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An Efficient Energy Optimization XLN Operation Model for IEEE 802.15.4-Based Mobile WSNs

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ABSTRACT

This paper investigates an IEEE 802.15.4 mobile wireless sensor networks have been showing a vast applications which is been examined in the literature. One of the significant identification in these is that it undergoes from packet overhead and packet-delivery ratio degradation prolonging with energy consumption. This paper originates a XLN (Cross-Layer Network) operation model that can enhance the energy consumption and throughput of the system in these networks. The modified efficient model integrates 4 layers in the network operation: a) Application Layer, which has been used to update the node location; b) Network Layer, which has been implemented to identify the routing of the networks through links; c) MAC (Medium Access Control) Layer, which has been focused on the efficiency of the networks and d) Physical Layer for the purpose of the transmission power from sensor node to the sink node. The location and position of the mobile node is interfaced in the routing operation as soon as the route discovery process is completed. The location and position (location) information is then employed by the transmission power control of the MAC Layer to adapt or adjust the transmission range w.r.to the link. Practically, neighbor list discovery broadcast will be employed only for active nodes. But, here this paper is implementing a new technique i.e., Mobility Aware Protocol, which identifies the mobility (speed) of the node so that only those nodes will be updated with its neighbor list broadcasting resulting in minimum power utilized by the network interface also in the reduction of the energy consumption of the node(s). One more major problem arising in this model was bottleneck issue which has been introduced to multiple sources resulting in high packet loss. This problem has been overcome by scheduling those packets of the sensor which are nearer to the sink node, which not only reduces the packet loss but also reduces the networks consumed energy resulting in higher PDR. To the best of our knowledge the presented operation model is an efficient procedure which has never been introduced. Through NS-II simulation, the results of energy consumption, PDR, throughput, packet overhead etc. has been shown.

Keywords: Cross-Layer Operation Model, IEEE 802.15.4 protocol, Energy Efficiency, Packet Overhead, Throughput, mobile nodes, wireless sensor networks.

1. INTRODUCTION

At network initialization, the mobile node is being started to broadcast a neighbor discovery message to establish neighbor(s) information collection and store it in a neighbors list (NB-List). As soon as the initialization process is being completed, then if a node in the network had data of interest to be transmitted, attached with this data was the location and position (location) information of the mobile node. This data in the node is provided by either a Global Positioning

Satellite module attached to the node or any other technical methods where the nodes are able to identify and investigate their individual locations. This node will start sending route request (RREQ) packets to establish/create a route to the destination node. The routing protocol utilized in this operation model is AODV (Ad-hoc On Demand Distance Vector) which is being implemented for recurring neighbor maintenance message which is a hello packet. Hello packets are nothing but the broadcast packets which is being utilized for the purpose of verifying the activeness of the node; therefore, it is feasible to evaluate the

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NB list from the network layer in the data-link. This eliminates the need of neighbor discovery messages to be sent by the MAC protocol. After the RREQ packets is been received by the destination node, it replies by sending a unicast route reply (RREP) packet. Therefore, the destination node can interface and employ its own state of information in the RREP message and replies it back to the next hop node in the reverse route [1]. The IEEE 802.15.4 standard MAC protocol for LRWPAN is determined specifically for static sensor networks and capacity to endorse mobile sensor networks which has not yet been introduced. This paper calculates the performance strategy based on the mobility of the node and beacon order through which we can observe the effect on energy that has been utilized, packet delivery ratio, packet overhead and time required for a packet to reach the sink node. This paper also elaborates few narrow research problems that need to be displayed for successful enhancements of IEEE 802.15.4 in MWSNs environment [2]. Mobility of sensor nodes in WSN has shown virtually new challenges particularly in PDR and energy consumption. Packet loss that is produced due to mobility of the sensor nodes is one of the major challenges similar with energy consumption. In this paper, it uses cross layer design between MAC and network layers to overcome these challenges. Thus, a cluster dependent routing protocol for a mobile WSN node is studied [3]. Firstly, a new location management scheme is deliberated to control the mobility of actors with minimum energy utilization for the sensors, based on a composite strategy that involves the location up-gradation and location prediction. The location management proposal enables efficient universal routing, and with respect to this, a favorable energy-aware protocol is proposed for sensor-actor network communication [4]. The problem of gathering inter-linked source data represents the effort on the network lifetime maximization that jointly considers the 3 layers. Here it is first assume that link access availability chances are estimated by considering the joint optimal design of transmission power control along with the routing. The paper proposes a distributed algorithm, Joint Routing and Power Control Algorithm (JRPA), for the solution. During the unknown probabilities of optimal link accessibility, as in several practical networks, the paper simplifies the problem formulation to incorporate all the 3 layers of routing, transmission power control link-layer random access. In this case, the problem cannot be re- solved into a convex optimization problem, but they appear a polarity gap when the Lagrangian dual method is invoked. This proposes an enhanced heuristic algorithm, Joint Routing, Power Control and Random Access Algorithm (JRPRA) [5].

