Chapter 11
Two-Level Data Collection for an Energy-Efficient Solution in Wireless Sensor Networks: Multi-Agent System Approach

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ABSTRACT

Density in sensor networks often causes data redundancy, which is often the origin of high energy consumption. Data collection techniques are proposed to avoid retransmission of the same data by several sensors. In this paper, the authors propose a new data collection strategy based on static agents and clustering nodes in wireless sensor network (WSN) for an efficient energy consumption called: Two-Level Data Collection Strategy (TLDC). It consists in two-level hierarchy of nodes grouping. The technique is based on an experience building to perform a reorganization of the groups. Cooperation between agents can be used to reduce the communication cost significantly, by managing the data collection smartly. In order to validate the proposed scheme, the authors use the timed automata (TA) model and UPPAAL engine to validate the proposed strategy; the results after and before reorganization are compared. They establish that the proposed approach reduces the cost of communication in the group and thus minimizes the consumed energy.

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1. INTRODUCTION

In the last years, the availability of sensors that are smaller, cheaper and intelligent enable new generation of networks, where nodes (sensors) are deployed in a specific area. Deployed nodes cooperate to achieve specific missions; it is the case of Wireless Sensor Networks (WSNs). This kind of networks allows a remote control of such monitored environments. Indeed, several domains profit from this important technology, such as military, agriculture, medical, etc...

Actually, WSN contains a high number of nodes, which are randomly and densely deployed on some area. All nodes in the WSN perform three sub-functions: sensing the environment, processing data which consist of local computation on sensed data and sending data (the communication sub-function). Sensed information will be rooted from their origin to the base station (sink), through a number of intermediary sensors.

Unlike traditional networks, a WSN has its own design and resource constraints. Resource constraints include, principally, a limited amount of energy. Each node has an autonomous energy source and must be used in an optimal way. It is, often, impossible to replace these nodes after their deployment. So they must stay alive as long as possible. Hence, the life duration of such network is one of the important performance criteria. A WSNs research field aims to responds to the above challenges by introducing new design concepts, elaborating new techniques, building new applications, and developing new algorithms.

The principal objective of this network is to gather information from the monitored area. It is well known that, the local data processing is very cost effective comparing to its communication. This is especially because that many of detected information are redundant; this is a consequence of the network density and the large number of nodes which sense the same measures.

One technique for minimizing energy consumption is the clustering, which gives the best result in terms of energy (Wang & Cho, 2014). The network is partitioned into smaller groups called clusters with particular node called cluster head (CH). The CH node supports data exchange with the Sink. It receives sensed data from all nodes in the group before sending it to the Sink; this leads to the rapid death of the group leader (CH) and raises the overload problem.

Another aspect of the clustering technique is the use of the multi-agents system (MAS); the MAS have proved their usefulness in the problems where it is difficult to anticipate all the situations. Decomposing the whole problem into a set of cooperating decentralized entities, moves the analysis problems from a global level to a local level and reduces the complexity of the design (Tynan et al., 2005; Bendjima & Feham, 2012; Jamont & Occello, 2006; Rogers et al., 2009). So, static agents are integrated in the nodes to enhance their intelligence through cooperation with neighboring nodes. They reduce the amount of the gathered information by treating the information locally.

In this paper, an energy-efficient data collection strategy is proposed to extend the lifetime of the network, using a new group reorganization technique based on experience building.

In practice point of view, the proposed strategy uses two levels of group hierarchy within the network. The nodes, inside the first grouping, that sense the same information (redundancy) are clustered as a subgroup that is what we call the second level of grouping.

This new strategy is based on multi-agent approach to build a cooperative infrastructure for collecting data at two levels. Moreover, the cooperation strategy is used to collect information ingeniously from the nodes, after local treatment and the importance estimation of the sensed data.