Thesis Abstract

DESIGN AND ANALYSIS OF ALGORITHMS FOR PERFORMANCE ENHANCEMENT OF WIRELESS SENSOR NETWORKS

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In today's scenario, there has been an increasing demand of Wireless Sensor Networks (WSN) for intensive monitoring and control in variety critical applications, such as environmental monitoring, precision agriculture, smart offices, battlefield surveillance, transportation traffic monitoring and for real-time monitoring of physiological parameters of the human body.

Wireless Body Area Network (WBAN) is an interesting subclass of wireless sensor networks which is used for telemedicine healthcare applications. A Wireless Body Area Network (WBAN) is a cyber-physical system which integrates the sensing and computational capabilities of distributed biosensor nodes with wireless networking for real-time monitoring and control of physiological parameters of the human body. A WBAN system consists of multiple wireless biosensor nodes. A wireless biosensor node is designed to sense and transmit the physiological parametric data such as pulse rate, blood pressure, body temperature, respiratory rate and ECG etc. Depending on the type of the measured physiological parameter, a biosensor node is either attached to the patient's clothes or embedded inside the body or surface mounted on a specific body part. WBAN nodes sense and transmit the physiological data to a central sink node. Sink node filters and uploads this data to a medical server for telemedicine purpose.

Remote health monitoring and telemedicine related applications rely heavily on the quality of service delivered by the underlying WBAN system. Therefore, a WBAN system needs to offer a timely, reliable and health-conscious data communication around human body. IEEE standardizing society defines IEEE 802.15.6 communication standards for WBAN systems. According to these standards, 95 % of intra WBAN communication links should provide more than 90 % network throughput. The maximum tolerable value for the end to end network latency is 0.125 sec.

IEEE 802.15.6 standards restrict the node signal power under the maximum limit of 0 dBm (0.001 W). In fact, the intra and inter WBAN data transmissions result in an exposure of the human body to non-ionizing EMF radiation energy. A partial amount of EMF radiation energy gets absorbed by body tissues and gets transformed into heat due to the lossy nature of the human body. The rate at which the human body absorbs EMF radiation energy (in Watt) per unit mass of tissue (in Kg) is termed as Specific Absorption Rate (SAR). SAR is the positive function

of node transmission power. As per the FCC's guidelines, the SAR above 1.59 W/Kg is unsafe for the human body. The signal power under 0 dBm constraint fulfils the FCC's SAR guidelines.

The WBAN systems commonly face the issue of limited node residual energy. Actually, the miniature size biosensor nodes are compatible with the human body. A miniaturized node possesses a minute onboard energy source, a large amount of which is spent in data routing.

The expectation of the excellent quality of service along with the constraint of limited node energy necessitates the implementation of an energy-efficient and QoS aware data routing protocol for WBAN systems. During our PhD Research work we proposed four different energy-efficient and QoS aware data routing protocols for WBAN systems which are discussed as follows.

(a) Energy Budget Based Multiple Attribute Decision Making (EB‑MADM) Algorithm for Cooperative Clustering in Wireless Body Area Network. In this work we proposed the design of low power, clustering based data routing protocol for WBANs. Proposed protocol incorporates a novel "Energy Budget based Multiple Attributes Decision Making Algorithm (EB-MADM)" for dynamic cluster head selection.

(b) A Hybrid Fuzzy-Genetic Algorithm for Performance Optimization of Cyber Physical Wireless Body Area Networks This protocol presents a fuzzy-logic based clustering-protocol for data routing in WBANs. Nodes are grouped into clusters and cluster head nodes are selected through a Fuzzy-Genetic Algorithm termed as EB-fg-MADM.

(C) Multi-Objective Optimization Framework Complying IEEE 802.15.6 Communication Standards for Wireless Body Area Networks. This protocol presents the implementation of a clustering-based routing protocol for WBAN that targets in achieving overall optimization of WBAN performance parameters including network lifetime, throughput, latency, node signal power and specific absorption rate (SAR) of human body for emf radiation. The suggested protocol applies a multi-objective NSGA-II optimization heuristic for cluster formation while taking into account various IEEE 802.15.6 standard .

(D) Optimal Hub Placement for Energy Efficient Data Routing in WBANs: The GA & Fuzzy-VIKOR based Hybrid Approach. This protocol presents an energy-efficient protocol for optimal hub node placement and clustering-based data routing in WBAN. The proposed protocol is denoted as GA-f-VIKOR. GA-f-VIKOR applies a Genetic Algorithm (GA) based energy optimization process for the optimal hub node placement and initial cluster formation. The fitness evaluation operator is implemented by deriving a model for global network energy consumption in data transmission. After which, the network autonomously selects the cluster head (CH) nodes for each transmission round. Fuzzy-VIKOR-MADM algorithm is used for CH selection. CH nodes are selected on the basis of three-node attributes: residual energy, energy cost and CH job count. Energy cost of a node is the estimated network energy consumption if the node acts as CH and runs a transmission round. CH job count of a node represents the number of times the node performed as CH in previous rounds. Node attributes are transformed into fuzzy grades such as very low, low, medium, high and very high. The ideal solution for CH selection is the node possessing the very high grade of residual energy attribute along with the very low grades of energy cost and CH job count attributes. The node possessing the attributes closest to ideal solution gets the CH job. The inherent simplicity of VIKOR algorithm makes it compatible for a real-time decision-making environment. Fuzzy transformation compensates for the vagueness of real-time attribute information. Practically measured physiological data samples are used for protocol simulation. GA-f-VIKOR achieves an extended network lifetime as compared to existing state of art protocols.