

An Enhanced Group Mobility Protocol for 6LoWPAN-Based Wireless Body Area Networks

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ABSTRACT: The IPv6 over low power wireless personal area network (6LoWPAN) has attracted lots of attention recently because it can be used for the communications of Internet of things. In this paper, the concept of group-based network roaming in proxy mobile IPv6 (PMIPv6) domain is considered in the 6LoWPAN-based wireless body area networks. PMIPv6 is a standard to manage the network-based mobility in all-IP wireless network. However, it does not perform well in group-based body area networks. To further reduce the handoff delay and signaling cost, an enhanced group mobility scheme is proposed in this paper to reduce the number of control messages, including router solicitation and router advertisement messages as opposed to the group-based PMIPv6 protocol. Simulation results illustrate that the proposed handoff scheme can reduce the handoff delay and signaling cost. The packet loss ratio and the overhead can also be reduced.

KEYWORDS: wireless body area networks, proxy MIPv6, handoff delay, signaling cost, 6LoWPAN.

I. INTRODUCTION

VARIOUS wireless sensor nodes can be attached to the human body or clothes and hence can form a wireless network named as the Wireless Body Area Networks (WBAN). These tiny sensors are used to measure particular parameters of the human body, such as the body temperature, blood glucose, pulse rate and heart-beat. These sensing values can be gathered and transmitted to the monitoring server for healthcare applications or surveillance systems. IPv6 is the latest IP version which has large address spaces and better auto-configuration mechanisms and thus it can overcome the IP shortage problem; while Low-power Wireless Personal Area Networks (LoWPANs) can support the communications of the Internet of Things (IOTs) and thus it has attracted lots of attention recently. Hence, the Internet Object Identifier 10.1109/JSEN.2013.2287895 group for IPv6 over Low power Wireless Personal Area Network (6LoWPAN), which is carried out over IEEE 802.15.4 interfaces. Since the maximum packet size of IEEE 802.15.4 [3] is 127 bytes, the sensors are unable to hold the complete IPv6 address. The limitation of the packet size is to maintain the low power consumption of sensors, which are powered by batteries only. As a result, 6LoWPAN adds an adaption layer to implement the seamless connection of MAC and network layer. Taking the characteristics of 6LoWPAN into account, the host-based mobility approach is unsuitable to be applied in IP based Wireless Sensors Networks (IP-WSN) since there are huge amount of tunneling, especially in the case of the WBAN mobility scenario. All of the sensors should have a mobility stack, such as Mobile IPv6, FMIPv6, HMIPv6. However, the sensors should actively participate in mobility-related signaling that the above protocols are not suitable for them. The network-based mobility protocol would be more suitable for this situation. Proxy Mobile IPv6 (PMIPv6) currently is being standardized by the working group of IETF's Network-based Localized Mobility Management protocol (NetLMM). PMIPv6 can be considered as the most suitable manner to manage the mobility of the 6LoWPAN-based WBAN. The sensors' signaling the mobility related message to the agent themselves is a heavy burden. Hence, reducing the signaling cost becomes an important

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issue because most of the sensors are powered by battery only. Using network-mobility scheme for mobile sensors is a proper solution because it can reduce signaling cost. When the sensors change the point of attachment, there is a delay time before obtaining the IP configuration. Therefore, how to decrease the times of exchanging the control messages in case that a number of sensors attach on one MAG is also an important issue. To solve the above problem, a new format of control messages for carrying many other identifiers in one message is proposed in this paper so as to reduce the numbers of the control messages and shorten the handoff delay. An enhanced group-based handoff scheme, which adopts the new formatted control messages, is proposed. The proposed handoff scheme contains three phases, namely the registration, up-link handoff, and down-link handoff phases. Simulation results have shown that the proposed protocol can reduce the signaling cost and handoff latency for mobile sensors and it can also decrease the overhead of the Mobile Access Gateway (MAG) in PMIPv6.

II. PRELIMINARIES

This section introduces the system model first followed by describing the basic idea.

A. SYSTEM MODEL

The proposed protocol is designed for a WBAN consists of 6LoWPAN sensors and a Personal Area Network (PAN). The MAG emulates the home link of MBS by replying the Router Advertisement (RA) message to the MBS. Thus, the MBS can configure the same address through the HNP in PMIPv6 domain. There is a centralized LMA in the PMIPv6 domain, which acts like a home agent for all mobile nodes. For increasing the coverage of one MAG scope, 6LoWPAN is in beacon-enable mode and equips with the FFDs to support multi-hop communications. Hence, the packet can successfully send to the MAG through multi-hop communications and vice versa network (PAN).

