CHAPTER 4

AN ADAPTIVE ENERGY PROFICIENT ROUTING IN MULTI SLOT MAC FOR WIRELESS HUMAN AREA NETWORK

An energy-efficient MAC protocol (Demirkol et al., 2006; Heinzelman et al., 2000) as a novel work were presented to provide healthiness Wireless Human Area Networks. Wireless Human Area Networks contains HAN protocol with a Transceiver and receiver connected to human body parts to guide fundamental signals like temperature of the human body, activity of human movements, heart pulse rate and so on. This network follows a master-slave architecture. The central master node acts as master router. When the link is established between the two nodes then within a cluster, there will be no likelihood of collision occurrence. Each communication node involved in the communication occurs the central node and is also addressed by the slave node uniquely. In order to remove ruin with the immediate transmitters, a fine channel named ‘SoC’ based assessment algorithm based on standard listen-before-transmit is established. To clutch the superimposed time slot, the particular idea of a wakeup fall back time is offered.

In health care sector, the efficient healthcare delivery has increased by using this new technology. The systems act as an eager
model for the efficient power saving by relying on the MAC protocols (Dam and Langendoen 2003; Buettner et al., 2006) such as Bluetooth and 802.11 as wifi and sometimes it becomes inefficient for applications specified in (Chevrollier and Golmie 2005; Brunelli et al., 2006; Stevan Marinkovic and Emanuel Popovici 2011).

Wireless Sensor Network (WSN) based MAC protocols has focused in many intensive research (Stevan Marinkovic and Emanuel Popovici 2011; Daryl et al., 2012; Langendoen and Halkes 2005; Ferrari et al., 2009). But it is not well suited for the biomedical applications. Hence another protocol named IEEE 802.15.4 (Stevan Marinkovic and Emanuel Popovici 2011) (Zigbee) has designed for such applications. Also for the particular applications it lacks the cross-layer optimization features. Similar to other sensor network protocols, the MAC consumes low power. This low power consumption is obtained by having a keen focus on the collision avoidance (Jae-Hoon Choi and Heung-Gyoon Ryu 2011).

Based on network topology adopted in the MAC protocol, many of the traditional problems which curse wireless sensor networks (Reddy and Monika 2012; Ferrari et al., 2009) have been eliminated systematically.

4.1 PROTOCOL DESIGN

As the ultimate objective to reduce the power consumptions from the actions like listening idle, overhearing and collision as target, an energy efficient protocol such as MAC protocol is proposed. Usually
used MAC protocol, IEEE 802.15.4 is not well suited for the specific applications due to the following varying factors such as

i) Failure to maintain the Data reliability in the MAC layer.

ii) Complexity in implementation due to increased multiple communication path.

iii) Limited time slots i.e. 16 slots in a super frame.

For efficient designing of Mac, the time slot should be equally spaced and all the assumptions about the network should be outlined clearly.

4.1.1 Aspects of Wireless Human Area Sensor Network

In the design procedure of the MAC Protocol, the subsequent aspects can be known the wireless human area sensor network.

i. Direct attachment of the wireless sensor nodes to the human body.

ii. Monitoring the information at a low frequency.

iii. Immediate response about the network changes are not required.

iv. Monitoring the sensors at low rate kB for example Temperature, pressure or heart-rate reading.

v. Due to minimum processing power and minimum memory, the sensor nodes are resource constrained.
vi. Central master node is incomparably a minimum resource and power constrained relative to the wireless sensor nodes.

The above mentioned aspects are influenced for the implementation of MAC protocol. Also some of the deployed wireless sensor protocol for the biomedical applications are Bluetooth, IEEE 802.11 and 802.15.4.

4.1.2 Network Architecture

A star network architecture is proposed for designing. For easy and accurate maintenance, only the maximum numbers of 8 slaves are connected to central node in a cluster. Maintaining time slot is considered when more number of slaves is if added. Under this architecture, channel assessment and collision avoidance with time division multiplexing (CA/TDMA) is concentrated more. As a result, this architecture leads to a significant power savings by reducing the likelihood of collision and idle listening. Also the master node takes the responsibility of dynamically controlling time-slot allocation. Therefore the slave node keeps n dynamically changing when it communicates with the master. As a result, the better cope up with the traffic management is maintained.

4.1.3 Basic Operation on Wireless Body Area Network

According to the three major communication processes, the proposed MAC protocol operations are performed. Wireless sensor node joins a cluster which is the first operation named Link establishment
process. After an assigned sleep period, a slave and master wake-up, which is the second operation. This mechanism is called wakeup service process. When a slave necessarily sends information to the cluster master it is the last stage, which is the exception process. That process is called an Alarm process. The master can only initiate the communication in all processes.

