AN ENHANCED GROUP MOBILITY MANAGEMENT METHOD IN WIRELESS BODY AREA NETWORKS

RADHWAN MOHAMED ABDULLAH[1], ALI A. ALWAN[2], KAMIL G. SALIH[3], and ZURIATI AHMAD ZUKARNAIN[4]

[1,3]University of Mosul, College of Agriculture and Forestry, Division of Basic Sciences, Iraq

[2]International Islamic University Malaysia, Kulliyyah of Information and Communication Technology, Department of Computer Science, Kuala Lumpur 53100, Malaysia

[4]University Putra Malaysia, Faculty of Computer Science and Information Technology, Department of Wireless and Communication Technology, Serdang 43400, Malaysia

E-mail: [1]radwanmas@yahoo.com, [2]aliamer@iium.edu.my, [3]Kamil@yahoo.com, [4]zuriati@upm.edu.my

ABSTRACT

Mobility management of wireless body area networks (WBANs) is an emerging key element in the healthcare system. The remote sensor nodes of WBAN are usually deployed on subjects' body. Certain proxy mobile IPv6 (PMIP) methods have been recommended, however, PMIP is relatively impractical in group mobility management pertaining to WBAN. It is likely to cause enormous registration and handover interruptions. This paper presents an approach aims at overcome these limitations using improved group mobility management method. The method emphasizes on incorporation of authentication, authorization, and accounting (AAA) service into the local mobility anchor (LMA) as an alternative to independent practice. Furthermore, proxy binding update (PBU) and AAA inquiry messages are merged. Additionally, AAA response and proxy binding acknowledge (PBA) message are combined. The experiment results demonstrate that the proposed method outperforms the existing PMIP methods in terms of delay time for registration, the handover interruptions and the average signaling cost.

Keywords: *Handover Operation, Wireless Sensor Network, Mobility Management, Pmipv6, Low-Power Wireless Personal Area Networks*

1. INTRODUCTION

The major challenge of world population growth is an expanding aging population due to elevated life expectancy. By 2025, the global aging population (aged > 65) is projected to grow a 2-fold from 357 million to 761 million [1]. Consequently, the expanding growth of the aging population has directly resulted in an increase in the healthcare expenses. Resultantly, these challenges have prompted the breakthrough of innovative technology-based developments to existing healthcare tools like small and intelligent medical sensors. The medical remote sensors are affixed on the body or beneath the subject's skin, where it transmits information to an exterior medical server. These sensors enable better physical mobility. The mortality rate due to serious medical conditions such as cancer and cardiovascular disease is increasing per annum.

This is mainly because many people are diagnosed with the disease when it is too late. In view of this, early detection of a particular disease could be achieved through the application of cutting-edge technological developments in WBAN systems. This would aid in the early preventive measures for a particular disease. "Fundamentally, the sensors nodes on WBAN can be utilized for progressive monitoring of health status" [2-4]. "In WBAN, sensors can be affixed to the human body or outfits" [5, 6]. Henceforth, the sensors function

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

to analyses the determinants of the health status. Subsequently, the determinants are collected and imparted to the central server for healthcare implementations.

The solution for the problem facing IP shortage is to create IPv6 addresses, since they contain wider spaces for such addresses. Recently, an increasing interest has been realized in the low-power wireless personal area networks (LoWPANs) due to the use of the internet of things (IOTs). In addition, a working group of the Late for IPV6 over ((6LoWPANs) was initiated by the Internet Engineering Task Force (IETF) [7]. Consequently, remote sensor nodes could likely be linked to IPv6 networks. But, the remote sensors nodes lack the capacity and ability to enhance and shore up the whole IPv6 address. This is because the ultimate packet size of IEEE 802.15.4 is 127 bytes. In order to have the 40-byte IPv6 packet header compacted into 2 bytes for inbound communication, there is an adaptation layer added by the 6LoWPAN in between the network layer and MAC. While doing that, the 6LoWPAN decompresses the layer for the outbound interface.

As the case with handover control, the mobile settings require that sensor nodes are used for mobility management. There are some host-based methods that are unsuitable for the application of internet protocol (IP) based sensor in WBANs [8-10]. While containing mobility stack, all of the sensors actively are involved in creating mobility-related signaling. One of the solutions that could be adapted to the mobility management in 6LoWPAN-based WBAN may be the network-based approaches which include proxy mobile IPv6 (PMIP). In line with the above, it has been suggested that several methods could be used for supporting mobility with regards to the 6LoWPAN-based WBAN [11, 12] as the latter uses the PMIP protocol [13]. As such, registration and handover interruptions could be reduced by such methods at the same time, delay performance could be improved. This paper proposes the use of an enhanced group mobility management method. The method designed for WBAN by implementing a new approach for PMIP. We believe that the proposed solution can lead to a significant reduction in the delay time for registration. Besides, it also leads to decrease the handover delay and, most importantly, reduces the average cost of the handover signalling cost. Therefore, the suggested method of the proposed study includes the authentication features, which are integrated into local mobility anchor (LMA) as an alternative to independent practice. Proxy binding update (PBU) message and authentication, authorization, and accounting (AAA) query message are combined. Additionally, AAA reply and proxy binding acknowledge (PBA) message are combined.

The main contributions of this paper have been outlined as follows:

- The paper highlights the issue of group mobility management in WBANs discussing the management of registration and handover interruptions in WBANs network and demonstrate that a new solution is required.
- We perform a thorough survey for the majority of the notable related works in the area of group mobility management in WBANs. The survey covers previous methodologies addressed and discussed issues pertaining to network management in WBANs. The review looks at and outlines the strengths and the shortcomings of each methodology.
- We introduce an enhanced group mobility management method in WBANs context. The proposed solution focuses on resolving the issue of registration and handover during deployment of the nodes.
- A new mobility management scheme has been proposed aiming at enhancing the management of node movements in WBANs. The proposed scheme involves several processes providing local mobility anchor (LMA) as an alternative to independent practice.
- We evaluate the efficiency and the effectiveness of the proposed strategy with a variety of experiments utilizing the network simulation. The experiments demonstrate the superiority of the proposed scheme in terms of registration and handover delays and the average signalling cost.