Fig 1 illustrates the 6LoWPAN protocol stack of the proposed protocol. 6LoWPAN uses the IEEE 802.15.4 standard as the link-layer protocol. The adaption-layer is used to compress the IPv6 packet header (40 bytes) into 2 bytes for incoming communication (6LoWPAN) and decompress for the outgoing interface (PMIPv6).

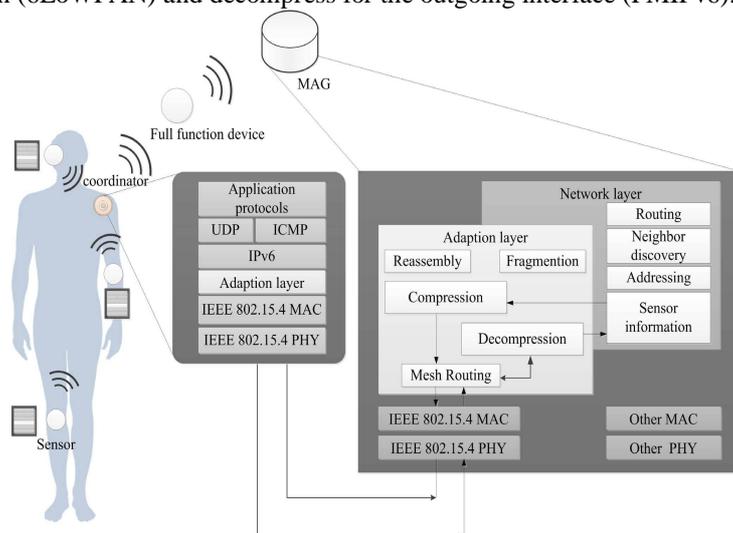


Fig1. The protocol stack and system model of Mobile Access Gateway (MAG) and sensors in WBAN coordinator.

The 6LoWPAN domain contains full-function devices (FFDs), which support all IEEE 802.15.4 functions and features. The Mobile Body Sensors (MBSs) send the packet through the FFDs to the Mobile Access Gateway (MAG), which has two interfaces for end-to end communication. The MAG receives the packet, and then decompresses the packet in adaption layer to follow the IPv6 packet format. Thus, the Local Mobility Anchor (LMA) set the binding state for the MBSs after receiving the packet from the MAG. When an MBS attaches to an MAG via wireless link, it sends a Router Solicitation (RS) message which includes the Mobile Node-Identifier (MN-ID) for using an address from its home network prefix (HNP).. The RS and RA control message of the conventional PMIPv6 protocol can be represented as

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(An ISO 3297: 2007 Certified Organization)

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$\langle \text{Header}, \text{ICMP}, \text{MN_ID}, \text{LL_ID} \rangle$, where *Header* contains the addresses of the source and destination, *ICMP* is a protocol for TCP/IP layer, *MN_ID* and *LL_ID* contain mobile node-identifier and link-layer identifier, respectively. The link-layer identifier can be represented as $\langle \text{Header}, \text{ICMP}, \text{HNP} \rangle$, where *HNP* contains the home network prefix of the sensor that assigned by the LMA.

B. BASIC IDEA

The basic idea of this work is to reduce the handoff delay and signaling cost for WBAN roams in PMIPv6. A new format of control message is proposed to combine the necessary information of the sensors into one message and thus the number of control messages can be substantially reduced. Besides, an enhanced group-mobility scheme is proposed to further reduces the handoff delay time between the LMA and the MAG. The signaling cost can also be reduced due to the group management. Fig. 2 illustrates the difference of signaling cost among three protocols. It illustrates the difference on delay time among the three protocols. The vertical axis represents the delay time during handoff process. The proposed group-based protocol can reduce the times of sending control messages and thus decreases the delay time.

