Chapter 15
Energy Efficient Packet Data Service in Wireless Sensor Network in Presence of Rayleigh Fading

Arnab Nandi
National Institute of Technology Durgapur, India

Sumit Kundu
National Institute of Technology Durgapur, India

ABSTRACT

Energy level performances of three packet delivery schemes in Wireless Sensor Networks (WSN) are evaluated in presence of Rayleigh fading. Three different information delivery mechanisms are investigated using regenerative relays with or without error correction capability. Energy consumption for successful delivery of a data packet for each mechanism is evaluated and compared under several conditions of node density, bit rate, transmit power, and channel fading. Energy efficiencies of different retransmission schemes are also evaluated. Further, an optimal packet length based on energy efficiency is derived. Impact of optimal packet size on average number of retransmission and total energy expenditure is analyzed for each delivery scheme.

INTRODUCTION

Recent advances in wireless communication technologies led to great interest in wireless sensor networks (WSNs). WSN consists of wireless interconnection of several sensor nodes which comprise of sensor devices with wireless communication facilities (Akyildiz et al., 2002). Most of the research work on WSN assumes idealized radio propagation models without considering fading and shadowing effects. However network performance degrades due to shadowing and fading (Goldsmith, 2005). Relayed transmission is a promising technique that helps in attaining broader coverage and in combating the impairment of the wireless channel. Relaying information on several hops reduces the need of large transmitter power and distributes the use of power throughout

the hops which results in extended battery life and lowered level of interference (Raghunathan, 2002). Energy conservation is one of the most important issues in WSN, where nodes are likely to rely on limited battery power. The connectivity of WSN mostly depends on the transmission power of the source nodes. If the transmission power is not sufficiently high there may be single or multiple link failure. Further transmitting at high power reduces the battery life and introduces excessive inter node interference. Given that the sensors have limited energy, buffer space, and other resources, different MAC protocols are being developed by several researchers (Dam & Langendoen, 2003; Kwon et al., 2006). Most of the previous research work in this field assumes free-space radio link model and Additive White Gaussian Noise (AWGN) (Bettstetter & Zangl, 2002; Panichpapiboon et al., 2006; Tseng & Chen, 2004). However signal fading due to multipath propagation severely impairs the performance of wireless link. Several approaches have been proposed in literature to prolong network lifetime. Sooksan et al. evaluated Bit Error Rate (BER) performance and optimal power to preserve the network connectivity considering only path-loss and thermal noise (Panichpapiboon et al., 2006). In Bettstetter and Zangl (2002) Bettstetter et al. derived the transmission range for which network is connected with high probability considering free-space radio link model. In Tseng and Chen (2004) the relationships between transmission range, service area and network connectedness is studied in a free space model. Narayanaswamy et al. (2002) proposed a protocol that extends battery life through providing low power routes in a medium with path loss exponent greater than two. In Mansouri et al. (2005) a new method is proposed utilizing a diversity scheme to reduce power consumption in large scale sensor networks.

In this paper, Energy level performances of three different information delivery mechanisms are evaluated in presence of Rayleigh fading. In all the three schemes, message packet is sent on hop-by-hop basis. Further in scheme I message is corrected at every hop. While in the other two schemes, message is corrected at the destination. However in case II, ACK/NACK propagates from destination to source via multiple hops through intermediate nodes while in case III it propagates directly. Further we derived energy efficiency of those retransmission mechanisms. Energy requirement for successful delivery of a packet is evaluated under several conditions of network such as node density. Impact of Rayleigh fading on energy requirement is also investigated. We propose a scheme utilizing optimal size packets to reduce energy consumption in WSN. An optimal packet length which corresponds to highest energy efficiency for a particular set of network conditions is evaluated for each packet delivery scheme. The impact of optimal size packet on energy consumption is indicated for Rayleigh fading channel. The energy requirement also depends on routing and the Medium Access Control (MAC) protocol used (Ferrari & Tonguz; Perkins, 2001, 2003).

SYSTEM MODEL

A square grid network architecture is considered as in (Panichpapiboon et al., 2006). Figure 1 shows a two tier sensor network using square grid topology (Hong & Hua, 2006; Panichpapiboon et al., 2006). Distance between two nearest neighbor is d_{link}. It is assumed that N numbers of nodes are distributed over a region of area A obeying square grid topology. The node spatial density ρ_{sq} is defined as number of nodes per unit area i.e., $\rho_{sq} = N/A$. The minimum distance between two consecutive neighbors is given by (Panichpapiboon et al., 2006)

$$d_{link} = \frac{1}{\sqrt{\rho_{sq}}} \tag{1}$$

Related Content

A Novel Energy Efficient and SLA-Aware Approach for Cloud Resource Management
Madhukar Shelar, Shirish Saneand Vilas Kharat (2019). *International Journal of Grid and High Performance Computing (pp. 63-84).*
www.irma-international.org/article/a-novel-energy-efficient-and-sla-aware-approach-for-cloud-resource-management/224031

Performance Aware Planning Algorithms for Cloud Environments
Jyoti Thamanand Kamal Kumar (2018). *International Journal of Distributed Systems and Technologies (pp. 1-15).*
www.irma-international.org/article/performance-aware-planning-algorithms-for-cloud-environments/196264

Overlay-Based Middleware for the Pervasive Grid
Paul Grace, Danny Hughes, Geoff Coulson, Gordon S. Blair, Barry Porterand Francois Taiani (2010). *Handbook of Research on P2P and Grid Systems for Service-Oriented Computing: Models, Methodologies and Applications (pp. 981-1002).*
www.irma-international.org/chapter/overlay-based-middleware-pervasive-grid/40836

Data-Aware Distributed Computing
Esma Yildirim, Mehmet Balmanand Tevfik Kosar (2012). *Data Intensive Distributed Computing: Challenges and Solutions for Large-scale Information Management (pp. 1-27).*
www.irma-international.org/chapter/data-aware-distributed-computing/62820

Bio-Inspired Techniques for Resources State Prediction in Large Scale Distributed Systems
Andreea Visan, Mihai Istin, Florin Popand Valentin Cristea (2011). *International Journal of Distributed Systems and Technologies (pp. 1-18).*
www.irma-international.org/article/bio-inspired-techniques-resources-state/55418