Improving Multi-storey Building Sensor Network with an External Hub

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Abstract—Monitoring and automatic control of building environment is a crucial application of Wireless Sensor Network (WSN) in which maximizing network lifetime is a key challenge. Previous research into the performance of a network in a building environment has been concerned with radio propagation within a single floor. We investigate the link quality distribution to obtain full coverage of signal strength in a four-storey building environment, experimentally. Our results indicate that the transitional region is of particular concern in wireless sensor network since it accommodates high variance unreliable links. The transitional region in a multi-storey building is mainly due to the presence of reinforced concrete slabs at each storey and the façade which obstructs the radio signal and introduces an additional absorption term to the path loss.

Keywords—Wireless sensor networks, radio propagation, building monitoring

I. INTRODUCTION

Today environmental monitoring is considered as one of the principle application for sensor networks [16]. One of the earliest known civil applications of sensor networks is in ecological habitat monitoring. A team from University of California Berkeley [14], [17], [18] used a wireless sensor network to observe birds on an island, using a base station connected over the web via a satellite communication link. This kind of “unattended” monitoring minimizes disruption to the objects of study by an observer walking around the island to collect data.

A sensor network is a computer network of many, spatially distributed devices using sensors to monitor conditions at different locations, such as temperature, sound, vibration, pressure, motion or pollutants. Usually these devices are small and inexpensive, so that they can be produced and deployed in large numbers, and so their resources in terms of energy, memory, computational speed and bandwidth are severely constrained. Various research problems of sensor networks such as data aggregation or fusion [3], [4], packet size optimisation [15], cluster formation [6], [7], target localisation [21], battery management [5], network protocols [10], [11], [19] are discussed in the literature with respect to crucial energy limitations. Efficient battery management for sensor lifetime [5] and guidelines for efficient and reliable sensor network design is investigated in [8]. Commercial radio technology has advanced and commercial standards such as Bluetooth, developed by the Bluetooth consortium [1], have started to appear. Ad hoc networks have been gaining popularity for military, space, biomedical and manufacturing applications in recent years because of their easy deployment and lack of infrastructure requirements. Unlike cellular wireless networks, ad hoc wireless networks do not need any fixed communication infrastructure. Three main networking protocols are known in wireless communications: direct communication, multi-hop communication and clustering. The routes can be single or multi-hop and the nodes which may be heterogeneous and communicate via packet radio. The heterogeneity of the nodes would allow some nodes to be servers and others to be clients. The ability of an ad hoc node to act as a server or service provider will depend on its energy, memory and computational capacities. Each node should estimate its own battery life before committing to a task. Even relaying packets for others may result in deteriorating its own limited battery power, and the node may not accept the task when it is devoted to another important activity. There is a fundamental, incompatible features between computer simulation and experimental evaluation of sensor networks. On one hand, computer simulations provide complete control and transparent into experiments, but, on the other hand, they cannot reproduce, trustworthy, all the parameters that affect a live system [16].

In this paper, we performed experimental study to investigate link quality distribution in sensor network deployment for building environment. This experiment will leverage queries in real sensor network and also will drive development of network architecture. Both man-made hazards such as crime and terrorism as well as natural hazards such as earthquakes, tsunamis and winds can cause damages to building. Sensor networks can be effectively used to reduce the impact of such hazards through early detection. Therefore, monitoring and automatic control of building environment is a crucial application of Wireless Sensor Network (WSN) in which maximizing network lifetime is a key challenge. We have previously investigated the link quality distribution to obtain full coverage of signal strength in a single floor of building environment. Our results confirmed the transitional region is particular concern in wireless sensor network since it accommodates high variance unreliable links. The reason due to this transitional region in inside building environment could be the obstacles including concrete/brick walls, partitions, office furniture and other items affect as additional absorption term to the path loss. We now extend the experimental work to explore the performance of a sensor network that is deployed into a four-storey building with a network hub located at mid-height on an adjacent building. This configuration allows the