III. AN ENHANCED GROUP-BASED HANDOFF SCHEME

To achieve the goal of reducing the signaling cost and delay time, three phases are proposed, namely the registration, up-link handoff, and down-link handoff phases. The proposed group-based handoff scheme works as follows: When a group of body sensors enter a PMIPv6 domain and attaches to an access link, the registration phase starts. One of the body sensors in the group needs to act as a coordinator and only the coordinator needs to exchange the control messages with the MAG. During the registration phase, only one *RSEG*, *RAEG*, *PBUEG*, and *PBAEG* messages are sent and thus reduces lots of signaling and registration cost. The body sensor performs an active scan periodically by sending a beacon request to the nearby FFDs. The nearby FFD, that receives the beacon request from the body sensor, advertises a beacon message including their MAG-IDs. Upon receiving the beacon messages, the body sensor decides whether itself is still in the same MAG or has moved to another MAG by comparing the current MAG-ID with the previous MAG-ID. If the body sensor has detected that it has moved to the new MAG, it then associates with the new MAG by performing the up-link handoff phase. After the up-link handoff phase, the down-link handoff phase starts. The details of the new packet format, the registration, up-link handoff, and down-link handoff phases are shown in the following subsections.

A. THE REGISTRATION PHASE:

The registration phase aims to reduce the amount of control messages. Fig. 7 illustrates the signaling call flow. One of the body sensors needs to act as a coordinator, which can interact with other sensors in 6LoWPAN environment. All the sensors use DHCP-based address configuration. The procedure of the group - based registration is given as follows: When a group of body sensors enter a PMIPv6 domain and attaches to an access link, the body sensor sends an *RSEG* message by multi-hop transmissions to the MAG. Upon the MAG received the *RSEG* message, the MAG uses all the *LL_ID* one by one for authentication by sending the AAA query. After a successful authentication, the AAA server sends a reply which includes the LMA's address and the MN's profile. After the MAG gets the LMA's address, MAG then sends a *PBUEG* message, which contains all the identifiers, to the LMA. Once the LMA receives the *PBUEG* message, LMA performs access authentication to verify whether *PBUEG* message is genuine or not. If the *PBUEG* message is trustworthy, the LMA initiates the DHCP solicitation procedure to request HNP's for

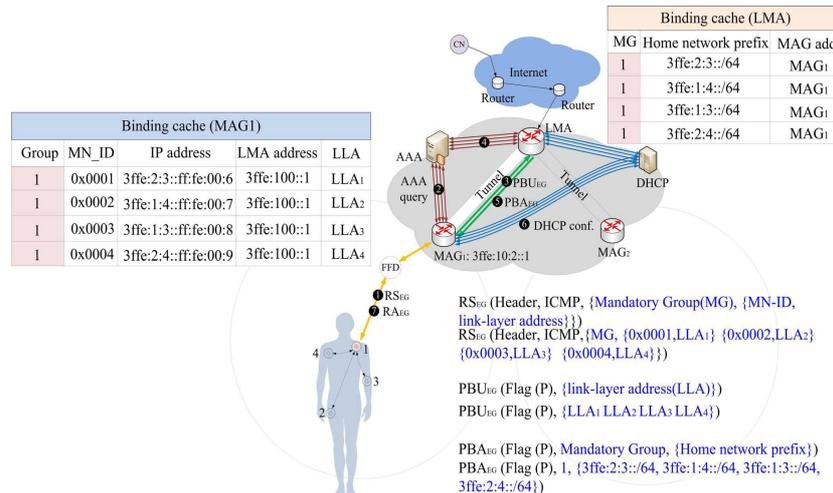


Fig2. An example of the registration phase.

The body sensors one by one. After the delegating router replies the unique HNPs for the body sensors (still one by one), the LMA creates the binding cache entry, stores the prefixes information, and assigns a BN, which is also added in the binding cache for classifying the body sensors into one group. Then, the LMA replies a *PBAEG* message, which includes all of the body sensors' HNPs and BN, to the MAG. The LMA also sets up its endpoint of the bidirectional tunnel to the MAG. *S6* After the MAG received the *PBAEG* message, the MAG stores the BN and requests the addresses from the DHCP server on behalf of the body sensors. The DHCP server then configures the respective Home of address (HoA) from those prefixes and sends it to the MAG. Upon received those messages, the MAG stores the IP address and sent an *RAEG* message back. In the first step, the group of body sensors are attached to an access first, *Si* then sends the *RSEg* message which contains all the identifiers to the LMA on behalf of the group of the body sensors. In the 5th step, the LMA replies a *PBAEG*, message including all the HNPs and BN number of the body sensor group to the MAG. The LMA also sets up its endpoint of the bi-directional tunnel to the MAG. Upon receiving the DHCP advertisement messages, the: *RAEG* message, which contains *B1* and the function of ACK, to the group of body sensors.

