

# Real Time Multi-hop Routing Protocol for Healthcare System Based on WSN

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## Abstract :

Wireless sensor networks are networks of large numbers of sensor nodes that have sensing, communication, and processing capabilities. Recently wireless sensor network (WSN) has been widely used in quite numerous application areas. In the various application fields of WSN, the most important technology we have to focus on in health application is the transmission reliability of the health data in multi-hop communication. The loss of short term health signal can be fatal life threatening. In this paper, our research is focused on the finding of optimized routing protocol for the health related mixed data of wave-like health signals, such as ECG, PPG and linear health signal, such as body temperature and blood pressure. The reliable minimum cost routing protocol developed in our experiment shows very low wireless data packet, and shows high reliable mixed signal transmission in multi-hop communication.

**Key words:** Healthcare, wireless sensor network, routing protocol, biomedical engineering, ECG

## Introduction

The elderly population, that is, those aged 65 years and over, currently comprises around 10 percent of the world's population, and this figure is projected to increase to 22 percent by the year 2050 [1]. Together with a concomitant socio-economic transition, this demographic shift has been forcing policy makers to prepare for the challenges of a rapidly aging society.

Providing patients with convenient health facilities at a low cost has always been a great challenge for health service providers. Moreover, the fast changing life style of the modern world and the problem of aging society pose an urgent need to modernize such facilities. This involves devising cheaper and smarter ways of providing healthcare to sufferers of age-related diseases. This paper presents a ubiquitous healthcare system for the continuous monitoring of patients under their natural physiological states or elderly persons with chronic diseases. Especially our system is designed for homecare or the monitoring of the elderly who live in country side or small rest home without enough support from caregivers or doctors, instead of patient monitoring in big hospital environment. Further insights into the natural cause and progression of diseases are afforded by context-aware sensing, which

includes the use of accelerometers to monitor patient activities, or by location-aware indoor tracking based on ultrasonic and RF sensing. Moreover, our research is focused on the finding of optimized routing protocol for the wave-like health signals, such as ECG, PPG etc. The fast link exchange minimum cost routing protocol developed in our experiment shows very low wireless data packet, and shows high reliable wave-like signal transmission in multi-hop communication.

## System architecture

Fig. 1 shows the conceptual system architecture of the designed wireless sensor network (WSN) based u-healthcare system which is composed of relay nodes on ceiling and mobile node. The patient or elderly wearing bio-shirt with an attached mobile node may go out of limited communication range of WSN. In order to ensure quality of biomedical signal transmission through multi-hop communication between mobile node and base station, relay nodes have to be deployed sufficiently at fixed locations on the ceiling of indoor environment for the data hand over. These relay nodes take a role of transmission of biomedical signals from a mobile node to gateway through multi-hop network. Relay node has only routing

capability to transfer physiological signals, such as ECG, PPG, body temperature and other bio-medical signals to the base station or to surrounding other relay nodes.

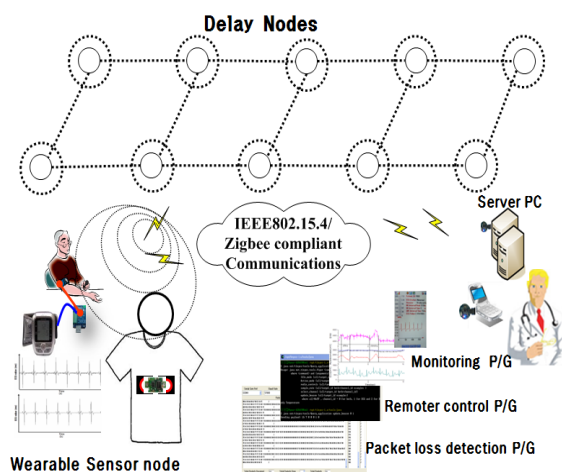


Fig.1 System architecture of u-healthcare system in WSN.

### Routing protocol in WSN

#### (1) Wireless communication in healthcare

Until now, wireless network and wireless sensor network technologies have been widely used for the remote home healthcare, mobile healthcare, remote care for residents in island. In table 1, the recent healthcare projects are summarized in accordance with the key technology of wireless or wireless sensor network. Here the wireless technology is the communication between two nodes, however the wireless sensor network technology is the communication between many deployed sensors with multi-hop communication.

Bluetooth module is normally used for the wireless communication between two nodes, and IEEE 802.15.4 standard is used for the WSN.

#### (2) Wireless sensor network in healthcare

Wireless sensor networks are networks of large numbers of sensor nodes that have sensing, communication, and processing capabilities. Sensor nodes in health monitoring are typically worn in the form of chest belt, wearable shirts, wrist belt, bio patch, and buckle like belt with the biomedical sensors on it. And the sensing data are transmitted through other sensor nodes or relay nodes to the base station. A base station may be a fixed or mobile node capable of connecting the sensor network to an existing communication infrastructure or to the internet where a user can access to the

reported data. As sensor signals are acquired, it is desirable to find the best route to pass the information to the base station. There have been various routing protocols developed for the various applications in wireless sensor networks. [2-4]

Table 1 Medical Status Monitoring in Healthcare Projects

Project	HW	SW	Sensing modality	Wireless or WSN	Obtrusive	Wireless Tech.
	Design					
Mobi Health	No		Multi	W	Medium	Bluetooth.
Code Blue	Yes		Multi	WSN	High	IEEE802.15.4
Alarm Net	No		Multi	WSN	Medium	IEEE802.15.4
Life Guard	Yes		Multi	W	High	Bluetooth
PATHS	Yes		Multi	W	High	Bluetooth
AWARENESS	No		Yes	W	Single	Bluetooth
USN LAB(Bi-direction MCF)	YES		Multi	WSN	High	IEEE802.15.4

Sensor nodes are scattered densely in a field. Special multi-hop wireless routing protocols between the sensor nodes and the sink node are needed. As sensor signals are acquired, it is desirable to find the best route to pass the information to the destination. There have been various powerful routing protocols.