The rest of this paper is organized as follows. A brief related work is given in section 2, followed by the description of the proposed enhanced group mobility management method in section 3. Section 4 illustrates the simulation environment and presents the numerical results of the experiments. The performance analysis is highlighted in section 5 through drawing a comparison between the proposed and existing methods via numerical analysis; finally, the conclusions constitute the last section, Section 6.

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

2. RELATED WORK

"Sensor devices plus protocols were subjected to a survey to determine the physical layer, data link layer, and radio technology features of body area networks" [14]. There have been a lot of research efforts made focusing on security issues in WBAN [15-17]. The work presented by He et al. [15] has proposed a new method tackling the issue of an attack-resistant and lightweight trust management in WBAN. ReTrust is the suggested method, consisting of two-tier architectures. These architectures tend to implement Collection Tree Protocol. Experimental results have indicated that not only could ReTrust detect malicious/faulty behaviors but it could also better the performance of the network. Another model being proposes is the distributed trust evaluation model. This model uses simple cryptographic techniques and medical sensor networks (MSNs) [16]. This proposed method banks on monitoring the relevant node behavior's. Such node behaviors incorporate transmission rate and leaving time, which are used to detect the malicious nodes. In the work of Zhang et al. [17], a key agreement method is introduced as means of generating a common key that employs the electrocardiogram (ECG) signals. This generated common key is shared with the neighbouring nodes in BANs.

Based on existing evidence, it is likely to emphasize that 6LoWPANs is proper for the sensors in WBANs, for such sensors are suitable for the requirements of IEEE 802.15.4 standard [18]. Accordingly, it is safe to argue that the 6LoWPAN mobility could be used as one of the promising approaches for the sensors in WBANs. Conversely, the current IPv6 host mobility protocols are not appropriate for 6LoWPAN-based remote sensors due to being tunnel approaches. Accordingly, all of the mobile sensors are engaged in mobility-related signaling in bid for ensuring constant communication [8-10, 19]. In Oliveira et al. [20] work, it is suggested that the requirements and resources face certain challenges with respect to adjusting the existing solutions to meet 6LoWPAN requirements, which means that more investigation must be done on 6LoWPAN mobility. A method is proposed by Islam et al. [21] with the intention to enhance the IP-WSN. This method is intended to make use of a new communication packet format in ingress interface in bid for addressing the handoff procedure. Whereas Oliveira et al. [20] suggest that it is not possible to utilize multi-hop communications in PMIPv6 protocol, Haw et al. [22] states that it is possible to use in the ingress interface a multi-hop communication method via the employment of mesh routing for the sake of expanding range coverage. Yet, the focus of this proposed method is one single mobile node. As such, the method fails in providing an effective solution with respect to more than one node circulating around. In the work of Bag et al. [23], a 6LoWPAN mobility supported method is highlighted. This method banks on 6LoWPAN types being dispatched. One of the method's pitfalls is the lack of any plain improvement to decrease handoff delay.

Moreover, it is clear that the network-based approach could be appropriate for supporting the mobility management of 6LoWPAN-based body sensors [13, 24]. The network node acts in place of the sensors and thus, shares the mobility-related signaling, and excludes duplicate address detection (DAD) of the IP address. By doing so, it decreases the cost of the control signaling and each sensor's late handover. . Since PMIP protocol supports multi-hop communications [20], a multi-hop communication method is suggested for ingress interface through the use of mesh routing [25]. But, such a method does not have the efficient capacity to operate several nodes moving around, because of being suitable for operating only one node. [25]. From a network-based perspective, network mobility (NEMO) [11] is recommended by a previous study [26] with respect to the based 6LoWPAN mobility method. This means that the handover is carried out by a mobile router with the intention to modify the dispatch of the 6LoWPAN. But unfortunately, such mobile router has been overloaded by this type of protocol. It therefore important to have the sessions and at the same time decrease the handover interruptions. The same holds true with regards to the signaling rate of group-based mobility in 6LoWPAN-based sensor in WBANs. In a study, it is proposed that there are countless interrelated sensor nodes that move together; perform handover simultaneously in PMIPv6 environment [27].

The value of each sensor of the signal-to-noise ratio (SNR) is calculated by the LMA, which at the same time, creates a group of sensors with the same SNR values. The said protocol decreases the cost of the handover signalling by sending PBA per each group. By using such method, several extra unwanted handover messages are saved such as PBU and de-registration (DeReg). Despite that, this protocol lacks the capability to decrease the messages of both router solicitation (RS) and router advertisement (RA). This is so because body sensors move in the PMIPv6 domain collectively. Accordingly, it is safe to state that the said protocol

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

is not proper for the 6LoWPAN-based sensor in WBAN.

3. AN ENHANCED GROUP MOBILITY MANAGEMENT METHOD

This section explains the detail components that consist of the proposed improved group mobility management method for WBAN roams in PMIPv6. It aims at reduces the registration delay, the handover delay and the average signaling cost of handover. The propose method consists of three components, namely: network model, initial registration, and handover operations. These components are further explained in the following subsections.

3.1 Network Model

Figure (1) gives an illustration of the network model for the proposed method. In this case, a group of 6LoWPAN sensors is put on to a human body. One of sensors functions as a coordinator. This sensor coordinator is the one having the ability to interchange with the control signaling messages in the PMD and acts on behalf of other sensors. Noteworthy that 6LoWPAN domain incorporates a PMD. In the proposed method, LMA is the one that carries out the AAA function. Also, it is noted that the handover operation is implemented within two adjacent MAGs needing no assistance from any AAA server for the group of sensors. Moreover, both the authentication processes and that of the sensors group are maintained by the LMA. It is further realized that each MAG lacks the ability to carry out the AAA operation with AAA server. This is because the LMA possesses the AAA functionality. Actually, in the pMAG domain, the coordinator communicates with the correspondent node (CN), and by the handover, moves to a nMAG.

