A Novel Protocol in Media Access Control for Wireless Body Area Network

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Abstract
Monitoring vital body sign is very important in medical science and is one of the basic requirements in this branch of science. This has been done manually in the past. With technology improvement in monitoring systems, automated system is used without human intervention. In these systems, sensors connect to patient's body and received data through sensors would be transmitted through wires connected to the central data system for displaying in its monitor. In this paper, we introduce implementing a media access protocol namely PO-MAC. In this protocol collected data through sensors would be transmitted to data center node (data center service node). For proposed implemented protocol evaluation obtained power transmission values, power consumption and delay rate is compared with 2 well known protocols in this area (scope).

Keywords
Monitoring; media access control; polling; Vital signs.

1. Introduction

Sensor networks are new generation in network that usually is consisted of many numbers of cheap nodes and connection between these nodes is wireless. The main purpose in these networks is collecting environmental data surrounded network's sensors. General operation procedure in these networks is collecting required data by nodes and then transmitting toward receivers. Traffic supervision, industrial automation, robots, control-monitor protection are significant applications of sensor networks [1]. Generally nodes consisted of 3 parts sensors, data processor and wireless data transmitter. Each node in addition to transmission part can measure one or more environmental parameters such as temperature, moisture, velocity of light and sound and is able to module environmental parameters independently. Data collection points are nodes with no environmental restriction and they accomplish control, supervision and interpretation of collected data in network through processing the collected data by environmental nodes. Collected data in wireless sensor networks (WSN) can be related with respect to time and location [2]. Body sensor networks (BSN) are kind of wireless body sensor networks (WBSN). Body sensor network (BSN) is a special purpose wireless sensor which with deploying wireless sensor nodes in one's body area can measure his biologic parameters and make his remote health monitoring possible, and is available in both wearable and implantable. These systems also supervise physical activities such as environmental parameters. These systems with representing some services like medical supervision, offering medical and pharmaceutical information, enhancing people memory, controlling home-based devices and communicating in emergency cases can be a great help for people. Existing sensors in network are portable and tiny. Each sensor node usually is capable of receiving one or more vital sign and processing them, storing processed data and transmitting those data to other sensor nodes and or wireless body sensor network (WBSN) server. BSN has smaller number of nodes in comparing WBSN and it has a major effect on reducing power consumption, processing, storage, communicating sources, precision, throughput and transmission delay. Reason for the importance of applying BSN in medical world is exclusive opportunity made by these networks that has transferred medical care from hospitals to the patient's home [3], [4]. In recent years, vital body sign monitoring is proposed as a health wireless network application. Vital body sign monitoring tools that mostly are applied in health and medical centers have made an almost undesirable situation for patients because of their large electronic parts and connection through wires to the other sensors. This situation is due to factors like limited moving option and visible tools on patient's cloth. Part (A) is shown general LAN network used in health centers; where in these networks sensors transmit data through wire to data control center and then data will be sent to receiver unit through wire. In traditional network, implemented control unit is really irritating because of the wires used for connection. For creating WSN tiny connectable sensors is required capable of communicating with wireless data receiving section [7], [11]. In part (B) Fig. 1, wireless network in health center is shown. In this state sensors are equipped to wireless receiver-transmitter and transfer data to data center. Wireless control section that receives data through wireless sensors will transfer received data to receiving section for monitoring [7].

In this paper we describe implementing media access protocol in a wireless system which contains sensor nodes and central node for receiving data. Taking into account that nodes are wireless and with increasing number of sensor nodes in network, preventing collision of dispatched signals from nudes is critical. This implementation tries to describe

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media access protocol to obtain a proper quality service (including well distribution, velocity of alarm, no lost warning). For implementing the protocol and achieving results such as throughput, delay and power consumption in this paper network simulating software NS2 is applied.

2. MEDIA ACCESS PROTOCOLS IN HEALTH AREA

With technology development and recent progress applying sensor networks in daily life became simply necessary. In this network sensor nodes depending on required data locate inside or outside of a human body, and have a short interval for receiving and transmitting data (8). In this section we investigate media access control protocol for WBAN networks.

2.1 TDMA protocol

TDMA divide media to equal time slots and make a setting for frequently revise. Therefore access to channel without collision risk would be possible. In this protocol each sensor has its own time slot and transfers its data in that period. TDMA protocol devotes equal right to all nodes and justice is for all (9). By this concept TDMA protocol can be considered proper for health scope. TDMA applies based on time sharing in networks.

