A Comparative Analysis of Hierarchical Routing Protocols in Wireless Sensor Networks

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ABSTRACT

Wireless Sensor Networks (WSNs) consist of small nodes with sensing, computation, and wireless communications capabilities. Many routing, power management, and data dissemination protocols have been specifically designed for WSNs. Routing protocols in WSNs might differ depending on the application and network architecture. However, wireless sensor networks have several restrictions, e.g. limited energy supply, limited computing power, and limited bandwidth, and hence, one of the main design goals of WSNs is to carry out data communication while trying to prolong the lifetime of the network and prevent connectivity degradation by employing efficient energy management techniques. This chapter will give a detailed description of the characteristics of routing in wireless sensor networks; it describes the routing protocols used in these networks pointing out the advantages and disadvantages of each.

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INTRODUCTION

Due to the recent development in the field of Micro Electrical Mechanical Systems (MEMS) (Min, Cho, Shih, Bhardwaj, & Sinha, 2001; Rabaey, Patel, & Roundy, 2000) radio communication has made it possible to form small tiny nodes with the capability of sensing, computing, and communication in a short range. They are capable of forming an autonomous intelligent network which functions with unattended management. Technology reviews at MIT and Global Future say that sensor technology is one of the ten emerging technologies that will change the world (Werff, 2003). The network is capable of monitoring activities and phenomenon which cannot be monitored easily by human beings, such as the site of a nuclear accident, some chemical field monitoring, or environment monitoring for longer periods of time. Wireless sensor networks offer information about remote structures, widespread environmental changes, etc. in unknown and inhospitable terrains (Manjeshwar, Zeng, & Agrawal, 2002). Also, the low cost makes it possible to have a network of hundreds or thousands of these sensors, thereby enhancing the reliability and accuracy of data and the area coverage.

Networking unattended sensor nodes are expected to have significant impact on the efficiency of many military and civil applications such as combat field surveillance, security, and disaster management. These systems process data gathered from multiple sensors to monitor events in an area of interest. For example, in a disaster management setup, a large number of sensors can be dropped by a helicopter. Networking these sensors can assist rescue operations by locating survivors, identifying risky areas and making the rescue crew more aware of the overall situation. Such application of sensor networks not only can increase the efficiency of rescue operations but also ensure the safety of the rescue crew. On the military side, applications of sensor networks are numerous. For example, the use of networked set of sensors can limit the need for personnel involvement in the usually dangerous reconnaissance missions. In addition, sensor networks can enable a more civic use of landmines by making them remotely controllable and target-specific in order to prevent harming civilians and animals. Security applications of sensor networks include intrusion detection and criminal hunting (Akkaya & Younis, 2005; AL-Karaki & Kamal, 2004).

There are a number of advantages of wireless sensor networks over wired ones such as ease of deployment (reducing installation cost), extended range (network of tiny sensors can be distributed over a wider region), fault-tolerance (failure of one node does not affect the network operation), self-organization (the nodes can have the capability to reconfigure themselves) But there are a few inherent limitations of wireless media such as low bandwidth, error prone transmissions, collision free channel access requirements etc. Also, since the wireless nodes are mostly mobile and are not connected in any way to a constant power supply, they derive energy from a personal battery. This limits the amount of energy available to the nodes. In addition, since these sensor nodes are deployed in places where it is difficult to either replace individual nodes or their batteries, it is desirable to increase the longevity of the network and preferable that all the nodes die together so that the whole area could be replenished by a new set of tiny nodes. Finding individual dead nodes and then replacing those nodes selectively would require pre-planned deployment and eliminate some advantages of these networks (Manjeshwar, Zeng, & Agrawal, 2002).

Routing protocols are the implementation of algorithms used to carry out the communication across an internetwork. A routing protocol uses specified metrics (energy, bandwidth, delay, etc) to determine which path to utilize to transmit a packet. Routing in wireless sensor networks is very challenging due to the following inherent characteristics that distinguish these networks.
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