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A ferry-assisted solution for forwarding function in Wireless Sensor Networks

Omar Ait Oualhaj [a,*], Abdellatif Kobbane [b], Essaid Sabir [c], Jalel Ben-othman [d], Mohammed Erradi [a]

[a] MIS/SIME, ENSIAS, Mohammed V University of Rabat, Morocco
[b] MIS/MobiTic, ENSIAS, Mohammed V University of Rabat, Morocco
[c] RTSE Research Group, ENSEM/MobiTic, Hassan II University, Casablanca, Morocco
[d] L2TI, University of Paris 13, France

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ABSTRACT

For sure, Wireless Sensor Networks (WSNs) are becoming an ultimate part of next generation mobile networks. They are a master piece for Ubiquitous computing. Indeed, they sustain development of numerous paradigms/ technologies such as distributed ambient intelligence, context-awareness and future mobile networking (e.g., B4G and 5G). Battery life remains one of the crucial problems to handle. In this article we propose an infrastructure-based topology using mobile ferries (mobile micro-base stations). In real life, a ferry could be robot, bus, tram, train or any other engine scrutinizing periodically a given area. Yet, message ferries are moving along concentric annulus and may collect data generated by the static sensors (could be classic sensors, smart meters, wearable devices, etc.) randomly distributed on given area. Next, transmissions are performed in a ferry-to-ferry forwarding scheme till arriving at the sink. Considered ferries could sense themselves data and therefore behave as mobile sensors allowing better awareness on the area state [1–3]. Our scheme could also assist Machine-to-Machine communications to increase the network lifetime, with potentially some cognitive-radio capabilities and opportunistic detection and access. Our proposal can easily be integrated in a smart-city for better interaction and green communications. Next, we present a queueing model (queues with finite capacity) to handle the generated traffic and to analyze the behavior of mobile ferries. We provided a close-form expression for both end-to-end throughput and end-to-end delay. The main objective of this work is to improve the energy efficiency of the cognitive sensors by asking cognitive sensors to not care about forwarding data of each other except for urgent data, this latter point is out of the scope of the paper. These static sensors will only care about data sensing, which will reduce their individual energy consumption.

1. Introduction

In Wireless Sensor Networks, sensor nodes typically avoid direct communication with a distant destination since a high transmission power is needed to achieve a reliable transmission. In fact Energy consumption is a core issue in Wireless Sensor Networks. Due to the finite energy resource, WSN protocols should make judicious use of such transmission

* Corresponding author.
E-mail addresses: omar.aitoualhaj@um5s.net.ma (O. Ait Oualhaj), kobbane@ensias.ma (A. Kobbane), e.sabir@ensem.ac.ma (E. Sabir), jalel.ben-othman@univ-paris13.fr (J. Ben-othman), erradi@ensias.ma (M. Erradi).

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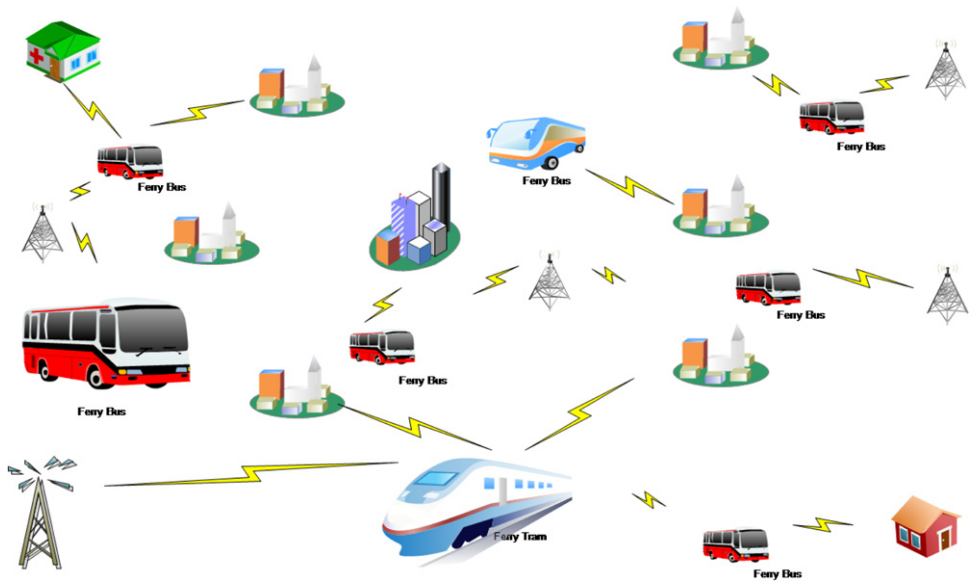

