© 2014 IJIRT | Volume 1 Issue 11 | ISSN: 2349-6002

Performance Analysis of RPL for Body Area Networks

Mercy Amrita.C, Mohanagowri.K, A. V. S. Elavarasi
Karpagam College of Engineering, Coimbatore-32

***Abstract*- In implanted sensor nodes, large power consumption causes damage to the tissues. Therefore, in designing a routing protocol for Body Area Networks, it is important to reduce the power factor into the routing metrics and low power should be consumed while routing. Lifetime of the nodes should be considered as main criteria for implanted sensor nodes. .So there comes the need of choosing the best protocol for low power consumption. The application of the RPL protocols is applicable in vivo sensor nodes. This paper deals with the analysis of RPL (Routing protocol for low power and lossy networks) with low power consumption in Body Area Networks, as it reduces the routing inconsistencies and is able to self- repair the network. The RPL protocol is evaluated in Contiki operating system using Cooja simulator.**

***Index Terms*- Body Area Networks, Routing Protocol for Low Power Lossy Networks, Lifetime, Implanted sensor nodes, Vivo sensor nodes, Contiki operating system, Cooja.**

I. INTRODUCTION

Wireless Body Area Network (WBAN) is a collection of low-power, miniaturized, invasive/non-invasive lightweight wireless sensor nodes that monitor the human body functions and the surrounding environment [1].

This Fig.1 shows the healthcare architecture of Body Area Networks [2]. It consists of Wireless Body Area Network (WBAN), the external network and the back-end server. WBAN consists of several sensors that measure medical data such as ECG, body movement temperature etc. These sensors are equipped with radio interface and send their information to a central device called medical hub. Medical hub is unique for each WBAN and act as a gateway between WBAN and the external network.

The backend server securely stores, processes and manage huge amount of medical bio-data coming from all patients. This data can be observed and analyzed by medical staff [2].In addition it supports a number of interesting applications such as ubiquitous healthcare, entertainment, interactive gaming, and military applications [1]. The characteristics of vivo sensor nodes are ,they supports the frequency of

403MHz and the range is 14 meters and for the frequency of 2.47GHz ,the range is 4.8 meters [1].

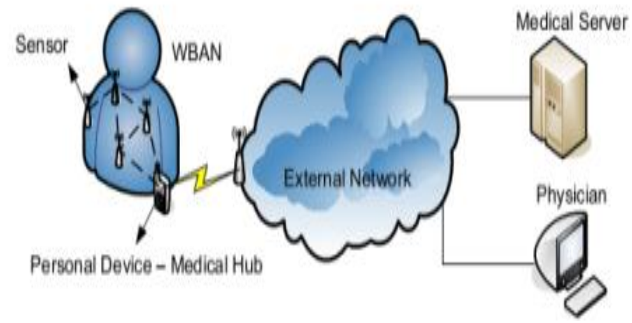

Fig.1 Healthcare Architecture

The problem of WBAN related to routing is Network Topology, Path-loss, Energy Efficiency and reliability. In implanted sensor nodes, the power generated by the node's circuitry and antenna could cause damage to the tissues. Therefore, in designing a routing protocol for WBANs, it is important to reduce the power. Lifetime is the important challenge of implanted sensor nodes, need to be addressed. The need of choosing the best low power consuming protocol for Body Area Networks need to be satisfied. Real time implementation of implanted sensor node needs the low power consuming protocol. This paper helps in understanding the compatibility for choosing RPL and connecting the domain of Body Area Networks. In real-time similar works of vivo sensor nodes are implemented in rats [9].

The remainder of the paper is organized as follows. In Section 2, presents the related works of Thermal Aware implanted routing protocols with their pros and cons. Section 3 deals with Research Statement, Section 4 deals with the proposed methodology and working of RPL with Control messages.. Section 5 presents the simulation results with a normal scenario of RPL and with a faulty node implementation. Section 6 presents the conclusion and future works.