In our proposed research, the three main communication processes play a important role in performing MAC operations.

![Proposed MAC Protocol Network topology](image)

**Figure 4.1 Proposed MAC Protocol Network topology**

The proposed system has the central node and the other nodes acts as the slaves. The sensor data are acquired by the slave nodes, which are the confirmed WBASN nodes and the sensor data are transmitted to the central node for processing. Each and every unique master slaves network is called as a cluster.

To simplify the administration, the maximal number of slaves coupled to a master in one cluster is 8 (More than 8 can be coupled, but we have to manage the time-slotting outside the protocol). Even though
it is possible to form complex networks of a ‘central master’ with other masters, the proposed system concentrates on the protocol as it relates to one cluster. The proposed system also has the network access which is clear channel assessment (Sanjit Kumar Dash et al., 2010; Chevrollier and Golmie 2005) and collision avoidance with time division multiplexing (CA/TDMA). The likelihood of collision and idle listening is significantly reduced by this network access, which leads to important power savings. The master in addition dynamically controls the allocation of time-slot. When it communicates with the master, the time slot of slave will be changed every time.

4.1.3.1 Link Establishment

A master node constantly tries to form a link, when it is enabled first. Vacant RF channel is first scanned. As it finds one, the master node stays on that medium and sends out a beam which contains a specific address and composition for a slave and then keeps waiting for a scheduled time for reply.

4.1.3.2 Wake up service

Till sleep both slave and master sleep timers start to count after link establishment. They both wake-up at the same time, as they start at the same time. During the wake-up, the master examines the slave which willingly watches. The slave’s sensor data can be requested by the master, or may demand status information. Even though the transmission goes on, the slave contains a new sleep time, establishing the next wakeup time-slot. During every communication, there is an optional
synchronization phase to ease the long-term time-slot drift between the master and slaves in a cluster. This arrives when the slave can integrate its timer with its master. The timers of master cannot be modified. This additional functionality is just offered, if required it may be used.

### 4.1.3.3 Wake up Fall Back Time

When intricate by the circumstance of sporadic alarm conditions, the time slotting’s central management can be a difficult task for master. During this period, the sensor data is continuously buffered. When WFT gets over, again it wakes up and explores for the master. Due to this reason, both master and slave wakeup during the common WFT and communicate, schedule restoration. WFT is also universal to the network and is basically set by the master at the link establishment process.

### 4.1.3.4 Cross Layer Functionality

Before dropping the packet, the MAC mechanically retries a programmable for a longer time, once a sending of information packet fails. Also it mechanically breaks down giant packets in to shorter frames and sent one at a time. The segmented data packets are reassembled as they received at the receiver by the protocol. The management of the frequency and rate of sensor knowledge acquisition area unit extra functions provided that depends on the operation. Within the ISO/OSI protocol stack, these functions area unit managed by the upper layers. Hardware implementation straightly at the MAC layer is most popular. Owing to this, the processor commonly ought to run
unendingly to execute these operates like determinative once to require subsequent detector reading, what percentage ought to be taken and once to change to a different detector.

4.1.3.5 MAC Complexity

12 K-gates for the slave and K-gates for the master for whole hardware MAC protocol, which includes the controlling of error and block framing. Simplicity of the protocol is pointed by the count of the gate in hardware implementations. We compared software implementations of both protocols, as there is no hardware implementation of 802.15.4. 16 kB of code is used to implement the proposed protocol (including application code) while 32 kB is required for 15.4. Around 500W power consumption is required for this implementation while 10 mW for 15.4.

4.1.3.6 System Power and Duty Cycle Analysis

Based on the duty cycle of operation, the average power consumption takes place. As a sensor node will have a lengthy sleep time, and has a lengthy active time, the duty cycle could be high and have moderate power. The interconnection between the parameters that influence duty cycle and average power computation have been analyzed detail.

4.2 PROTOCOL IMPLEMENTATION

The MAC protocol was introduced as a main part of a custom system-on-chip (SoC) ASIC for Wireless Human Area Network
applications is the detailed system modeling. It is called Sensium, mixed-signal SoC. Through a DMA controller, the data memory is directly accessible by the Sensor Interface ADC (Lee Badger et al., 2011; Mell and Grance 2012) (to write sensor readings) and by the hardware MAC (to read/write sensor readings for direct transmission/reception).

