Chapter 31
Extending Lifetime of Biomedical Wireless Sensor Networks using Energy-Aware Routing and Relay Nodes

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ABSTRACT

Biomedical wireless sensor networks are a key technology to enable the development of new healthcare services and/or applications, reducing costs and improving the citizen's quality of life. However, since they deal with health data, such networks should implement mechanisms to enforce high levels of quality of service. In most cases, the sensor nodes that form such networks are small and battery powered, and these extra quality of service mechanisms mean significant lifetime reduction due to the extra energy consumption. The network lifetime is thus a relevant feature to ensure the necessary quality of service requirements. In order to maximise the network lifetime, and its ability to offer the required quality of service, new strategies are needed to increase the energy efficiency, and balance in the network. The focus of this work goes to the effective use of the available energy in each node, combined with information about the reliability of the wireless links, as a metric to form reliable and energy-aware routes throughout the network. This paper present and discusses two different deployment strategies using energy-aware routing and relay nodes, assessed for different logical topologies. The authors' conclusion is that the use of energy-aware routing combined with strategic placed relay nodes my increase the network lifetime as high as 45%.

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INTRODUCTION

A Wireless Sensor Network (WSN) is a distributed, self-organised network of small and highly constrained wireless nodes that interact to carry out a specific task (Akyildiz, Melodia, & Chowdury, 2007). WSNs differ from traditional wireless networks in several aspects. The WSN nodes have limited processing power, memory, and in several applications they use battery power or energy scavenging (Watteyne, Molinaro, Richichi, & Dohler, 2011). In addition to these limitations the communication channels have narrow bandwidths, and the wireless links may be exposed to high levels of interference.

A Biomedical Wireless Sensor Network (BWSN) is a small-size WSN designed for medical applications or healthcare services (Abreu, Ricardo, & Mendes, 2011). Typical applications of BWSNs include patient monitoring, catastrophe and emergency response, and ambient assisted living for disabled or elderly people (Caldeira, Rodrigues, Lorenz, & Shu, 2012). Being a special set of the WSNs, the BWSNs share the same challenges and they add some others, depending on their purpose and application.

BWSNs have the potential to improve the healthcare quality through the development of new applications and services. In this context, due to the nature of the data carried by BWSNs, they have to guarantee high standards of Quality of Service (QoS). However, the QoS policy should not be focused only on typical QoS communication metrics such as delay, jitter, bandwidth, and packet reception rate. Moreover, due to the limited resources of WSN nodes, and in particular due to the limited capacity of the batteries, the QoS strategy must be planned accordingly. Therefore, to avoid the network nodes from becoming energy-depleted, it is necessary to provide energy efficiency and balance to the network in order to maximize its lifetime.

In what follows, the QoS requirements of BWSNs are outlined (section II), and then the need for energy efficiency and balance in BWSNs is discussed, and two deployment strategies based on energy-aware routing and relay nodes to increase the network lifetime are presented (section III). In Section IV, the proposed methodology is assessed and the results analysed, and finally some conclusions are drawn.

QOS REQUIREMENTS OF BIOMEDICAL WIRELESS SENSOR NETWORKS

Nowadays, healthcare professionals base most of their decisions on the information obtained from electronic or/and computer systems. Such information on the health condition of an individual must have medical quality. According to (American College of Medical Quality, 2010), medical quality can be defined as *"the degree to which health care systems, services and supplies for individuals and populations increase the likelihood for positive health outcomes and are consistent with current professional knowledge"*. This definition makes clear that communication networks used to transport medical data must ensure a service with quality, providing valid and accurate data. In the context of communication networks this requirement is expressed in terms of QoS.

In the industrial and scientific community, the QoS is understood in different ways. In its E.800 recommendation, the International Telecommunications Union defines QoS as the *"totality of characteristics of a telecommunication service that bear on its ability to satisfy stated and implied needs of the user of the service"*. Regarding this definition, communication networks (in which BWSNs are included) used to transport medical data are a keystone to ensure high standards of quality in the services provided by healthcare professionals. On its turn, the RFC2386 defines QoS as: *"A set of service requirements to*

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