II. RELATED WORKS

Thermal aware protocols are classified based on their routing decisions as per hop basics and end to end basics. TARA, LTR, ALTR, HPR, TSHR are based on per-hop basis of routing and LTRT uses End to End routing. This paper [3] addresses the issues of routing in implanted sensor networks and the possibility of overheating is reduced. This paper is the first paper to consider the thermal influence in a sensitive application environment. A node whose temperature exceeds the predefined threshold value will be marked as a hotspot node and the nodes communicate from source to destination leaving behind the hotspots. It follows a withdrawal strategy. The enhancement of TARA is Least Temperature Routing Protocol (LTR) and Adaptive Least Temperature routing protocol (ALTR) [4].Least Temperature Routing Protocol (LTR) tries to forward packets to the coolest neighbor. MAXHOPS are defined as 40 hops and if the received packet's hop-count exceeds the value, the packet will be dropped. ALTR protocol is similar to LTR protocol with a small improvement to minimize the packet delivery delay. Enhancement of energy efficient routing is Hotspot Preventing Routing algorithm. The proposed algorithm [6] reduces the average packet delivery delay in the network by preventing the formation of hotspots and reducing the delay by means of the shortest hop algorithm and threshold value. The enhancement of HPR is Thermal Aware Shortest Hop Algorithm. This proposed protocol [7] states that when some nodes in the shortest path have a high temperature, ignores the path. This protocol is presented for application where there is a high priority for delivering a packet to the destination, and if the packet is dropped, it is retransmitted. It uses fixed and dynamic threshold. The enhancement of TSHR is LTRT, a thermal aware routing algorithm, is used to reduce the temperature caused by biomedical sensor implanted in human bodies. Nodes temperatures are converted into graph weight and minimum temperature routes are obtained. Minimum temperature of the node is defined as 1 unit [5]. This protocol accomplish in optimization of routing. Energy Efficient Thermal and Power Aware Routing Protocol (ETPA) [12] is needed in Body Area Networks and this protocols holds good with Temperature, packet hop count, packet delivery ratio, packet delay, Traffic Generation, Depletion, Scalability, Mobility. This routing protocol has shown to have significantly higher depletion time which leads to long lasting communications and efficient usage of scarce resources of BAN. A detailed survey of Thermal Aware Routing Protocol is given in [14].

III. RESEARCH STATEMENT

In implanted sensor nodes, the power consumption of the nodes are the main problem need to be addressed. Therefore, in designing a routing protocol for WBANs, it is important to reduce power and safe routing should be considered. This paper deals with the checking of RPL (Routing protocol for low power and lossy networks) feasibility for Body Area Networks, as it reduces the routing inconsistencies and is able to self- repair the network. Self healing property is the key objective of the RPL protocol. If there is a possibility of fault in a network self-healing property works well with RPL, it heals the networks from damage and the performance is not affected during routing.

IV. OVERVIEW OF RPL

Ipv6 Routing Protocol for Low Power and Lossy Networks (RPL) [8] is a routing protocol specifically designed for Low power and Lossy Networks (LLN) compliant with the 6LoWPAN protocol. It currently shows up as an RFC proposed by the IETF ROLL working group. Goals are to minimize memory requirement, low complexity in routing, data forwarding mechanisms, reduce routing signals, use compact routing algorithm and efficiently discover links and peers.RPL is more optimized for data acquistation network.

A. RPL Design

RPL is specifically designed for large scale devices. The devices communicating over the networks are made for low power constraints .The goals of RPL are to

- Maintain less memory.
- Routing Complexities are removed.
- Lessen the energy consumption.
- Link discovery is done efficiently.
- Less Power Consumption.

B. Working Of RPL

RPL builds multiple destinations oriented directed acyclic graphs (DODAG) in tree based network without forming any loops .RPL node can be a part of one DODAG only. So DODAG is non overlapping and their union is called as Directed Acyclic Graph. Routing requirements vary within the networks.RPL instance define the routing metrics. The key feature of RPL is to provide the best routing solution for low power sensor devicies.RPL consumes less power and it has been proved under different scenarios.RPL starts with the DODAG (Destination Oriented Directed Acyclic Graph) construction.

- ✓ Root node advertises by sending control messages called DODAG information object(DIO)
- ✓ DIO includes configuration attributes to all nodes.
- ✓ From DIO RPL node learns about its neighbors and rank and it also specifies how a node must select its parent node within parent set.
- ✓ Nodes also multicast DODAG information solicitation (DIS) to tell neighbor to solicit DIO message.
- ✓ DAO (Destination Advertisement Object) sends the available routes and path from destination to source .
- ✓ RPL supports both upward routing and downward routing.

