nodes and network constraints. To fully enable such a functional behavior, context-awareness, broadly recognized as an important paradigm in pervasive and mobile computing environments, offers great opportunities by providing systems with full awareness of current environment context (Perera et al., 2014). This paradigm has been defined in (Salber et al., 1998) as “…the ability to provide maximum flexibility of a computational service based on real-time sensing of context…” In (Abowd et al., 1999), the authors defined context sensitive systems and applications as “…those that respond to changes in their environment. Typically these responses are designed to improve a systems’ performance or to make its behaviour more relevant to the situation in which it is being used…”

A context-aware system requires acquiring contextual information from various sources; in this context, WSNs are considered among the main appliances to gather and send contextual information to the processing station (Taherkordi et al., 2008, Borges et al., 2013) in order to identify the corresponding situation and behave accordingly. For their large deployment, an autonomic network management is required to enable sensor nodes to self-behave with less human interventions. In relation with autonomic networks, context-awareness was defined in (Agoulmine et al., 2006), as “…perception and cognitive reaction to an event or more generically to a condition, relevant to the same intelligent node or, respectively to the environment. Context-awareness is a foundation for the rest of the operational features: self-configuring, self-healing, self-optimizing, and self-protecting…” In the same context, authors in (Jennings et al., 2007) define the notion of adaptability, one of most the important operations in autonomic networks, as “…the capability to adapt the functionality of the system in response to changes in user requirements, business rules, and/or environmental conditions…”

Defined, in (Ganz et al., 2011), as “…the information which is not related to the real sensing operation and information…” the sensor node context may concern any information characterizing the situation of the sensor and providing knowledge about other entities within the environment, such as the current battery status, location, radio information and its capabilities (Ghrab et al., 2016). Context can include also collected information from the environment, shared between nodes in the network, cross-layer information, etc. Sensed data or captured events may to be part of the node’s context since, sometimes, the data content or the relevance of data can also be considered as contextual parameters useful to handle recent applications with heterogeneous traffic demands. Authors in (Makris et al., 2013), provide more generalized definition that considers the context as “…a collection of measured and inferred knowledge rather than just a set of values with no underlying understanding of what these values ultimately mean…” As context can be deduced from observing network activity (De et al., 2012), or estimated through analyzing the history of some parameters, such as traffic load (Ghrab et al., 2015), this definition can be approved in the context of WSNs. In this chapter, the authors suggest a more generalized definition for context-awareness in WSNs as “…the ability to adapt sensor nodes functional behavior and decision making to changing contexts at different layers. They define the context in WSNs “as any