2. MOTIVATION FOR IEEE 802.15.4 USING XLN PROTOCOL MODEL

We need to maximize the network lifetime while guaranteeing that full information about the network can be communicated to the sink node. There are two challenges in solving the mentioned problem in a segregated manner. Firstly, it is necessary to disseminate information about the remaining energies of the sensor nodes in the overall network, which resembles in high communication overhead. Secondly, global network information is required while using Slepian-Wolf coding to allocate data rates to the sensor nodes. To solve the problem, it has been determined a rate allocation for individual sensor node, the power allocation and random access probability for individual link, and the routing of data from the sensors to the sink node. Using Slepian-Wolf coding, we can use a shortest path algorithm such as Bellman-Ford to compute the distance between each sensor node and the sink, and then assign a rate to each sensor node sequentially. The left problem is then to jointly optimize the power control, link random access, and routing to maximize the network lifetime [5]. The design principle of XLN protocol is a unified cross layering such that both the information message and the features of 3 fundamental communication paradigm (medium access, routing, and congestion control) are considered in a unique protocol operation. Similarly, XLN protocol incorporates the required features by into account of the channel effects. Before explaining the specifics of the XLN protocol operation, the paper firstly, introduces the initiative determination concept, which constitutes the core of the XLP. This concept is being coupled with the receiver-based contention mechanism providing freedom to each and every node involved in transferring of the data packets. At last, the cross-layer initiative determination approach comprises the core of the XLN protocol and absolutely incorporates the intrinsic communication features required for successful communication in WSNs [6]. Among the renowned specifications, IEEE 802.15.4, originally established for low-rate WPANs, has become one of the major promising enhancements for several interconnections between wireless sensor devices [7]. IEEE 802.15.4 is the standard for WSNs that resembles the specifications and features of the PHY and MAC sub-layer in WSNs. The MAC protocol is required to coordinate sensor nodes accessibility to the wireless medium. Even though, prominent by a set of strengths that is been assisted to its advances in various WSNs, IEEE 802.15.4 MAC undergoes from several restrictions that play a vital role in decomposing its performance characteristics. With respect to this paper, it has been provided surveys for these respective protocols and target the methodologies they follow to enrich the performance of the IEEE 802.15.4MAC protocol [8].

