Distributed Methods for Multi-Sink Wireless Sensor Networks Formation

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INTRODUCTION

A Wireless Sensor Network (WSN) is composed of a set of hundreds of devices deployed in a common area, which are connected among them. Each device has the same capabilities; it is able to collect information from the surrounding environment through one or more sensors, process this information in a local manner. Data collection is usually made by a sink node or base station. A WSN can be used to control multiple tasks in one environment; the sensors require of data sensed from multiple sources by delivering information to multiple sinks at the same time.

There are a wide variety of current research problems in this area, such as tracking, surveillance, military applications, building automation, disaster management, and agriculture, among others. The applications are designed to obtain precise information from the environment regardless of the human presence. Radio communication, processing, transmission/reception generally are the main cause of power consumption. A multi-sink approach is becoming an efficient scheme to reduce the energy consumption in the whole network, either in a centralized or distributed application. In this paper, distributed techniques are presented and analysed.

The analysis is focused on the used strategies in a multiple sink environment, whether the nodes are static or mobile and how applications can be improved by mixing more than one strategy; the objective of the application such as event detection, following a target, finding the best route, collecting and data aggregation, among others. The survey covers recent and traditional works and presents a discussion of their advantages and drawbacks. A simple and operational distributed algorithm that performs network formation and data collection using a multi-sink environment is presented.

This article is organized as follows: the next section presents the generalities and features of WSNs. The third section presents a classification of distributed approaches based on multi-sink environments; the fourth section describes the classification of the related works and discusses their proposals. The fifth section focuses on the simple and operational proposal of a distributed and multi-sink protocol for a WSN; finally, the last section presents the concluding remarks, which drive further research in the area.

BACKGROUND

Wireless Sensor Networks

Wireless Sensor networks with a single sink node have constraints; one of them is presented during the data collection, where bottleneck (Hochbaum & Shmoys, 1986) and hotspot problems (Sungjin

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& Kim, 2006) can arise. Another limiting factor emerges when the purpose of the application is finding a target and the sink is far away from it; in this case, the routing can require great expenses of energy. Another drawbacks are presented when the sink require of responses in a short period of time and the routing is not efficient, when the sink node is not available, or there is a high demand for transmissions and one sink is not enough.

Multi-sink platforms have arisen as response to this kind of problems; a multi-sink platform provides redundancy, avoids problems in the data collections and increases the efficiency of the application. A set of sinks can be strategically or randomly distributed in the coverage area to collect and process the information from the environment. The sink or sinks can be static or mobile according to the available resources of the application.

Once the topology strategy is specified, the information can be collected following a distributed o centralized policy via multi-hop mode. In this article, we focus on the distributed strategies. *Distributed techniques* allow to the nodes take their own decisions in a locally way and dispense the information to a limited set of neighbours nodes within a scope area, which provide energy savings and spreading the information in a uniform manner to avoid the overhearing or hot spot problems. The flexibility of distributed systems enables targeting random environments without complications during the information collection.

A WSN aims to gather environmental data, the node devices placement may be known or unknown a priori. Network nodes can have *a driven* (IP communication) or *logical* communication (topological communication defined by users or by the application) with all devices; such communication defines the topology according to the application. The logical topology is mainly defined based on the nodes communication. It can be either ad-hoc or strategy based (self-organization, clustering, pheromone tracking, and so on) (Carlos-Mancilla et al. 2016).

Certainly, one of the most important advances in the current proposals has been the *self-organization* (SO) approach in which the nodes are considered autonomous; they interact with the neighbour nodes and are independent of the information of the rest of the nodes. The aim is to achieve collective tasks that exceed its individual capabilities. Examples of these techniques are found in nature (insect colonies, biological cells, the flock of birds, the foraging behaviour of ants, etc.) (Mamei et al., 2006), (Schmeck et al., 2010). Finally, distributed multi-sink approaches support large density scenarios without compromising the network performance. In Table 1 a summary of the main features considered in distributed and centralized multi-sink applications is presented.

Table 1.Metrics in multi-sink applications

Metrics	***Centralized***	***Distributed***
Large scale	It is not applicable in big scale networks; the handled information is high.	The handled information is within a range of transmission; small or large ranges do not affect the performance of the network.
Routing	It can be efficient for small networks.	The routing is fast for the amount of information managed.
Energy saving	The number of transmissions and receptions needed to refresh the whole network is expensive.	It is low for transmissions, receptions, and notification of changes in the network.
Redundancy	It is good when there is a failure shown in the system.	According to the application, the redundancy can be faced in an efficient manner.
Reconfiguration	It is expensive spreading the changes to the whole network	The reconfiguration accuracy depends on the application.