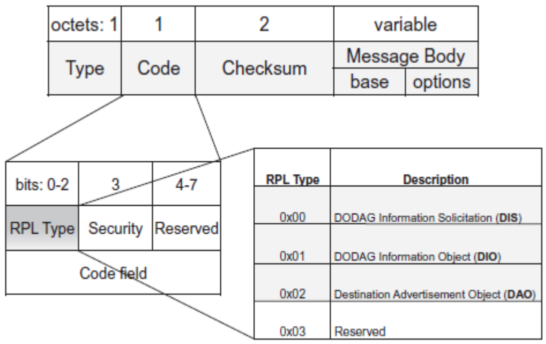

Fig.2 RPL Control messages

RPL control messages whose structure is given in Fig.2[8] RPL control messages consists of ICMPV6 header Which has Type, Code and Checksum. Message body has Message base and many options.

C. Control Messages

Destination Oriented Directed Acyclic graph Information Solicitation (DIS): The DIS is used to solicit a DODAG Information Object (DIO) from an RPL node. The DIS may be used to probe neighbor nodes in adjacent DODAGs.

Destination Oriented Directed Acyclic graph Information Object (DIO): The DIO is used to construct a new Directed Acyclic Graph and then sent in multicast through the DODAG structure.

Destination Advertisement Object (DAO): The DAO is used to propagate reverse route information to record the nodes visited along the path.

D. Self healing in RPL

RPL supports graph repair mechanisms in case of link and node failures. RPL specifies two techniques, which are complimentary in nature and actions (known as local and global repair). When a link or neighboring node failure is detected to be unavailable and the node has no other router in the 'up' direction, a local repair is triggered to quickly find an alternate parent/path. As local repairs take place the graph may start to diverge from its optimum shape, at which point it might be necessary to rebuilding the graph (DODAG) [13]. Global repair is a repair mechanism that rebuilds the graph from scratch. It is an optimization technique but it has a cost. The global repair can be triggered only from the root and has a cost of additional control traffic in the network. Each node in the graph will rerun the objective function for preferred parent selection.

V. Simulation Results

Simulation is done using Contiki OS [11] Cooja Simulator.. Code running in Java Virtual Machine can interoperate with the applications written in C language. RPL is tested under various scenarios and a scenario of faulty node is included and routing behavior is analyzed. This work is based on the working and analyzing RPL under various scenarios.

If there is a possibility of faulty node during routing the faulty node is eliminated and routing takes an alternative path to reach the destination.

Table 1 Scenario Properties For 6 Nodes using Rpl

Nodes	6
Simulation Time	6.03 seconds
Terrain	10*10m²
MAC	CSMA Contiki MAC
Channel	26
Transmission Range	10 m
Routing Protocol	RPL
Type	Proactive and Reactive
Topology	Hierarchical

Scenario 1: RPL

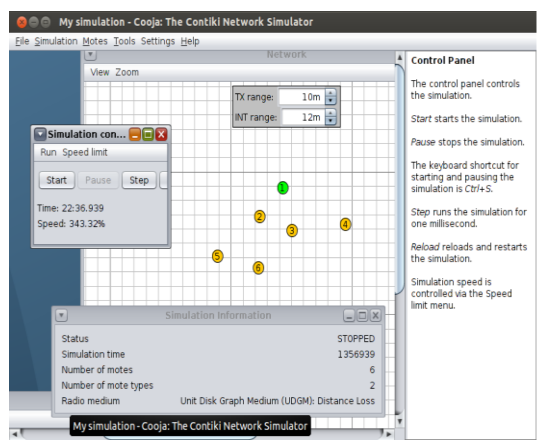

Fig.3 Nodes Communication where 1 is the server node and other nodes are clients.

Scenario 2: RPL with Faulty node.