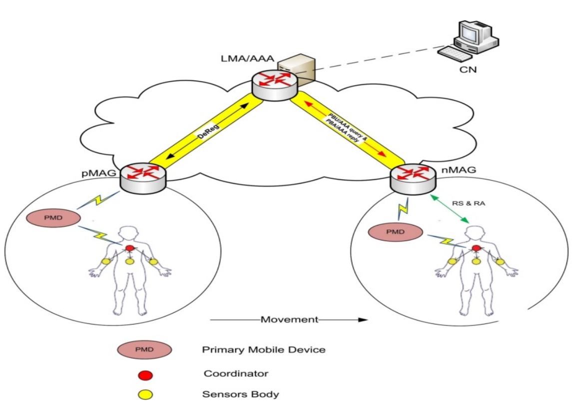

Figure 1: Network model for the proposed method

3.2 Initial Registration

The stage of registration aims at reducing the control messages volume. . The initial registration of the suggested method is illustrated in Figure 2. As soon as a group of body sensors enters into a PMIP coverage area, a grouped RS message is sent to MAG by the coordinator which is attached to the nearest MAG. The grouped RS message contains the data on group link-layer addresses (LLAs) and MN-IDs to MAG. After receiving the respective RS message from the coordinator, MAG sends an aggregated PBU and AAA query message to LMA/AAA. It should be noticed that these features are not similar to the previous group mobility management methods. The proposed method contains combination of these two messages which leads to a significant reduction in the average cost of signaling of handover and the delay registration cost as well. In response to the PBU/AAA query message, the LMA/AAA send back PBA/AAA reply message. Next, MAG commences the DHCP solicitation method to demand home network prefixes (HNPs) for the body sensors one by one. After that, the DHCP server provides answers for each body sensor using the unique HNPs. Along with making the binding cache entry, the MAG stores the information of the home network prefix. Not only does the DHCP server design the respective home-of-address (HoA) from the prefixes, but it also sends the HoA to the MAG. Finally, the MAG responds by sending the coordinator an RA message with as some sort of feedback to the RS message.

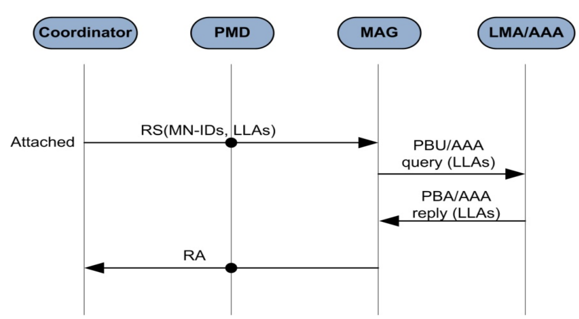

Figure 2. Initial registration

3.3 Handover Operations

Active scans along with adjacent PDMs are occasionally carried out by the body sensors. This process is done by sending a beacon request. The beacon request is sent to the adjacent PMDs by the body sensors. As such, the PMDs stimulate the beacon message which has their MAG-IDs to the body sensors. After the acceptance of the beacon message, the body sensors determine if the sensors are still in the identical MAG or have been transferred to a new MAG. This is through the comparison of the present MAG-IDs to the former ones. If both the present and previous MAG-IDs are identical, this indicates that there is intra-PAN mobility. Put differently, if the current MAG-ID could be singled out from the old one, then, it is proven that the body sensors have the capability of detecting the movement from the old MAG to the new one.

Figure 3 illustrates the detailed signaling flow of the handover process. Upon the detection of the detachment of the coordinator from its link by pMAG, the pMAG removes the binding and routing state for that coordinator and sends a DeReg message to LMA/AAA to close the packets delivery tunnel. After receiving this request, the LMA/AAA accepts the request and waits for the nMAG to update the binding on a new link. Once the coordinator attaches to the nMAG, it sends an aggregated RS message to nMAG. Then, the aggregated PBU/AAA query and PBA/AAA reply messages will be with LAM/AAA by the nMAG. After this operation has been finished, there is a response sent by nMAG to the coordinator. This response contains a router advertisement (RA) message. Now, as soon as CN receives the PBU message sent by nMAG, the route is optimized. Following that, the mapping table of the CN is updated. CN would then send a PBA to nMAG. As a result, both nMAG and CN will now be able to use the optimized route.

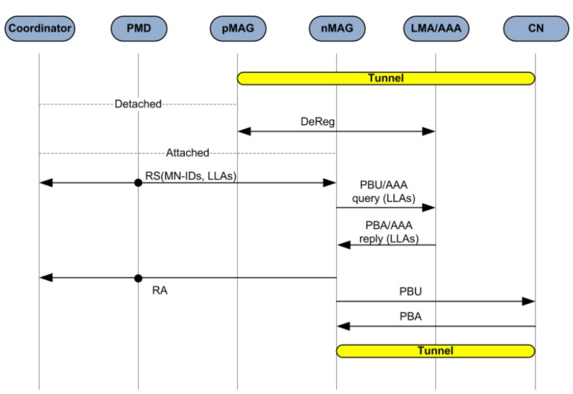

Figure 3. Signaling flow of the handover operations

4. SIMULATION ENVIRONMENT AND NUMERICAL RESULTS

Figure 2 illustrates the proposed network scenario. This scenario incorporates three WiMAX, five WLAN networks and 20 MNs. The WiMAX cell's radius was 2,000m while for WLAN cell it was 150m. The speeds of MNs range between 5, 10, 15, and 20 and to 25 m/s in random paths. In Table 1, there is a brief account of the parameter variables employed by default in the simulations showing the used network topology. The simulation method used in this paper has been tested in order to determine the different speeds of the four scenarios of the traffic type in MNs. These MNs have various packets' volumes. Each scenario exemplifies an individual traffic class. Video, Best Effort, Video and Background classes are incorporated in the individual traffic class. The values of the network characteristics represent these traffic classes in accordance with the recommendations provided by ETSI standards [18] as QoS requirements. Every class is used to reflect various altitudes of priority-based ratio. It, accordingly, gives various levels of priority for the candidate networks. The simulation was operated through the use of four scenarios and two modes of priority distributions. This is for the sake of collecting the needed statistics. TOPSIS is employed to select the network preferences. A discussion is elaborated to highlight how priority criteria are allocated for each scenario and how related conditions could have an impact on the ultimate output of the performance metrics.