2.2 IEEE 802.15.04 Protocol

This protocol has been used in health area with low data rate, low power consumption, free period and competitive period. For simultaneous receive and transmission data package ultra-casts from data center receiver node, and apply competitive period for data transmission. This protocol due to low data rate and short transmission interval doesn't suit WBAN. Applying IEEE 802.15.04 Protocol is not the best solution for WBAN because is not able to perform applying program with data rate higher than 250 Kb/s and data transmitting package in almost longer interval (distance) (10 m) [3].

2.3 CSMA protocol

In CSMA protocol sensor node is able to listen to the channel before transmitting its data. This capability allows sensor node not to send its data while channel is busy and keep on listening. Detecting channel is free transmission performs. This protocol includes non-persistent, 100% persistent and p% persistent modes. In non-persistent mode if node senses that media channel is busy, it waits for a random period of time to listen to that again. In 100% persistent mode, node keeps on listening to the channel until it gets free. In P% persistent CSMA if node senses media is idle (free) transmission performs with p probability, and with (1-p) probability it waits for next time slot for transmission. Applying CSMA protocol for online implemented healthcare is not appropriate because it's possible with increasing nodes in network and listening to channel and collision detection, sensors can't send their data [10]. This protocol has applied in healthcare with low data rate, low energy consumption, free period and competitive period. For simultaneous receive and transmission data packages ultra-cast from data center receiver node, and uses competitive period for data transmission. This protocol due to low data rate and short transmission interval is not suitable for WBAN [11].

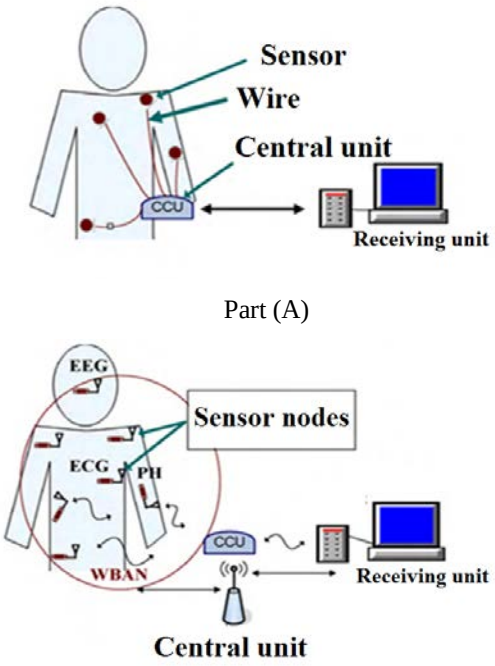

Fig. 1 Health networks. Part A: Wired health network. Part B: Wireless health network.

3. Proposed Protocol

In this section we detailed how to implement proposed media access protocol which is designed especially for health and medical environment. Since invocation has been applied in implementing this protocol, it's named PO-MAC. Invocating sensor node in WBAN and intensive care unit (ICU), instant monitoring such as body temperature, heart signals, breath and etc. is very important. PO-MAC protocol procedure has shown in Fig. 2.

Proposed transmitted frame includes start, distant address, origin frame control section address, data section and error detection section. Data center node is a node that is connected to the computer and is responsible for invocating

sensor nodes and their transmitted data. A scenario can be seen in Fig. 2, is desired nodes invocation by data center node. Media access layer route of all existing nodes in network is addressed in media access layer route of data center node in network. Therefore, all existing sensor nodes in network receive transmitted frame by data center node. Individual node's identity is available in transmitted frame, and all nodes compare it with their own sensor ID by receiving and if the existing ID in transmitted frame by data center node is same as sensor's ID, sensorial activity performs and data will be transmitted to data center node address. In active verification mode, safety of received frame from data center node guaranteed. In PO-MAC protocol each sensor node can use channel for transmitting its data in a particular time slot, therefore equality is among all nodes and each sensor node is allowed to access to channel.

