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ScienceDirect

Procedia Manufacturing 11 (2017) 878 – 888

Procedia MANUFACTURING

27th International Conference on Flexible Automation and Intelligent Manufacturing, FAIM2017, 27-30 June 2017, Modena, Italy

A Wireless Intelligent Network for Industrial Control

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Abstract

In this paper, we describe a distributed clustering technique for wireless sensor node tracking in an industrial environment. The research builds on extant work on wireless sensor node clustering by reporting on: (1) the development of a novel distributed management approach for tracking mobile nodes in an industrial wireless sensor network; and (2) an objective assessment of the cluster management approach both in terms of its tracking performance and its use of network resources. To support this work, we introduce two classes of metrics: a set of three tracking performance metrics, and a set of three network efficiency metrics. The results of our experiments show that the proposed distributed system adapts readily to changes in the sensing environment, but this higher level of adaptability is at the cost of overall efficiency.

Peer-review under responsibility of the scientific committee of the 27th International Conference on Flexible Automation and Intelligent Manufacturing

Keywords: Industrial Control; Wireless Sensor Networks; Manufacturing Systems

1. Introduction

In recent years, there has been an emerging phenomenon where everyday objects are connecting to the internet. This phenomenon is known as the internet of things (IoT). Advances in technology have led to a plethora of new devices with the ability to connect to the internet. Potential applications of these devices and their associated services range from consumer electronics, industrial and manufacturing, military and surveillance, and medical and

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Peer-review under responsibility of the scientific committee of the 27th International Conference on Flexible Automation and Intelligent Manufacturing
doi:10.1016/j.promfg.2017.07.191

rehabilitation. One of the key challenges with these devices and services, however, is their interoperability – more specifically, their ability to universally communicate with each other [1].

To address this key challenge, many researchers are turning to the World Wide Web as a platform for smart things [1]. This phenomenon is being called the “Web of things” (WoT), where web refers to the idea that all things can be accessible via web technologies. An example of such a web technology is the Hypertext Transfer Protocol (HTTP) [2].

One of the most important elements in the WoT paradigms is wireless sensor networks (WSN). As noted by Alcaraz et al. [3], the benefits of using WSN in WoT applications go beyond remote access. This integration gives heterogeneous information systems the ability to collaborate and provide common service. An example of this is an indoor mobile tracking system. In this paper, a mobile-object tracking system is developed using multi-agent systems to manage the wireless sensor networks. Figure 1 shows the basic problem tackled in this paper: distributed dynamic cluster formation to track mobile wireless sensor nodes in a factory environment. In this figure, we show a set of static wireless sensor nodes (Anchor Nodes and Sink Nodes) that are used to track mobile wireless sensor nodes: the Anchor Nodes provide distance estimates of the Mobile Nodes to the Sink Nodes, where the localization calculation takes place.

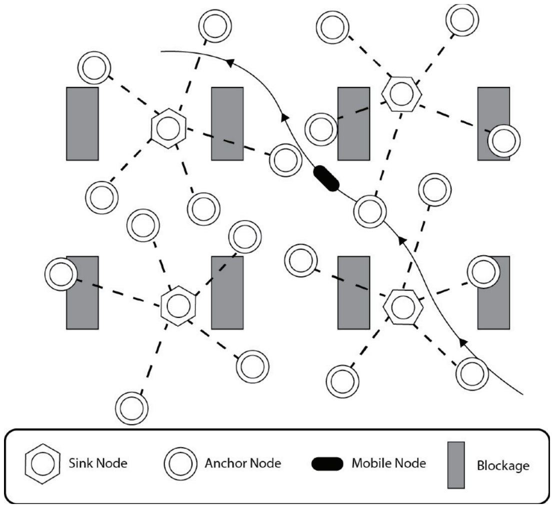

Fig. 1. Mobile node tracking in a factory wireless sensor network.

Hardware and software technologies are currently available to provide sophisticated monitoring, control, and diagnostics of industrial systems at lower costs than ever before. There are, however, several implementation challenges when these new technologies are applied in industrial environments. Given the distributed nature of many of these systems, management and coordination are key challenges. Reliability and robustness given harsh industrial conditions, which can arguably require higher reliability requirements than other commercial systems, is another key implementation issue.

WSNs applied in the industrial domain must be capable of rapidly adapting to change to support the flexibility and responsiveness required of the system. More specifically, the WSN should can allow sensor nodes to be added and/or removed from the system on-the-fly to support changes in the configuration of the shop floor, and be capable of handling signal loss that occurs during the tracking process because of blockage and/or noise from machinery. Thus, the wireless sensor network must be dynamically reconfigurable: i.e., it should have “. . . the ability to repeatedly change and rearrange (its components) in a cost-effective way” [4].

This paper addresses this set of challenges with the following contributions. First, we develop a novel distributed management approach for tracking mobile nodes in a 400–676 node network subject to harsh industrial conditions presented by signal blockage and noise. Although Mobile Node tracking can be accomplished using a centralized