Also, this section explains and discusses the numerical results of the proposed solution for group mobility management in WBANs. In order to evaluate the effectiveness and the performance of the proposed method, we developed a simulation using the NIST mobility package [28]. The mobility package involved in the simulation is developed for the NS2 network simulator version 2.29 with PMIP [8-10]. Three recent methods have been implemented and used as a benchmark for the comparison purposes against our proposed method. These methods include PMIP method [13], which is denoted as method 1 in the experiment result figures. The second method is PMIP Group method [11], which is named as method 2 in the experiment results. Lastly, the third method PMIP coordinator method [12], which is called method 3 in the figures of the experiment result. The experiment results of these three methods are reported in this paper for the aim of a clear analysis of the initial registration, and handover operations. Furthermore, the proposed method was implemented for evaluating the performance in terms of registration delay, handover delay and average signaling cost. The default value of each parameter is designed as detailed below [29]:

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

$H_{\text{MAG-LMA}} = H_{\text{MAG-LAM/AAA}} = 5$, $H_{\text{MAG-AAA}} = H_{\text{LMA-AAA}} = 5$, $L_{\text{wl}} = 10$ms, $L_w = 2$ms, $q = 0.5$, $T_q = 5$ms, $N_S = 10$, $S_c = 96$ bytes, $S_d = 200$ bytes, $B_{\text{wl}} = 11$Mbps, and $B_w = 100$Mbps

The findings revealed that L_{wl}, T_q and N_s may rely upon the network circumstances. Accordingly, the performances of candidate methods were compared by changing the values of the parameter.

4.1 Registration Delay

Figure 4 demonstrates the effect of link delay in wireless networks (L_{wl}) on the registration delay. For all candidate methods, the results indicate that the registration delay positively correlated with L_{wl} value. This reveals that the suggested method had superior performance compared to other methods. This is due to that the proposed method makes use of the AAA functionality over LMA, and thus the operation both the AAA query and reply are not needed between AAA and LMA. As pointed out in the suggested method, the MAG combines aggregated proxy binding and authentication operations.

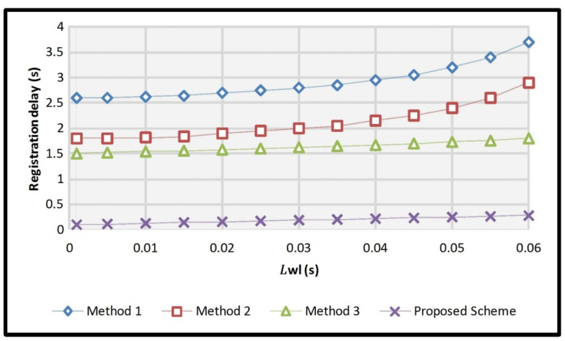

Figure 4. Impact of L_{wl} on registration delay

Figure 5 demonstrates the effect of different queuing delay (T_q) at every node on the registration delay. There was a positive correlation between the registration interruption and T_q value for all candidate methods. Therefore, the suggested method had superior performance compared to other the candidate methods. This is by cause of each LMA implements the AAA functionality.

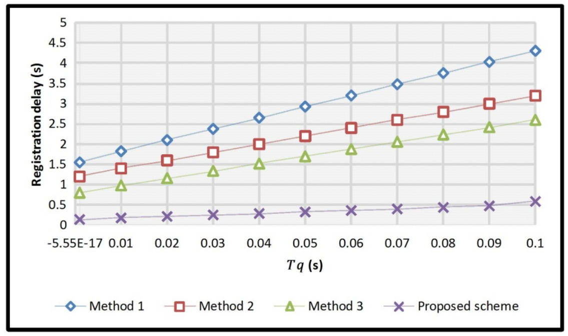

Figure 5. Impact of T_q on registration delay

Figure 6 demonstrates the effect of the amount of sensors (N_s) on registration interruption. The findings indicated that the handover interruption positively correlated with N_s for the remaining methods. Moreover, the suggested method is unaffected by N_s. This is mainly due to the volumes of the authentication messages for each registration despite the quantity of the body sensors. In addition, since the suggested method makes use of the AAA functionality over LMA, the operation between LMA and MAG are not required to send/receive the PBU/PBA because they tend to merge within the authentication messages. Therefore, each body sensor requires conveying a lesser quantity of control messages. Consequently, this leads to lesser registration interruption as the amount of body sensors rises.

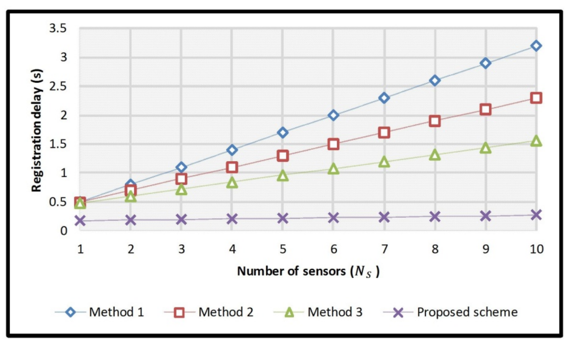

Figure 6. Impact of N_s on registration delay

4.2 Handover Delay

Figure 7 demonstrates the effect of link delay in wireless networks (L_{wl}) on handover delay. There was a positive correlation between the handover interruption and L_{wl} for entire candidate methods. This reveals that the suggested method had superior performance compared to the existing methods. This is caused by the AAA function that is performed by the LMA and handover procedure that is conducted amongst two adjacent MAGs without the assist of AAA.