Fig. 1. The means of public transportation (Bus, Streetcar) that can play the role of the Ferry.

power by decreasing the energy consumption which allows maximizing the lifetime of the network. In addition, in order to adapt to their dynamic environments, WSNs introduce the mobility of their nodes which raises the variety of their applications. The mobility of the nodes in these networks brings new research challenges such as: the choice of mobility patterns, the positioning (placement) of mobile elements and the adaptation of routing protocols [4,5]. Therefore, wireless sensor networks attracted huge attention from researchers as an ultimate part of next generation Ubiquitous networks. Indeed, they sustain development of numerous paradigms/ technologies such as distributed ambient intelligence, context-awareness, wearable devices, and future mobile networking (e.g., B4G and 5G) [6]. This impacted various domains such as system, security and monitoring, energy efficiency and environment protection, e-health, precision agriculture, intelligent transportation and home-care services. To meet the new applications requirements, the communication in such systems has to cope with many constraints such as: limited capacity resources, energy depletion strong fluctuations of traffic, real-time paradigm, dynamic network topology, radio link breakage and interferences.

In this work, we rethink the sensors deployment problem by considering special mobile base stations, called ferries, aiming to serve as relays in a store-and-forward fashion Fig. 1. Ubiquitous systems bring many promising paradigms aiming to deliver significantly higher capacity to meet the huge growth of mobile data traffic and to accommodate efficiently dense and ultra-dense systems. Sensor nodes could be Machine-Type-Communication (MTC) devices or smart-meters generating huge amount of data to be delivered to processing units. A crucial challenge is that these kinds of ubiquitous networks need to be engineered to better support existing and emerging applications including broadband multimedia, MTC/M2M applications, Internet of things, sensor networks and RFID technologies. Hence, many of these systems require not only stringent quality-of-service (QoS) including better latency, reliability, higher spectral and energy efficiency, but also some quality-of-experience and quality-of-context constraints. Our ferry-assisted architecture was designed to provide a promising solution, bringing efficient spectrum usage and green networking.

The remainder of the paper is organized as follows. First, Section 2 presents the related works. The problem formulation and our analytic model are presented in Section 3. In Section 4 we study the transfer of packets in the path. Finally, in Section 5 we present the simulation results, and conclude the paper in Section 6.

2. Related works

Wireless Sensor Networks are mainly composed of battery powered devices and energy scarcity is one of their main characteristics. Several energy aware routing protocols [7] have been proposed to reduce WSN energy consumption and particularly at the communication level. Other approaches based on controlled mobility of some network components such as message ferries [8–10] and/or sinks [11–13] have also been investigated.

In the UmassDiesel project, computers have been installed in 30 out of 40 buses and these served as Message Ferry to deliver messages to throw boxes [10]. The DakNet project [14] has been successfully deployed in remote parts of both India and Cambodia to provide villagers with asynchronous access to internet services. The project exploits public buses infrastructure to physically carry information between kiosks in villages and the remote internet hub. The buses are acting as mobile access points in a ferry like communication scheme. In [8] the authors propose an optimal ferry route design mechanism to enhance the connectivity of sparse ad hoc networks. The OPWP method is proposed to determine