

Chapter 57

Reliability Evaluation Methods for Resilient Wireless Sensor Networks

M. Saeed Ansari

Iran University of Science and Technology, Iran

Ali Mahani

Shahid Bahonar University of Kerman, Iran

ABSTRACT

Wireless sensor networks (WSNs) are deployed for various applications such as military applications, environmental monitoring, security and surveillance, health care applications and so on. In most of these applications, reliable data transport is of great importance and also a facet of quality of service (QoS). This chapter discusses reliable data transport approaches and protocols. The presented protocols should be energy efficient besides they guarantee reliability in data transmission. The authors review protocols mostly based on packet and event reliability taking advantage of retransmission and redundancy mechanisms. In addition, network component failures and fault tolerant techniques should be also considered in reliable WSN designs. Since different reliability evaluation modeling approaches is presented. Finally the authors highlight the challenges to WSNs reliability enhancement and some future research directions are addressed in particular.

INTRODUCTION

Wireless sensor network (WSN) is a well-studied research area and it has drawn the attention of many researchers in the last two decades. WSNs are probably the best candidate for the new generation of control and monitoring systems (Akyildiz et al., 2002, Yick et al., 2008). Recent advances in wireless communication technology and micro-

electro-mechanical systems (MEMS) have enabled taking advantage of tiny, low-power and low-cost sensors in wireless sensor networks. This reduction in size and cost of sensors has made them vulnerable to environmental noises which increases information inaccuracy. The other significant issue which is actually one of the major challenges in WSNs is to reliably transport of successfully sensed data over multiple hops toward sink(s)

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(Willig et al., 2005). As is said in (Mahmood et al., 2011, Pereora et al., 2007), reliability can be classified into two different categories i.e.

- Packet reliability
- Event reliability
- Hop-by-Hop reliability
- End-to-End reliability

Packet reliability deals with reliably transport of collected data to the sink(s) and event reliability is a factor to determine how observable an occurred event in the environment is. In fact the difference between packet reliability and event reliability is that when we talk about event reliability there is no need that all the messages reach to the sink(s), just one notification of each event is enough. Since there are strong limitations in terms of processing, memory, power and etc. energy efficient methods are presented in order to increase network's life-time. These approaches mostly put the sensors in the sleep mode to optimize their power consumption which leads to multi-hop data transmission. As mentioned before, successful delivery of the sensed data despite collisions, congestions and channel errors is another problem in WSNs. Both Hop-by-Hop reliability and End-to-End reliability deal with this problem. In Hop-by-Hop, all the nodes in the path are responsible for a reliable transmission whereas, in End-to-End only the source node and destination node (mostly the sink) are responsible. To increase packet or event reliability retransmission and redundancy mechanisms are offered. As is clear through End-to-End reliability and Hop-by-Hop reliability definitions, in End-to-End reliability just the source node retransmit the lost data whereas, in Hop-by-Hop reliability every single node in the path is able to retransmit the lost information by holding the data in its buffers (Mahmood et al., 2011). Redundancy mechanisms can be used instead of retransmission techniques. What a redundancy technique does is to add some overhead data to the original one which

allows the receiver to recover the lost data. So to guarantee the reliability the lost packets should be retransmitted or some redundancy technique should be taken which both are an overhead on the energy consumption of the network. So to enhance the reliability, network resources should be considered besides reliable data transmission.

Consider network resources, one of the key steps offered in the design of a WSN is reliability modeling. It can be used to estimate networks elements performances in order to advance the design of the network. Usually to find out the reliability of a WSN, the designers do a three steps procedure. They first develop the network measure reliability mathematical model. Then they figure out the model's parameters and finally based on the model and measured parameters they compute network reliability (Venkatesan et al., 2013).

BACKGROUND

Based on the nature of the WSNs, each node in the network tends to send their collected information to the sink(s). Clearly there would be traffic of transmitted packets around the sink(s) and as there is strong limitation in the buffering space in sensor nodes, this lead to packet loss. Of course this is not the only reason of packet losses in the network. Other reasons such as collisions between packets, node failures (due to software/hardware errors, energy depletion and etc.) and others may cause packet losses. As mentioned before despite all these faults, the applications expect packet reliability in WSNs.

In general to increase network reliability, WSNs constraints should be taken into account. WSNs constraints are power, transmission range, sensing radius, processing and others. As mentioned before the three important duties in WSNs is to sense the environment, processing data and also data transmission. Each of these three phases, are supposed to meet different requirements.

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