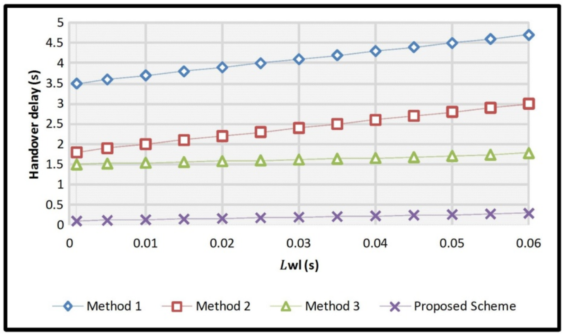

Figure 7. Impact of L_{wl} on handover delay

Figure 8 illustrates the effect of queuing delay (T_q) at every node on the handover delay. The results indicate that the handover interruption positively correlated with T_q for entire candidate methods. Therefore, the suggested method had superior performance compared to other candidate methods.

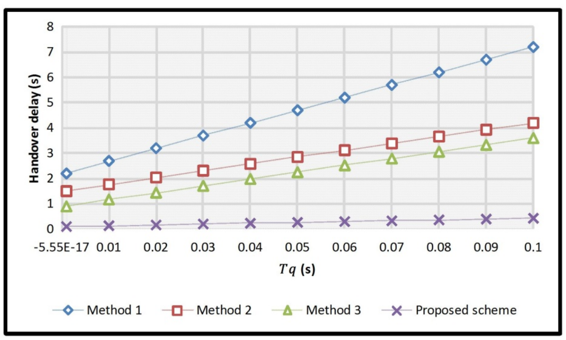

Figure 8. Impact of T_q on handover delay

Figure 9 displays the effect of the amount of sensors (N_s) on handover delay. There was a positive correlation between the handover interruption and N_s for the remaining methods. Moreover, the proposed method is not influenced by N_s. This is due to that every handover has messages for both PBU/AAA query and PBA/AAA reply. These messages have constant sizes in spite of the quantity of the body sensors. While the suggested method intends to execute the AAA functionality over LMA, the operation of the handover is executed amongst two adjacent MAGs that do not need the support of AAA. The authentication operations, nevertheless, are no longer necessary between AAA and LMA. As a result, a lesser quantity of control messages is needed to be transformed by each body sensor. Consequently, this experiences lesser handover interruption as the amount of body sensors rises.

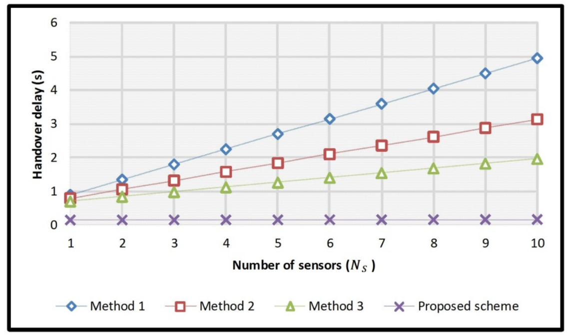

Figure 9. Impact of N_s on handover delay

4.3 Average Signaling Cost

Figure 10 illustrates result of the experiments that have been conducted to investigate the impact of the amount of sensors (N_s) on the average signaling cost of handover. The results show that the number of control messages keep exchanging over the network model. The figure also shows that the average signaling cost of the proposed method is steadily the lowest compared with the other three methods. This is due to the fact that the proposed protocol uses one message to carry other sensors nodes information that in turn reduces the control message. We also observed that our proposed method is not influenced by the number of sensors N_s. The reason behind this improvement is that the total signaling costs of the proposed method not increased when the number of body sensors increases. This is because the numbers of the PBU/AAA query and PBA/AAA reply messages for each handover of the proposed method is a constant no matter how many body sensors are considered.

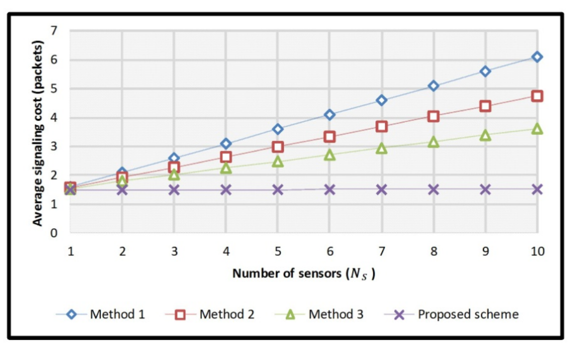

Figure 10. Impact of N_s on Average signaling cost

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

5. PERFORMANCE ANALYSIS

This section reports the performance evaluation and analysis of the enhanced group mobility management method that have been proposed in this paper. The analysis emphasizes on comparing the proposed solution with most recent methods in terms of the time delay for handover registration, the handover delay and the average signalling cost of the handover. These are the most critical performance metrics that have been considered to measure the performance of the mobile handover method by many research works [6, 12, 30-31]. Four candidate mobility methods and considered in the analysis, namely: Method1 [13], Method2 [11], Method3 [12], and our proposed method. Further details on the detail analysis are given in the following subsections.

5.1 Analysis Model

Figure 11 illustrates a network that has been recommended for such process. Bandwidth, latency, and average queuing delay are used to represent each wired/wireless link. A generic model has been assumed for presenting the multiple access control (MAC) method. This method is highlight the analysis of registration and handover interruptions pertaining to the suggested mobility method. Table 1 summarizes the notations and the parameters used for analysis. .