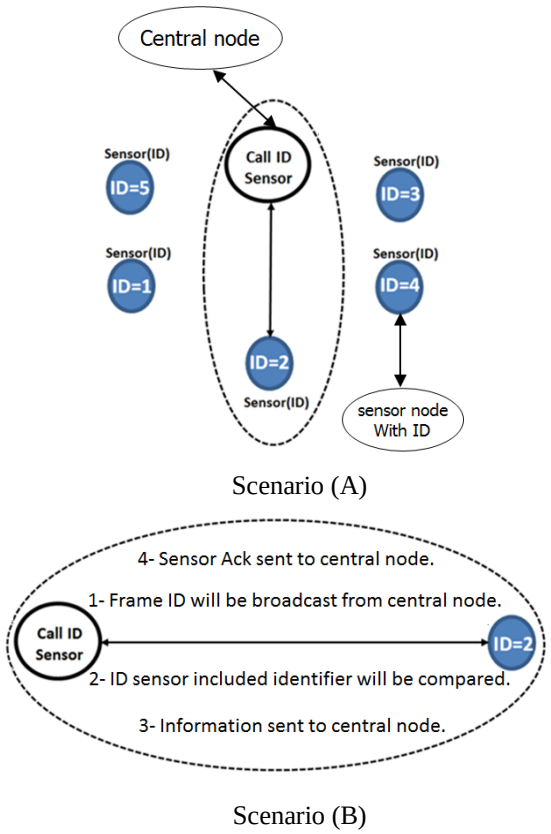

Fig. 2 Operation protocol PO-MAC. Scenario (A): call ID sensor, Scenario (B): Example of poling in WBANs networks.

4. proposed protocol simulation

In this paper the proposed protocol mechanism is evaluated with NS-2 simulator and all graphs are concluded from MATLAB software. The simulation parameters are shown in table 1. Transmission delay in radio link is assumed 0 and there is no transmission deviation.

Power consumption in additional listening is assumed 0.35 W, 0.395 W when receiving data and 0.66 W when transmitting data. Node power consumption in idle mode (sleep mode) is considered 0. Simulation parameters are shown in table 1. Simulation has done in a 7 steps of smart nodes chain. In this topology 7 smart nodes are in same orientation (direction) that node No. 0 namely Sink and interval between 2 neighbor nodes 2 m and their distance to Sink 8 m and transmission power for each node is 10 m.

4.1 Throughput of proposed protocol

As is shown in Fig. 3 throughput of the proposed protocol enhances by increasing data rate. TDMA protocol with time sharing and allocating time slot to sensor nodes in high rate data doesn't performs well. Because in high rate data simultaneous access fails, and transmission/receive precision decreases.

Table1: simulation parameter

Parameters of NS2 simulation	
Bandwidth Radio	100 Kbps
Radio communication	10 m
Collision area	5 m
Packet length	32 byte
Energy transmission	0.66 W
Energy Receiving	0.395 W
Energy Idle	0.352 W
Energy sleeping	0 W
Antenna length	1.5 Cm

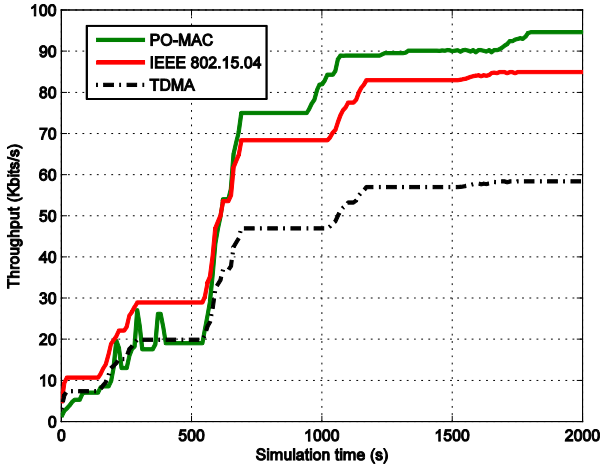

Fig. 3 Throughput per data rate in time

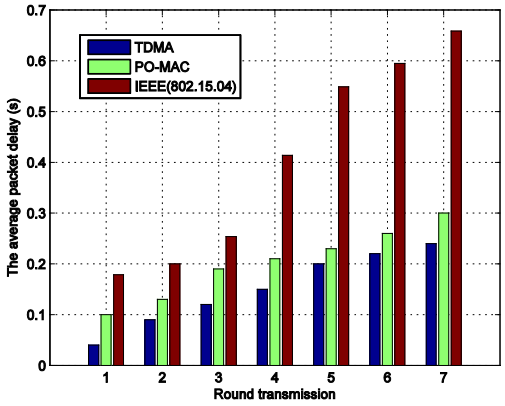

Fig. 4 Average data packet delay per steps number

IEEE 802.15.04 protocol contains a verification packet and applies handshake method that allows enhancing operation output. PO-MAC also applies combination of Invocation protocol and TDMA. Invocation protocol provides simultaneous access between sensor node and data center node, and TDMA allocate (determine) specified time slot to each node. These operations together present accuracy and appropriate output in 100 Kb/s data rate in achieved results.