B. THE UP-LINK HANDOFF PHASE: The body sensor performs an active scan that searches a list of the available channels by periodically sending a beacon request to the nearby FFDs. The nearby FFD, The signaling call flow for the proposed handoff scheme. the beacon request from the body sensor, advertises a beacon message including their MAG-IDs. Upon receiving the beacon messages, the body sensor decides whether itself is still in the same MAG or has moved to another MAG by comparing the current MAG-ID with the previous MAG-ID contained in the beacon message. If the comparative results of all the MAG-IDs in the received beacon messages are the same, the movement represents intra-PAN mobility, and the body sensor has moved within the same PAN area. On the other hand, if the body sensor moves from the previous MAG (p-MAG) to the next MAG (n-MAG), the body sensor is able to detect its movement since the current *MAG_ID* is different from the previous *MAG_ID*, as contained in the received beacon messages. The body sensor can then be associated with the new MAG procedure.

The proposed protocol is able to reduce $(n - 1)$ RS messages because it replaces per identifier per RS message with a set of all identifiers. Furthermore, by using the assigned BN, it can also save $(n - 1)$ handoff messages such as deregistration *PBU*, *PBU*, and *PBA*. The proposed group based handoff scheme is described as follows. When the previous link on MAG (p-MAG) detects the detachment event from the body sensor, the MAG will signal the LMA by sending the deregistration *PBU*. Instead of all nodes sending the deregistration *PBU* respectively (as the original protocol did), here the MAG sends only one *LL_ID* from the body sensor.

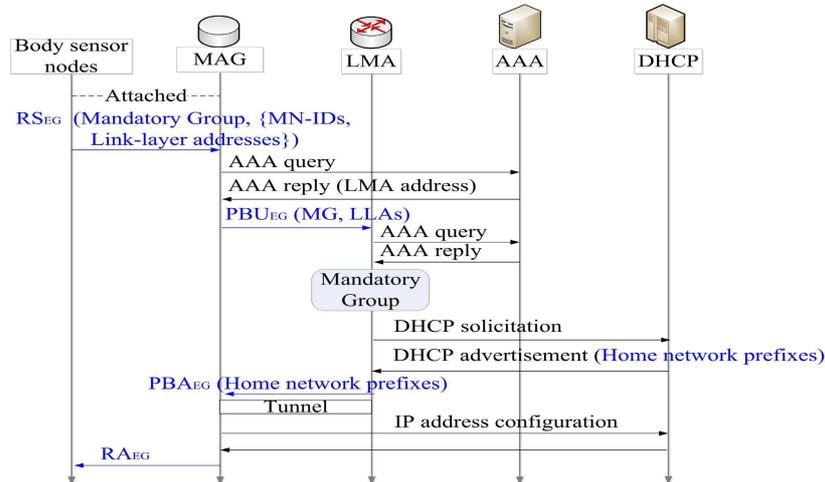


Fig. 3 shows the detail of signaling call flow for the handoff

Upon the LMA receives this message, LMA can obtain the rest sensors' information due to previously assigned BN, which is stored in the binding cache. After the LMA has confirmed all the information of sensors, the LMA will remove the binding and routing states if the LMA does not receive any PBU message within the given amount of time. Then, the LMA replies a PBA message and informs the MAG not to send other unnecessary deregistration PBU message. This way, the proposed scheme can reduce $(n - 1)$ times of sending deregistration PBU to advertise the LMA.

IV. PROPOSED METHOD

A. PARTICLE SWARM OPTIMIZATION (PSO)

Inspired by the flocking and schooling patterns of birds and fish, Particle Swarm Optimization (PSO) was invented by Russell Eberhart and James Kennedy in 1995. Originally, these two started out developing computer software simulations of birds flocking around food sources, then later realized how well their algorithms worked on optimization problems. Particle Swarm Optimization might sound complicated, but it's really a very simple algorithm. Over a number of iterations, a group of variables have their values adjusted closer to the member whose value is closest to the target at any given moment. Imagine a flock of birds circling over an area where they can smell a hidden source of food. The one who is closest to the food chirps the loudest and the other birds swing around in his direction. If any of the other circling birds comes closer to the target than the first, it chirps louder and the others veer over toward him. This tightening pattern continues until one of the birds happens upon the food.