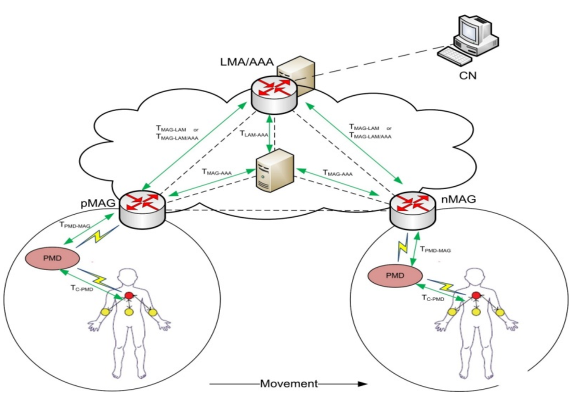

Figure 11. Performance analysis

According to Figure 11, $T_{x\text{-}y}(S)$ is denoted as the transmission interruption of a message with size S sent from x to y through the "wireless" link, in which every message can endure the failure at the probability of q via "*iid*" error model. Therefore, $T_{x\text{-}y}(S)$ is denoted as $T_{x\text{-}y}(S) = [1/(1 - q)] \times [(S/B_{wl}) + L_{wl}]$. Meanwhile, $T_{x\text{-}y}(S, H_{x\text{-}y})$ is symbolized as the transmission interruption of a message with size S sent from x to y through the "wired" link, in which $H_{x\text{-}y}$ characterizes the amount of wired hops amongst node x and node y. Therefore, $T_{x\text{-}y}(S, H_{x\text{-}y})$ is denoted as $T_{x\text{-}y}(S, H_{x\text{-}y}) = H_{x\text{-}y} \times [(S/B_w) + L_w + T_q]$.

Table 1. Notations used in the Analysis

Field	Description
Sc	Control packets size (bytes)
Sd	Data packets size (bytes)
NS	The amount of sensors in the coverage area
Bw	The bandwidth in wired networks (Mbps)
Bwl	The bandwidth in wireless networks (Mbps)
Lw	The delay in wired networks (ms)
Lwl	The delay in wireless networks (ms)
$Ha\text{-}b$	The number of hop between nodes a and b
q	The failure probability in Wireless networks
Tq	The queuing delay at each node

5.2 Registration Delay (RD)

Reference [13] shows that body sensors are affixed to MAG. This is so that the coordinator and PMD send MAG RS messages. Initially, MAG conducts the AAA process for authentication to all sensors of the body. Next, it conducts the PBU process through the use of LMA, targeting all sensors of the body. At this point, the AAA process is performed by LMA via the AAA server aimed at all sensors of the body. LMA responds to MAG by sending the PBA message following authentication. MAG will immediately respond to the entire body sensors by sending the RA messages. Consequently, the RD of Method1 is obtained as follows:

$$RD_{Method1} = N_S \times \{2T_{C\text{-}PMD}(S_c) + 2T_{PMD\text{-}MAG}(S_c) + 2T_{MAG\text{-}AAA}(S_c) + 2T_{MAG\text{-}LMA}(S_c) + 2T_{LMA\text{-}AAA}(S_c)\}. \quad (1)$$

As explain in reference [11], the whole operations of method 2 are similar to method 1. In contrast to method 1, the method 2 utilizes between MAGs and LMA the aggregated PBU and PBA messages. Hence, the RD of method 2 is obtained as shown below:

$$RD_{Method2} = N_S \times \{2T_{C\text{-}PMD}(S_c) + 2T_{PMD\text{-}MAG}(S_c) + 2T_{MAG\text{-}AAA}(S_c) + 2T_{LMA\text{-}AAA}(S_c)\} + 2T_{MAG\text{-}LMA}(S_c). \quad (2)$$

As explain in reference [12], the method 3 uses between MAG and the coordinator the aggregated RS and RA messages. Therefore, the RD of method 3 is acquired as below:

$$RD_{Method3} = 2T_{C\text{-}PMD}(S_c) + 2T_{PMD\text{-}MAG}(S_c) + 2T_{MAG\text{-}LMA}(S_c) + N_S \times \{2T_{MAG\text{-}AAA}(S_c) + 2T_{LMA\text{-}AAA}(S_c)\}. \quad (3)$$

In the suggested method, upon affixing the coordinator to nMAG, then the coordinator sends a grouped RS message to nMAG by way of PMD on behalf of all sensors of the body. After that, nMAG exchanges the PBU/AAA query message and PBA/AAA reply message with LMA/AAA. It answers with a grouped RA message to the coordinator based on this performed process. Therefore, the RD of the suggested method is obtained as shown below:

$$RD_{Proposed\ Method} = 2T_{C\text{-}PMD}(S_c) + 2T_{PMD\text{-}MAG}(S_c) + 2T_{MAG\text{-}LAM/AAA}(S_c). \quad (4)$$

5.3 Handover Delay (HD)

The time interval among the period in which body sensors are unable to accept the packets from pMAG and that period in which body sensors can accept the first packet from nMAG is called the handover delay.

According to Reference [13], as soon as the body sensors get disconnected from pMAG, pMAG will send to LMA the DeReg messages for the sensors of the body. Also, once the sensors of the body are linked to nMAG, they will send to nMAG through the coordinator and PMD the RS messages. Following that, nMAG will conduct the AAA query and answer process through the AAA server in order to obtain the authentication of the entire body sensors.