3. RELATED WORK

This paper evaluates the specifications of IEEE 802.15.4 in a mobile sensor network for low rate wireless personal area networks. The key objective is to detect how the standard MAC performs in terms of throughput and node effective association time with its coordinator for MWSN. In this paper, the coordinator is stable and only the nodes are modeled as mobile. This is to ensure the appropriate result when the node is beyond the range because of the distance from the coordinator. This paper evaluates the performance based on node's mobility and beacon order to examine the effect on energy utilized, PDR and overall time required for a node to associate with its coordinator. This paper also investigates at the effect of node's mobility when the node combines and re-unites with different coordinators [2]. The mobile sensor can distribute sensing, networking and computing resources to provide required coverage and specified sensing accuracy to collect data from nearby static sensors with higher energy efficiency, to monitor the static sensors, to rectify and sustain the network, while the wireless network and static sensors provide environmental sensing, communication and coordination. In this paper, various protocols have been considered (e.g.: AODV, DSR, DSDV, OLSR) to estimate and investigate the packet loss, transport loss and routing loss by using two different radio propagation model namely: Two-Ray Ground model and Shadowing model. From which it has observed that the transport loss as well as the routing loss of the AODV protocol with Two-Ray Ground Propagation model is lower than that of AODV protocol with Shadowing Propagation model [9]. Specifically, An integrated cross-layer protocol has been established which provides the communication techniques for sensor network to utilize the sectored antennas completely [10].In this paper, we observe the consistency in node mobility patterns to decrease the frequency of route reconstructions and ensuring the efficient data transmission to mobile nodes. To increase the packet delivery ratio and eliminate the drawbacks of packet loss occurred due to node mobility, the paper proposes a ZigBee node positioning and tree topology construction framework. In a particular way of approach, the framework holds good regularity in mobility patterns during the construction process of the routing tree and positioning of nodes. It also consists of an overhearing functionality for mobile nodes for further enhancing the data delivery ratio [11].This paper proposes an Efficient Energy Consumption and QoS aware multipath routing protocol (EQSR) that maximizes the lifetime of the network through the concept of balancing energy consumption across multiple sensor nodes, which utilized the mechanism of service interpolation to provide retarded sensitive traffic to reach the destination node within an receivable delay, which in turn decreases the end-to-end delay by illuminating out the traffic across multiple paths, and increases the throughput by implementing data redundancy. EQSR utilizes the residual energy, buffer size of the available node, and SNR to estimate the best alternate hop through the route/path construction phase. Relying on the view of service interpolation the EQSR protocol determines a queuing model to have applications in both real and non-real time traffic [12]. In this, the paper introduces a capability of adapting various conditions and cross-layer framework for reliable and energy-efficient data collection in WSNs based on the IEEE 802.15.4/ZigBee standards. The scenario of the framework employs an energy-aware adaptation module that stores the application's reliability requirements, and autonomously manipulates the MAC layer based on the topology of the network and the traffic conditions in order to reduce the power consumption. Specifically, it also proposes a less-complexity distributed algorithm, known as Adaptive Access Parameters Tuning (ADAPT), that can mutually meet the application-oriented reliability under a wide range of active conditions, for both single-hop & multi-hop networking surroundings. The solutions with respect to the concept can be compensated into WSNs based on IEEE 802.15.4/ZigBee without the need of any further modifications to the standards. This paper introduces the bottleneck problem of IEEE 802.15.4/ZigBee-based networks. The bottleneck problem exists at the nodes nearby to the ZigBee coordinator since they have several data to transfer during the data gathering process by the sink node. This is a basic fundamental problem which minimizes the network throughput and increases transmission delay. A possible solution to overcome this drawback is to schedule each node's broadcasting time properly. The very basic two fundamental problems to be answered for such scheduling are when and how much long a node should be kept awake to transmit/receive packets. To obtain efficient and proper scheduling, in this paper, it proposes a centralized Top-Down Maximum Load First (TDMLF) mechanism which uses the contention-free Guaranteed Time Slots (GTS) defined in IEEE 802.15.4. Through raising the number of concurrent transmissions, the proposed scheme achieves high level system utilization and thereafter mitigating the bottleneck problem. Through system implementation, the paper states that TDMLF successfully minimizes the negative drawbacks caused due to the bottleneck problem [13]. This paper introduces various IEEE 802.15.4 MAC approaches such as a) Parameter tuning, which tunes the parameters of the super-frame to improve the performance without modifying the 802.15.4 standard b) Cross Layer, which introduce solutions based on the interaction between the different layers of the protocol stack c) 802.11, which migrates solutions that has been proposed for 802.11 to the 802.15.4 domain d) Priority, which enhances the QoS support of 802.15.4 such that nodes and traffics are prioritized e) Duty-Cycle, which manipulates the active nodes of the super-frame in a way to achieve more power conservation f) Back-Off, which introduces the modifications to enhance the performance in terms of different metrics, especially power consumption g) Quality of Service, which optimizes the GTS allocation scheme to better support time-sensitive applications h) Hidden Terminal Resolution, which supports IEEE 802.15.4 MAC's awareness of the hidden terminal problem to unnecessary collisions [8]. Figure (1) illustrates the various IEEE 802.15.4 MAC approaches to obtain efficient performance.