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Vol. 4, Issue 3, March 2015

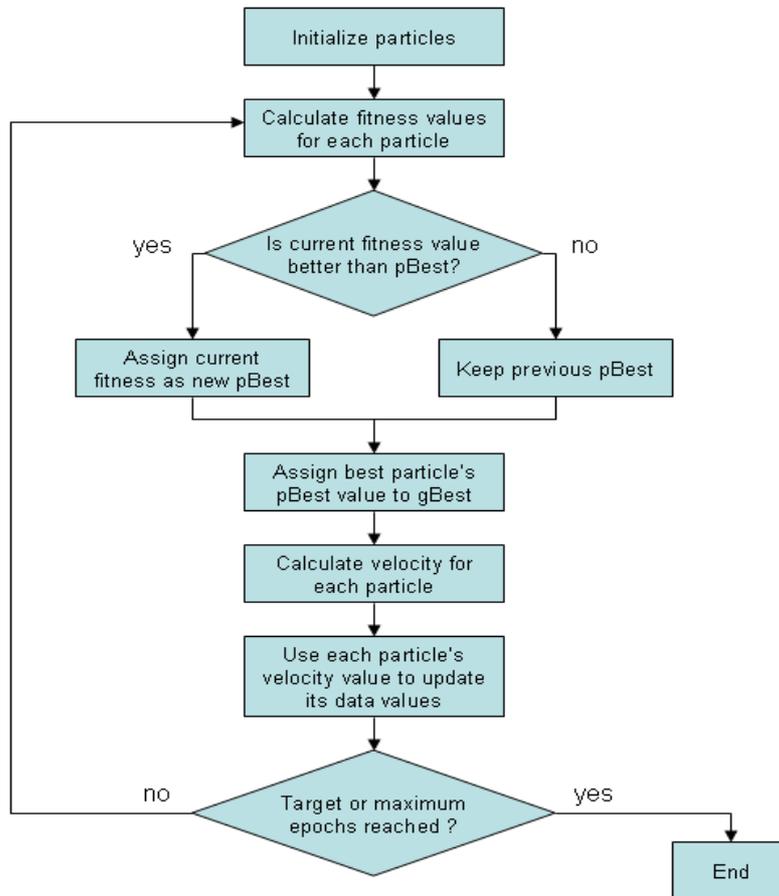


Fig4. Flow diagram illustrating the PSO

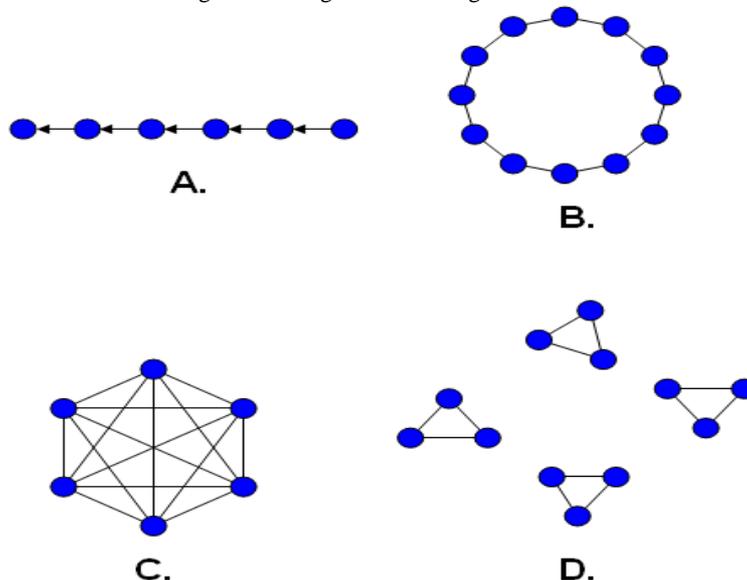


Fig5 A few common population topologies (neighborhoods).

International Journal of Innovative Research in Science, Engineering and Technology

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 3, March 2015

(A) Single-sighted, where individuals only compare themselves to the next best. (B) Ring topology, where each individual compares only to those to the left and right. (C) Fully connected topology, where everyone is compared together. (D) Isolated, where individuals only compare to those within specified groups. Neighborhood definitions and how they're used have different effects on the behavior of the algorithm. The particles' data could be anything. In the flocking birds example above, the data would be the X, Y, Z coordinates of each bird. The individual coordinates of each bird would try to move closer to the coordinates of the bird which is closer to the food's coordinates (gBest). If the data is a pattern or sequence, then individual pieces of the data would be manipulated until the pattern matches the target pattern. The velocity value is calculated according to how far an individual's data is from the target. The further it is, the larger the velocity value. In the birds example, the individuals furthest from the food would make an effort to keep up with the others by flying faster toward the gBest bird. If the data is a pattern or sequence, the velocity would describe how different the pattern is from the target, and thus, how much it needs to be changed to match the target. Each particle's pBest value only indicates the closest the data has ever come to the target since the algorithm started. The gBest value only changes when any particle's pBest value comes closer to the target than gBest. Through each iteration of the algorithm, gBest gradually moves closer and closer to the target until one of the particles reaches the target. It's also common to see PSO algorithms using population topologies, or "neighborhoods", which can be smaller, localized subsets of the global best value. These neighborhoods can involve two or more particles which are predetermined to act together, or subsets of the search space that particles happen into during testing. The use of neighborhoods often help the algorithm to avoid getting stuck in local minima.