Subsequently, nMAG implements with LMA the PBU process for the entire sensors of the body. Now, the AAA query/reply process is performed by LMA via AAA server for the sensors of the entire body. Following the authenticating this process, LMA replies to n-MAG by dispatching the PBA message. Following the handover tunnel has been formed among nMAG and LMA, nMAG sends a reply to the entire sensors of the body through the RA messages. Accordingly, the HD of Method1 is obtained as follows:

$$HD_{Method1} = N_S \times \{2T_{C\text{-}PMD}(S_c) + 2T_{PMD\text{-}MAG}(S_c) + 2T_{MAG\text{-}AAA}(S_c) + 4T_{MAG\text{-}LMA}(S_c) + 2T_{LMA\text{-}AAA}(S_c)\} + T_{MAG\text{-}LMA}(S_d). \quad (5)$$

Reference [11] demonstrates that the method 2 uses the aggregated DeReg and PBU/PBA messages. Hence, the HD of Method 2 is acquired as shown below:

$$HD_{Method2} = N_S \times \{2T_{C\text{-}PMD}(S_c) + 2T_{PMD\text{-}MAG}(S_c) + 2T_{MAG\text{-}AAA}(S_c) + 2T_{LMA\text{-}AAA}(S_c)\} + 4T_{MAG\text{-}LMA}(S_c) + T_{MAG\text{-}LMA}(S_d). \quad (6)$$

Reference [12] indicates that the method 3 uses the aggregated RS and RA messages among MAG and the coordinator. Hence, the HD of Method 3 is obtained as below:

$$HD_{Method3} = 2T_{C\text{-}PMD}(S_c) + 2T_{PMD\text{-}MAG}(S_c) + 4T_{MAG\text{-}LMA}(S_c) + N_S \times \{2T_{MAG\text{-}AAA}(S_c) + 2T_{LMA\text{-}AAA}(S_c)\} + T_{MAG\text{-}LMA}(S_d). \quad (7)$$

In the suggested method, once attached to nMAG, the coordinator uses PMD to sends a grouped RS message to nMAG. This is on behalf of body sensors. Then, nMAG uses aggregation to carries out the AAA operations and proxy binding with the LMA/AAA. Next, nMAG replies by sending the coordinator a grouped RA messages. Consequently, the HD of the suggested method is obtained as follows:

$$HD_{Proposed\ Method} = 2T_{C\text{-}PMD}(S_c) + 2T_{PMD\text{-}MAG}(S_c) + 2T_{MAG\text{-}LAM/AAA}(S_c) + T_{MAG\text{-}LAM/AAA}(S_d). \quad (8)$$

In conclusion, we obtained the following formulas:

$$RD_{Proposed\ Method} < RD_{Method3} < RD_{Methos2} < RD_{Method1} \quad (9)$$

$$HD_{Proposed\ Method} < HD_{Method3} < HD_{Method2} < HD_{Method1} \quad (10)$$

Thus, the results of the performance analysis have proved that the proposed method has enhanced the performance of the group mobility management in term of registration delay and handover delay during the handover process. Nevertheless, the total processing time of the methods are calculated through many experiments which equal to 500ms [6, 12, 29]. This time represent an important part of the whole processing time of the algorithm. The time recorded for message exchange among fixed nodes (LMA, MAG and AAA) was around 10ms and the recorded message processing time is 1000ms approximately. The round-trip transmission time among the sensor nodes and other nodes is varied between [50 to 500] ms. In this paper; we assume similar parameter settings for the experiments that have been conducted to evaluate the three methods. In our proposed enhanced group mobility management method, we assume that the total time between the sensor nodes and other nodes is decreased by four times for the registration delay. While, plus five times for the handover delay that is happening in the network. This means that the minimum time in the best case will be 350ms and in the worst case it can be up to 2500ms. In other word, our proposed method has shown an enhanced result by up to 70% under the same conditions of the other three methods.

6. Conclusions

In the current study, an improved group mobility management method is suggested for WBAN. For the proposed method, the AAA function is implemented by the LMA and thus it can minimize the number of control messages. Moreover, the PBU/AAA query messages for the group of moving sensors are combined by the MAG in order to further lessen the delay of both registration and handover between the MAG and the LMA/AAA. The findings have shown that in contrast to other methods, the proposed method has a superior performance with respect to registration, handover interruptions and signaling cost. This will consequently decrease the pressure mounting on healthcare systems along with providing support for aged population to have a better life and health care. In this regard, future studies should focus on the security issues related to WBAN.

REFRENCES:

[1] Sun-Min H., Kyu-Jin K., Md M. I., Eui-Nam H., Weimin H., Victor S. F., Andrei T., Aung A., Maniyeri J. and Jit B. "Multi-modal Sensing Smart Spaces Embedded with WSN Based Image Camera", *Proceedings of PETRA 10*, Samos, Greece, ACM New York, USA, June 23–25, 2010, pp. 294-369.

[2] S. Dharshini, and M. Monica Subashini, "An overview on wireless body area networks", Innovations in Power and Advanced Computing Technologies (i-PACT), DOI: 10.1109/IPACT.2017.8244985IEEE, April 2017.

[3] Cavallari R., Martelli F., Rosini R., Buratti C., and Verdone R., "A survey on wireless body area networks: technologies and design challenges", *IEEE Communications Surveys and Tutorials*, 2014, Vol. 16, pp. 1635-1657.

[4] Sharma R., Ryait H. S., and Gupta A. K., "Wireless body area neworka review", *Research Cell*, Vol. 17, 2017.

[5] Jiang X. And Yunru Z., "A survey on body area network", *Proceedings of WiCOM 09, IEEE Networking and Mobile Computing,* Beijing, China, 24-26 Sept. 2009, pp. 1-4

[6] Gohar M., Choi J. G., and Koh S. (2015) An ID/locator separation based group mobility management in wireless body area network. Journal of Sensors, 2015, pp. 1–12.

[7] Kushalnagar N., Montenegro G., and Schumacher C., "IPv6 over low-power wireless personal area networks (6LoWPANs): overview, assumptions, problem statement, and goals", *RFC, 4919, IETF*, 2007.

[8] Johnson D., Perkins C., and Arkko J., "Mobility support in IPv6", *RFC 3775, IETF*, 2004.