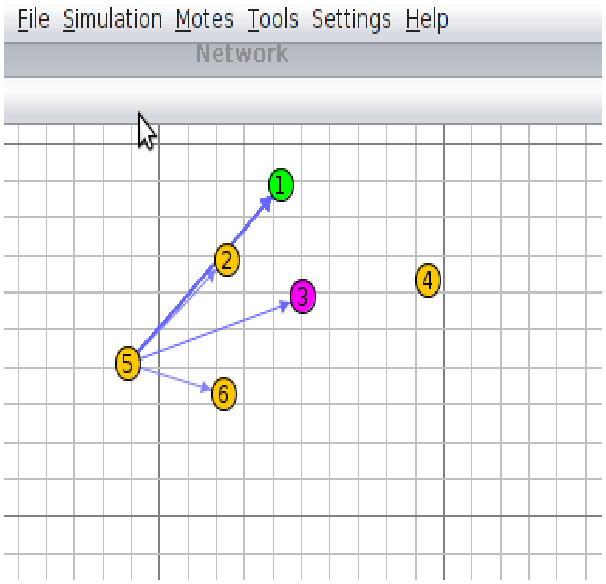

Fig.4 Nodes Communication where 3 is the faulty node.

A scenario with 6 nodes are run with cooja Simulator and node 3 is treated as faulty node.Node 3 does not transmit any packets and power consumption for each node is analyzed

A. Performance Evaluation Of Scenarios

Average Power Consumption**:** Power consumed by the sensor node during transmission and reception of packets.

Radio Duty Cycle**:** It represents the average ratio of radio usage times (sending and listening) to the total run time for one node, averaged among all nodes, except the sink which stays always on.

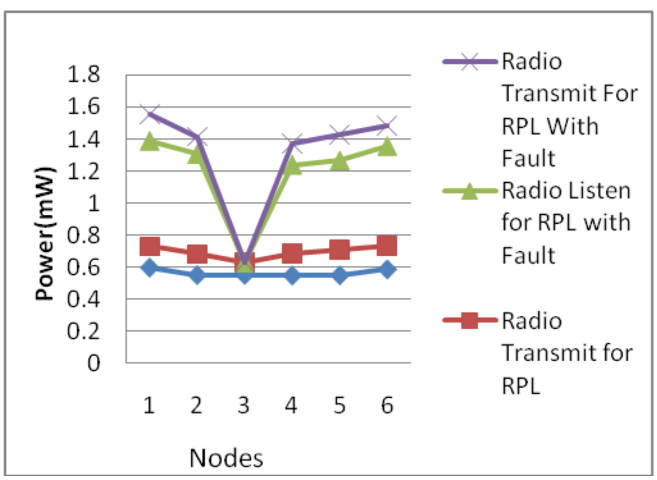

Fig.5 Performance Evaluation of Radio Listen and Transmit of RPL and Faulty node

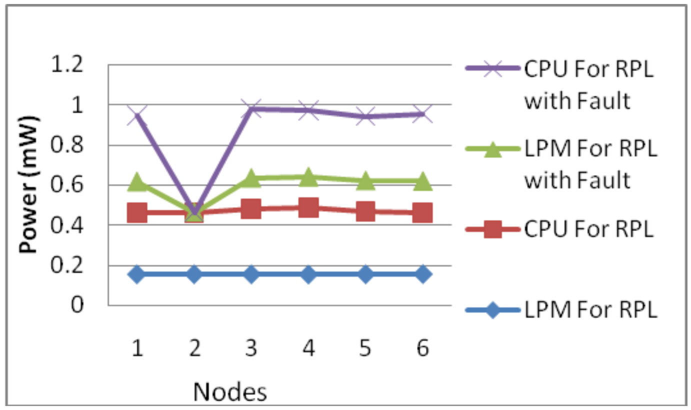

Fig.6 Performance Evaluation of LPM and CPU modes of RPL and Faulty node.

Inference: Scenario1 includes the normal RPL protocol and scenario 2 includes RPL with a faulty node 3 in the network. From Fig 5 radio transmits and radio listen of both the scenarios are analyzed. Power consumption is less even in the case of faulty node 3, because of the self healing property of RPL. The protocol adapts the property of self healing even when the topology changes and also in the case of node failure. The protocols help in the healing process of faulty node and make the protocol effective by low power consumption. Self healing property works with reactive protocol in RPL .In case of a fault occurrence in the topology, it heals the network and less power consumption is achieved during send and receive phase. From Fig 6 evaluation of RPL protocol and with faulty node are evaluated for Low Power mode and CPU mode.RPL holds good even in the case of faulty node 3.Power consumption is also lesser for node 3.Self healing property highlights the lower power consumption in RPL.