Routing protocols for sensor networks can be classified as either cluster-based hierarchical or flat. Table 2 summarizes the existing routing protocols. Data reporting in WSN is application-dependent and also depends on the time criticality of the data. Data reporting can be categorized as either time-driven, event-driven, query-driven or a hybrid of all these methods. As such, sensor nodes will periodically switch on their sensors and transmitters, sense the environment, and transmit the data of interest at constant periodic time intervals. In event-driven and query-driven methods, sensor nodes react immediately to sudden and drastic changes in the value of a sensed attribute due to the occurrence of a certain event, or respond to a query generated by the base station or another node in the network.[5] Since energy supplies are limited communication among nodes must be both network and energy efficient. To

prolong the network lifetime, routing protocols for wireless sensor networks in healthcare environments must support both periodic basis continuous monitoring and event-driven monitoring.

*Table 2 Comparison of Existing WSN Routing Protocols*

Routing Protocol	Network Structure	Mobility	Power Consumption	Nodes extension
Flooding	Flat	Limited	very limited	very limited
Directed Diffusion	Proactive/flat	Limited	Limited	Limited
Rumor Routing	Hybrid/flat	very limited	N/A	Good
LEACH	Reactive/hierarchical	Fixed BS	Maximum	Good
TEEN	Reactive/hierarchical	Fixed BS	Maximum	Good
APTEEN	hybrid/hierarchical	Fixed BS	Maximum	Good
MCF	Proactive/flat	No	N/A	Good

### (3) Wireless communication in healthcare

Generally speaking, the primary objective of a wireless sensor network is to maximize the node/network lifetime, while performance metrics are secondary objectives. On the other hand, the main aim of a wireless healthcare system should be reliable data transfer with minimum delay.

In a healthcare network, different sensors acquire and transmit data at different sampling rates, subject to different quality of service constraints. Due to this multiple data delivery model, traditional methods of data aggregation cannot be applied to healthcare networks. Nor are energy-saving techniques that use data compression. This type of heterogeneous environment makes data routing more of a challenge. Also scalability is a major issue, because single gateway architecture is not scaleable for a large set of sensors.

The time-driven delivery method is suitable for applications that require periodic data monitoring. However the routing path in our wireless sensor network field is optimized automatically in the self-organizing network by the OS programming in each wireless sensor nodes of the field server.,

*Table 3 Routing protocols used in healthcare*

Routing Protocol	Size (nodes)	Topology	Data amount	Data delivery model	Project
LEACH	100	Cluster-head	Max.	Continuous	Artificial Retina
GBR, SAR	10-20	Star	Mod.	Periodic	Vital sign
APTEEN, GEAR	20-100	Three-Tiered	Large	Hybrid	Aware home
Flooding	<10	Star	Max.	Continuously	UH-PKNU
MCF	10-100	Star	Max.	Continuously	UH-PKNU

In Table 3, several routing protocols which were used in the healthcare projects are listed.

### Routing protocol in test

Special properties of healthcare data, including waveform data and linear data simultaneously from sensors, are considered when the system architecture including routing protocol was designed. Also the effect of packet size and routing update time on the reliability of wireless data transfer has been carefully researched.

We tested three routing protocols such as flooding, bi-directional MCF (minimum cost protocol) and LEACH protocols to find optimal routing protocols for u-healthcare applications [6].

In the seven serial hop communication environment like in Fig. 2, ECG signal was sent from node 7. The packet reception ratios were compared at the node 1 after the 7 hop communication from node 7 to node 1 by the above three routing protocols such as flooding, bi-directional and MCF protocols. From the experiments, bi-directional MCF protocol shows best wireless packet reception ratio of 96.5 %. This experimental result shows that the developed bi-directional MCF routing protocol is very reliable protocol for the hybrid healthcare data.

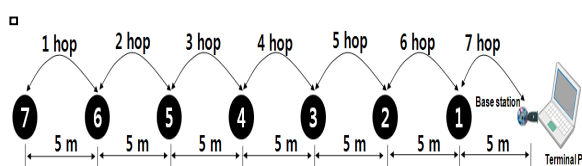


Fig.2 Experimental set-up for multi-hop communication.

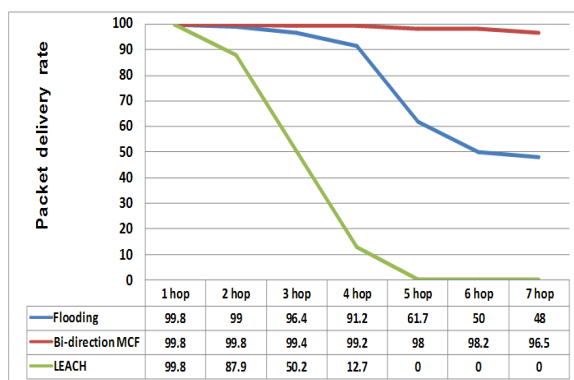


Fig.3 Packet reception ratio for different routing protocols.

## Conclusions

Many routing protocols have been designed and used in various wireless sensor network applications such as environment monitoring, health monitoring, location monitoring and etc.. As healthcare applications commonly handle several types of waveform data, the application of wireless sensor network technology to u-healthcare is rather more demanding than its application to other real-time systems monitoring such factors as temperature, humidity, acoustics, light and pollution. Among three different routing protocols such as flooding, bi-directional MCF and LEACH protocols, bi-directional MCF protocol shows best reliable multi-hop communication.

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