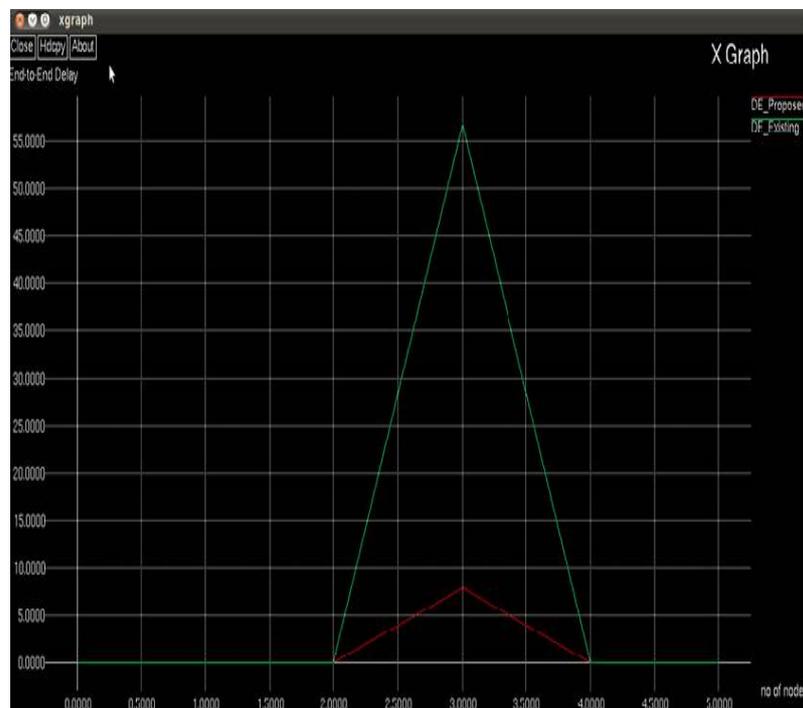


Fig.6 Graph illustrating No of nodes Vs delay

International Journal of Innovative Research in Science, Engineering and Technology

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Vol. 4, Issue 3, March 2015

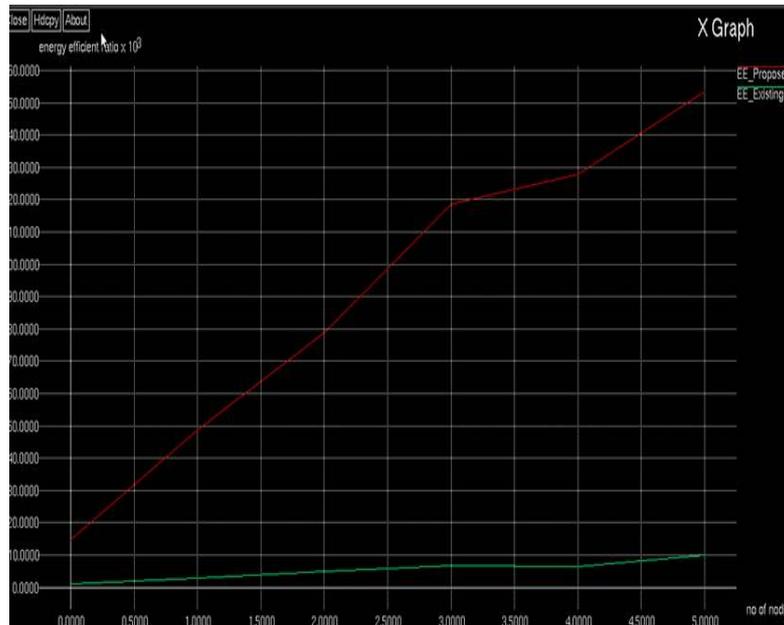


Fig.7. Graph illustrates No of nodes Vs efficiency

V. CONCLUSION

The PSO and genetic algorithm is proposed in order to reduce delay and achieving better efficiency. A new format of control message is proposed to combine the necessary information of the sensors in to one message and thus it can reduce the number of control messages.

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