VI. Conclusion

In implanted sensor nodes, power consumption of the nodes is the problem to be addressed and it could cause damage to the tissues. Sensor nodes can transmit and receive data. Therefore, in designing a routing protocol for WBANs, it is important to reduce the power consumption. Our contribution to this paper is the performance evaluation of RPL protocol for Body Area Networks. Wide analyses of RPL protocol are done for two scenarios, normal RPL and RPL with faulty node. This protocol proves that it will lessen the power consumption of implanted sensor nodes by the property of self healing. Future work is to enhance RPL with other performance metrics such as latency, Throughput, etc.

References

[1] Ullah, S.; Higgins, H.; Braem, B.; Latre, B.; Blondia, C.; Moerman, I.; Saleem, S.; Rahman, Z.;Kwak ,KSA comprehensive survey of Wireless Body Area Network August 2010.

[2] Dave Singelee.; Benoit Latre.; Bart Braem,; Michael Peeters,; Marijke De Soete,; Peter De Cleyn,; Bart

Preneel,; Ingrid Moerman and Chris Blondia.; A Secure Low Delay Protocol for Multi-hop Wireless Body Area Networks .In 7thInternational Conference on Ad Hoc Networks & Wireless, Sep 2008.

[3] Tang, Q.; Tummala, N.; Gupta, S.K.; Schwiebert, L. TARA: Thermal-aware Routing Algorithm for Implanted Sensor Networks. In Distributed Computing in Sensor Systems; Springer: BerlinHeidelberg, Germany, 2005

[4] Bag, A.; Bassiouni, M.A. Energy Efficient Thermal Aware Routing Algorithms for EmbeddedBiomedical Sensor Networks. In Proceedings of the IEEE International Conference on MobileAdhoc and Sensor Systems (MASS), Vancouver, BC, Canada, 9–12 October 2006.

[5] Takahashi, D.; Xiao, Y.; Hu, F. LTRT: Least Total-Route Temperature Routing for EmbeddedBiomedical Sensor Networks. In Proceedings of Global Telecommunications Conference(GLOBECOM), Washington, DC, USA, 26–30 November 2007.

[6] Anirban Bag and Mostafa A. Bassiouni Hotspot Preventing Routing Algorithm for Delay-sensitive Biomedical Sensor Networks .In proceedings with IEEE International Conference on portable Information Devices,2007.

[7] Tabandeh, M.; Jahed, M.; Ahourai, F.; Moradi, S. A Thermal-aware Shortest Hop RoutingAlgorithm for in vivo Biomedical Sensor Networks. In Proceedings of the 6th International Conference on Information Technology: New Generations (ITNG), Las Vegas, NV, USA, 27–29April 2009.

[8] Gaddour, Olfa, and Anis Koubaa. "RPL in a nutshell: A survey." Computer Networks 2012.

[9] Latre,Benoit ,et al. "A low -delay protocol for multihop wireless body Area networks".Mobile and Ubiquitous system:Networking & Services,2007

[10] A.M Natrarajan P.and Balasubramani "Operational Research" 2006

[11] Osterlind ,Fredrik " A sensor network simulator for the Contiki OS",SICS Research Report,2006.

[12] Movassaghi, Samaneh, Mehran Abolhasan, and Justin Lipman. "Energy efficient thermal and power aware (ETPA) routing in body area networks." Personal Indoor and Mobile Radio Communications (PIMRC), IEEE 23rd International Symposium on. IEEE, 2012.

[13] P Vasseur, Navneet Agarwal, "RPL: The IP routing protocol designed for low power and lossy networks Internet Protocol for Smart Objects (IPSO) Alliance", http://www.ipso-alliance.org/wp-content/media/rpl.pdf.2011

[14] Mercy Amrita.C and Pravin Renold.A "Thermal Aware Routing Protocol For Body Area Networks: A Survey " ,in the proceedings of TEQIP II Sponsered National Conference on Wireless Networks Computing and Communications pp 22-29,2014