4.3 SYSTEM POWER AND DUTY CYCLE ANALYSIS

Based on the duty cycle of operation, the average power consumption takes place. As a sensor node has a lengthy sleep time, and also has a lengthy active time, the duty cycle would be immense and have average power. The application of spot measurement such as temperature and glucose and for continuous controlling applications like ECG, Packet Transferring, Control log etc. uses the computed result. The correlations between the parameters that affect duty cycle versus sleep time and average power computation for symbol rate sequences have been analyzed details are shown in Figures 4.2 and 4.3.

Figure 4.2 Duty Cycle Vs Sleep Time
4.4 IMPLEMENTATION OF THE WIRELESS HUMAN AREA NETWORK PROTOTYPE

4.4.1 Experimental Environment

Figures 4.3 denote our controlled environment for measurement and evaluations which provides correct corrections of error and want the correct understanding of the input signals. We opted to employ ECG recorded signals because real sensors do not correctly represent their input. The computational environment carries the explanation of the input signal $u(t)$, the PDA and the TDM implementation, and calculation of performance. The data transfer between the computational environment uses software package (ArbExpress, Tektronix) and the generator nand/or oscilloscope which uses the CSV (comma-separated value) file format.
4.4.2 Reconstruction Accuracy in the Computational Environment

We hand-picked and G signal from the MIT-BIH public arrhythmia information so as to emulate a practical category of sensor generated signals. When a 7-th order polynomial interpolation, one amongst the (scaled) signal is segmented. We tend to utilize a periodic input in our experimental platform attributable to measure constraints. A section of length a pair of 2.5 s of the signal into Fourier-series is distended by a periodic Wireless Human Area Network restricted waveform u(t) was developed. 750 Fourier coefficients are computed using quick FFT algorithmic rule. The measured results of u(t) are achieved and utilized.

4.4.3 Comparative Analysis

<table>
<thead>
<tr>
<th>Power efficient Mechanisms</th>
<th>Protocols</th>
<th>Basic Operation</th>
<th>Advantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Schedule-Contention</td>
<td>SMAC</td>
<td>Reduce power consumption through periodic sleep listen</td>
<td>Energy waste caused by idle listening is reduced</td>
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<tr>
<td></td>
<td>TMAC</td>
<td>Introduces adaptive duty cycle that can adapt to different traffic patterns</td>
<td>Increased throughput and end-to-end latency</td>
</tr>
<tr>
<td></td>
<td>DMAC</td>
<td>Uses carrier sensing method to avoid collision</td>
<td>Adjust duty cycle according to sleep schedule</td>
</tr>
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<td>Power efficient Mechanisms</td>
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<td>Advantages</td>
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<tr>
<td>Schedule-Contention</td>
<td>LMAC</td>
<td>Uses round robin technique to transmit the data</td>
<td>Extends the network lifetime, decrease number of transceiver switches</td>
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<tr>
<td></td>
<td>ERMAC</td>
<td>Uses energy criticality function and allows more critical nodes to go sleep</td>
<td>No contention mechanisms is involved</td>
</tr>
<tr>
<td>TDMA</td>
<td>HMAC</td>
<td>Uses heartbeat rhythm to synchronise the clocks of nodes</td>
<td>Bandwidth efficiency is improved</td>
</tr>
<tr>
<td></td>
<td>Body MAC</td>
<td>Uplink and downlink sub frames are introduced</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Med MAC</td>
<td>Uses Multi-Super frame structure and beacons to synchronise the nodes</td>
<td></td>
</tr>
<tr>
<td>Low Power Listening</td>
<td>Wise MAC</td>
<td>Uses preamble sampling technique to listen the idle medium</td>
<td>Adaptive to traffic load, low power consumption</td>
</tr>
<tr>
<td></td>
<td>BMAC</td>
<td>Asynchronous Mac protocol uses adaptive duty cycling to reduce duty cycle</td>
<td>Improved latency, high throughput, flexible</td>
</tr>
<tr>
<td>Energy Efficient</td>
<td>Proposed MSMAC</td>
<td>Multi slot MAC protocol using SoC</td>
<td>Improved Energy Efficient</td>
</tr>
</tbody>
</table>

In our research study existing MAC protocols for Wireless Human Area Network have been analyzed towards energy consumption. Owing to different hardware constraints and application requirements
most of the protocol is not been accepted as a standard. The proposed new MSMAC protocol is meeting the standard and energy efficient has been much improved.

On examination with different systems, the consumption of power is that RF power demand is considerably lower for this work. Shorter batteries like flexible-thin or zinc-air area made possible, that can not be used for any of the opposite standards. The conclusion for this can be that energy is that the penalty these protocols purchase their generality. We are able to reach a lot of reduced power necessities employing a proprietary protocol just like the one conferred.