[9] Xin Yang, Ling Wang, Zhaolin Zhang, "Wireless Body Area Networks MAC Protocol For Energy Efficiency and Extending Lifetime", *Journal Article*, Vol. 2, No.: 1, 2018.

[10] Soliman H. and Castelluccia C., "Hierarchical Mobile IPv6 Mobility Management", *British Royal Flying Corp*, 2005.

[11] Arefin, Md. Taslim and Hanif Mohammad Haque, A.K.M Fazlul, "Wireless Body Area Network: An Overview and Various Applications", *Journal of Computer and Communications*, Vol. 5, pp. 53-64, 2017, DOI: 10.4236/jcc.2017.57006.

[12] Chen Y. S., Hsu C. S., and Lee H. K., "An enhanced group mobility protocol for 6lowpan-based wireless body area networks", *IEEE Sensors Journal*, Vol. 14, pp. 797-807, 2014.

[13] Hyeon S., Han Y. H., Lee H. B., and Cho H. Y., "Empirical performance evaluation of IETF mobile IPv6 and proxy mobile IPv6", *Proceedings of the international conference on mobile technology, applications, and systems mobility*, Yilan, Taiwan, 10 - 12 September, 2008 , p. 7, ACM New York, USA.

[14] Yuan-Yao Shih, Pi-Cheng Hsiu, Ai-Chun Pang, "A Data Parasitizing Scheme for Effective Health Monitoring in Wireless Body Area Networks", *IEEE Transactions on Mobile Computing*, Vol. 18, No.: 1, 2019.

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

[15] He D., Chen C., Chan S., Bu J., and Vasilakos A., "Retrust: Attack resistant and lightweight trust management for medical sensor networks", *IEEE Transactions on Information Technology in Biomedicine*, Vol. 16, No.: 6, pp. 623-632, 2012.

[16] He D., Chen C., Chan S., Bu J., and Vasilakos A., "A distributed trust evaluation model and its application scenarios for medical sensor networks", *IEEE Transactions on Information Technology in Biomedicine*, Vol. 16, No.: 6, pp. 1164-1175, 2012.

[17] Zhang Z., Wang H., Vasilakos A., and Fang H., "Cryptography and authentication in body area networks", *IEEE Transactions on Information Technology in Biomedicine*, Vol. 16, No.: 6, pp. 1070-1078, 2012.

[18] Istepanian R. S. H., Jovanov E., and Zhang Y. T., "Introduction to the special section on m-Health: beyond seamless mobility and global wireless health-care connectivity", *IEEE Transactions on Information Technology in Biomedicine*, Vol. 8, No.: 4, pp. 405–414, 2004.

[19] Montenegro G., Kushalnagar N., Hui J., and Culler D., "Transmission of IPv6 packets over IEEE 802.15.4 networks", *RFC 4944*, 2007.

[20] Oliveira L. M. L., Sousa A. F., and Rodrigues J. P. C., "Routing and mobility approaches in IPv6 over LoWPAN mesh networks", *International Journal of Communication Systems*, Vol. 24, No.: 11, pp. 1445-1466, 2007.

[21] Islam M. M. and Huh E. N., "Sensor proxy mobile IPv6 (SPMIPv6) A novel scheme for mobility supported IP-WSNs sensors", *Sensors*, Vol. 11, pp. 1865-1887, 2011.

[22] Haw R., Cho E., Hong C., and Lee S., "A 6LoWPAN sensor node mobility scheme based on proxy mobile IPv6", *IEEE Transactions on Mobile Computing*, Vol. 11, No.: 12, pp. 2060-2072, 2012.

[23] Bag G., Raza M. T., Kim K. H., and Yoo S. W., "Lowmob: Intra-pan mobility support schemes for 6LoWPAN", *Sensors*, Vol. 9, pp. 5844-5877, 2009.

[24] Shin M., Camilo T., Silva J., and Kaspa D., "Internet draft- 6LoWPAN mobility", *Internet-Draft*, pp. 5–10, 2007.

[25] Jinho K., Rim H., Eung J. C., Choong S. H., and Sungwon L., "A 6LoWPAN sensor node mobility scheme based on proxy mobile IPv6", *IEEE Transactions on Mobile Computing*, Vol. 11, No.: 12, pp. 2060-2072, 2012.

[26] Kim J. H., Hong C. S., and Shon T., "A lightweight NEMO protocol to support 6LoWPAN", *ETRI Journal*, Vol. 30, pp. 685–695, 2008.

[27] Li Y., Jiang Y., Su H., Jin D., Su L., and Zeng L., "A group-based handoff scheme for correlated mobile nodes in proxy mobile IPv6", *Proceedings of GLOBECOM 09*, Honolulu, HI, USA, 30 Nov.-4 Dec. 2009, pp. 1-6, IEEE.

[28] *NIST Project*, Seamless and Secure Mobility, http://www.nist.gov/itl/antd/emntg/ssm_seamlessandsecure.cfm, 2009

[29] Makaya C. and Pierre S., "An analytical framework for performance evaluation of IPv6-based mobility management protocols", *IEEE Transactions on Wireless Communications*, Vol. 7, pp. 972– 983, 2008.

[30] Radhwan M. A., Azizol A., Nor AsilahWati A., Mohamed O. and Shamala S., "The Rapid Vertical Handover for Efficient IPv6 Mobility Support in Heterogeneous Wireless Networks", *Arabian Journal for Science and Engineering*, Vol. 39, pp. 851-860, 2014.

[31] Radhwan Mohamed Abdullah, Abedallah Zaid Abualkishik, Ali A. Alwan. "Improved Handover Decision Algorithm Using Multiple Criteria", *Proceedings of The 9th International Conference on Emerging Ubiquitous Systems and Pervasive Networks (EUSPN 2018)*, Leuven, Belgium, Procedia Computer Science (Elsevier), November 5-8, 2018, pp. 32–39