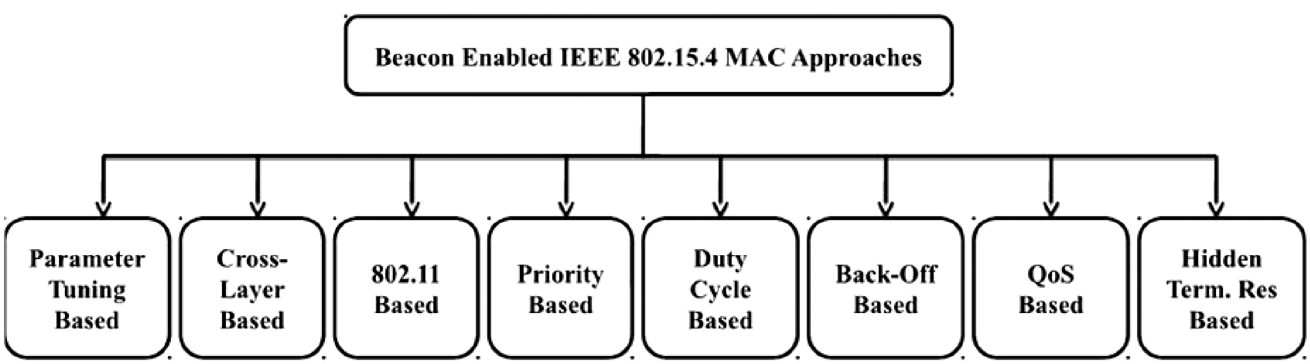

Figure 1: Various IEEE 802.15.4 MAC Approaches

4. PROPOSED MODEL

After the completion of the initialization stage, if a node in the network has the data of interest to be send, therefore attach this data to be sent which resembles the location information of the mobile node. The information of the location in the mobile nodes will be provided by the GPS module installed along the node. As soon as the location information is updated, then the node starts sending the route request (RREQ) packets to create the route (link) towards the destination from the source. The Ad-hoc On Distance Vector routing protocol uses a periodic neighbor maintenance message which is known as the Hello Packet which directly resembles the Broadcast Packets through it has created a possibility of utilizing the NB-List from the network layer in the data link layer which has eliminated the use of neighbor discovery message which has to be transmitted to the MAC protocol. After the successful transmission of the RREQ packet from the source (sensor) node to the destination (sink) node, an acknowledgment message is been sent by the corresponding sink node in form of a unicast route-reply (RREP) packet. Thereafter, the sink node updates its own location information in the RREP message and sent back to the next hop node in the opposite (reverse) route direction. The next hop in the opposite reverse route direction estimates the distance between the corresponding node and the sink (destination) node including which the information is being exported to the data-link layer. The transmission power control based on the distance of the information provided is being utilized by the MAC protocol and then it calculates the power which is required to utilize for the transmission of the data packets from sensor node to the sink node. Here the radio propagation model i.e. Two-Ray Ground model is being used to estimate/calculate the transmission power as well as the range depending upon the distance derived by the nodes. The appropriate or similar distance between the nodes is being determined as the Euclidian distance between the corresponding points. Figure (2) represents the protocol stack of the Wireless Sensor Network (WSN). To reduce the broadcast of the control packets and also to minimize the energy consumption, the nodes are navigated only in the active routes to broadcast the Hello Packets to the corresponding neighbors. Active route is the link that is being established between the sensor node and the sink node after the execution of route discovery process.

4.1. Energy Model of the efficient XLN operation

At the initial stage of the network processing where the node has the data of interest at which the node starts to broadcast node packets to create their neighbor tables. The energy by the network is the energy utilized by the each node after the successful transmission and reception of the node packets. Secondly, to discover the route towards the destination node, it transmits the Hello Packets to store the RREQ packets between the nodes. The power utilized by the nodes in this condition is the sum of the power utilized for transmitting the hello packets and the power utilized for broadcasting the RREQ packets. The proposed operation model of the XLN limits periodic broadcasting of the hello packets to the nodes which are present in the active route. Lastly, the transmission power will be adjusted depending upon the distance calculated by the source node and nodes present in middle of the active route. Due to this, the power utilized can be determined during the transmission state which is a function of distance and time taken to broadcast complete data packets. The hello packets which are being transmitted involves the power consumption which in turn bounded by the route lifetime. It is defined in the characteristics of the routing protocol.