5. Proposed protocol delay

In this section we compute delay in data packet transmission from sensor node to data center node for the implemented protocol. As can be seen in Fig. 4 different periods in IEEE 802.15.04 protocol represents high latency (delay) in this protocol. IEEE 802.15.04 protocol with applying 3 steps (phases) handshake method (sending request, transmitting received DIFS period, SIFS period, receiving Ack. And etc.) grants data packet transmission. On the other hand spends almost a long time. Since TDMA also specifies time slot, has well delay too. PO-MAC protocol has even more delay comparing to TDMA protocol due to data invocation.

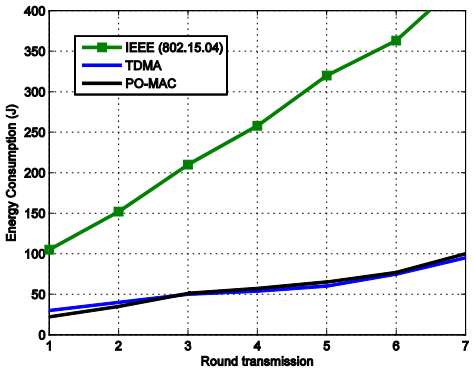

Fig. 5 Total power consumption per number of steps in network

In this section we calculate power consumption for data packet transmission from sensor node to data center node for the implemented protocol. Compared power consumption due to number of steps between previous protocols and the proposed one has shown in Fig. 5. Nodes in network with IEEE 802.15.04 protocol due to its permanent active mode and additional listening when channel is idle loses too much power. Taking into account TDMA infrastructure that allows nodes accessing to channel in specified (determined) time slots, the power consumption in this protocol and the proposed PO-MAC protocol is almost equal. The reason is that of the proposed protocol works on the basis of TDMA with the difference of also applying invocation operation in determined time slots.

6. Type Of topology

In this section relation to type of topology (mesh and Star) simulation discussed. As shown in Fig. 5, Slave-Master topology has high throughput more than mesh and Star topology. In mesh topology, network setup where each computer and network device is interconnected with one another, allowing for most transmissions to be distributed, even if one of the connections go down. This topology is not commonly used for most nodes networks as it is difficult to have redundant connection to every node. Star topology is one of the most common network setups. Every node connects to a central network device. The central network device acts as a server and the peripheral devices act as nodes. As shown in Figure 7, the average delay was investigated with regard to the three topologies were used in our result scenario (Slave-Master) is lower latency.

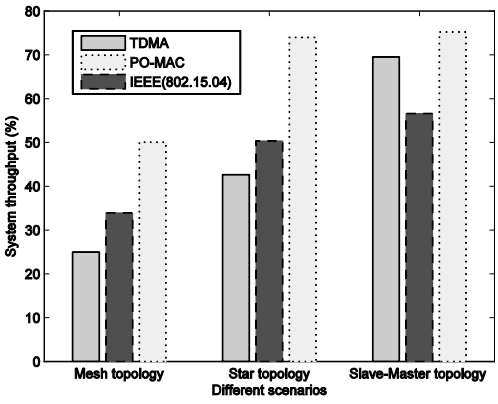

Fig. 6 Compare terms of throughput result topologies simulated.

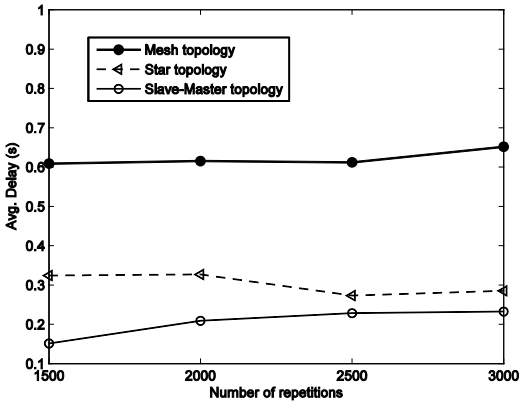

Fig. 7 Compare average of delay result topologies simulated.

7. Conclusion

Recently monitoring vital body sign in different sciences such as medical science is significantly important and has different application. Signs like body temperature, heartbeat, breath rhythm, brain signals and etc. are required for vital sign. In recent researches, investigation on this area and health has developed more. Since creating a wireless network required particular condition, considering nature of these networks needs its special design and organizing. Cases such as measurability, withstanding against omission and or failure of nodes, proper delay reliability in network protocol design shall be considered. Noticing the importance of quality service parameters, in this paper a novel protocol for media access control namely PO-MAC is proposed which tries to improve some quality service parameters. This optimized protocol with applying TDMA infrastructure in each equal work cycle uses distinct time slot and performs invocation.

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