4.2. Energy Model of the efficient XLN operation

The proposed efficient XLN operation model has been evaluated by deriving the following parameters:

Energy consumed per packet: It is defined as the ratio of the energy consumed per network to the total number of packets which are successfully transmitted.

$$E_{packet} = \frac{Enetwork}{No.\ of\ \ successful\ packets\ transmitter}$$

Packet Delivery Ratio: It is defined as the ratio of the percentage of the number of data packets successfully delivered to the number of data packets successfully generated.

$$PDR(\%) = \frac{No.\ of\ \ successful\ packets\ delivered}{No.\ of\ \ successful\ packets\ generated}$$

4.3. Model Evaluation Parameters

The network animation for the 7 sensor nodes with 1 sink node is shown in Figure (3). The Figure (3) represents the broadcasting of the data packets within the active routes by minimizing the drawback of the

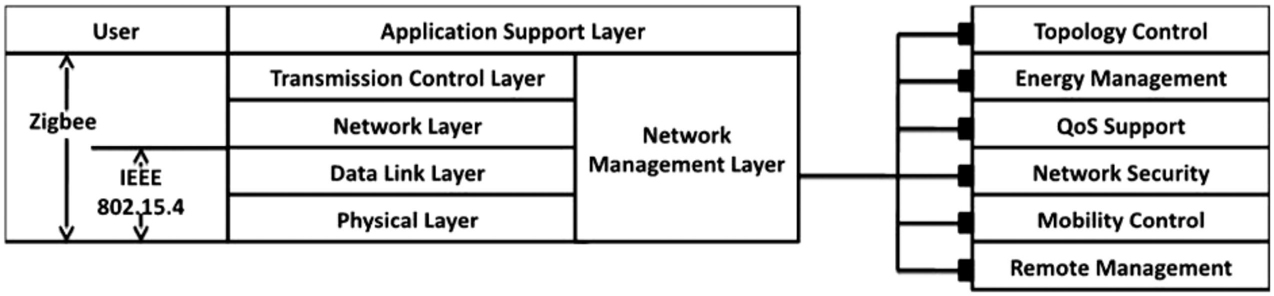

Figure 2: Protocol Stack of WSN

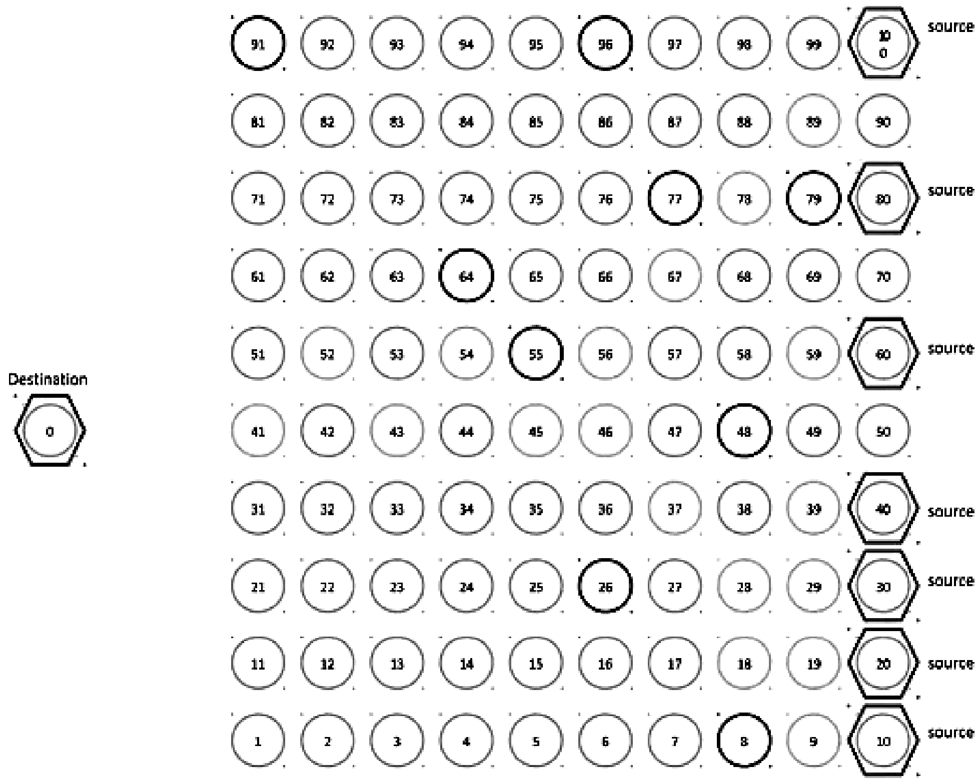

Figure 3: Network Animation Process

Simulation Parameters	Values
No. of nodes	10, 20, 30, 40, 60, 80, 100
Initial Energy (Joules)	1000
Mobility	1m/s – 3m/s
Radio propagation model	Two Ray Ground Model
Transmission Range	40 meters
Simulation Time	500 seconds
Mobility Pause Period	50 seconds
Routing Protocol	AODV
MAC Protocol	IEEE 802.15.4
No. of Sources	7 nodes
Transport Protocol	UDP
Application	CBR
Packet Size	100 bytes
Queue Length	150 packets

Figure 4: Simulation Parameters

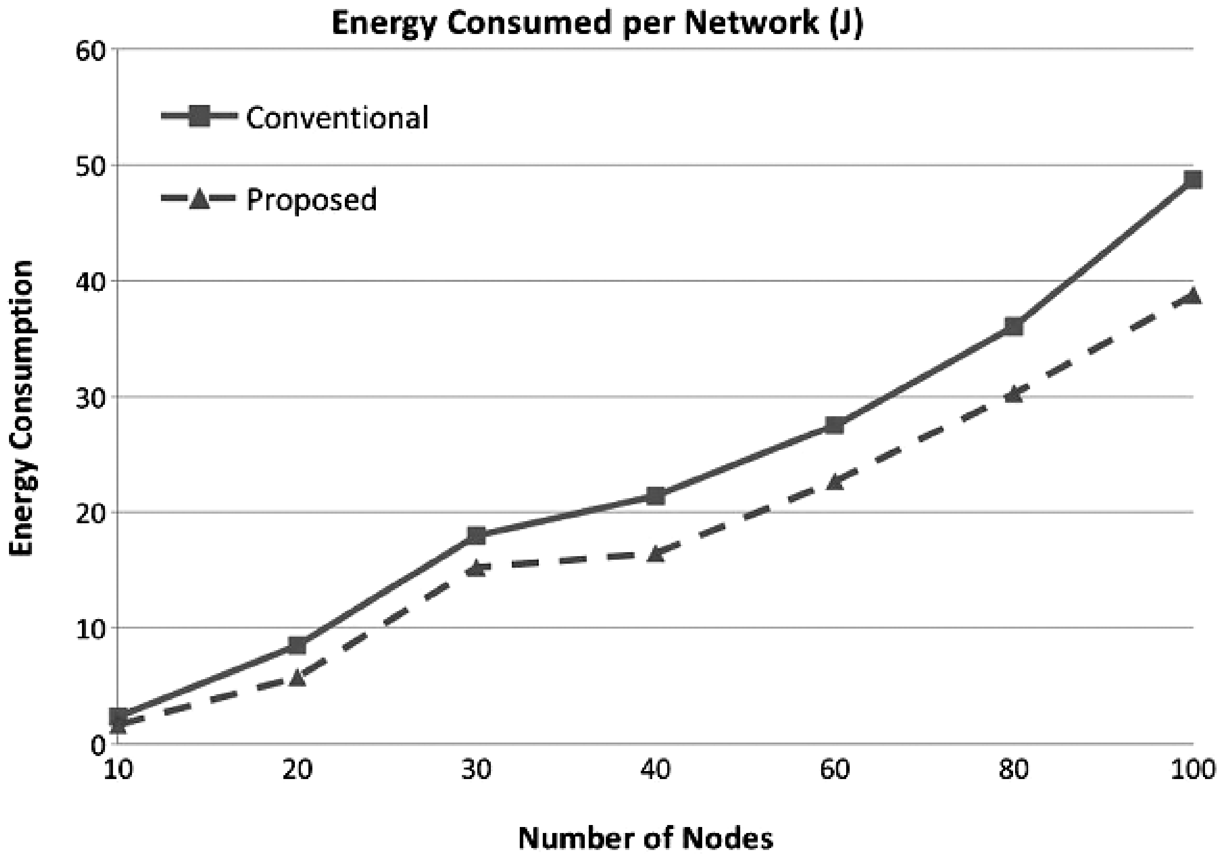

Figure 5: Energy Consumed per Network

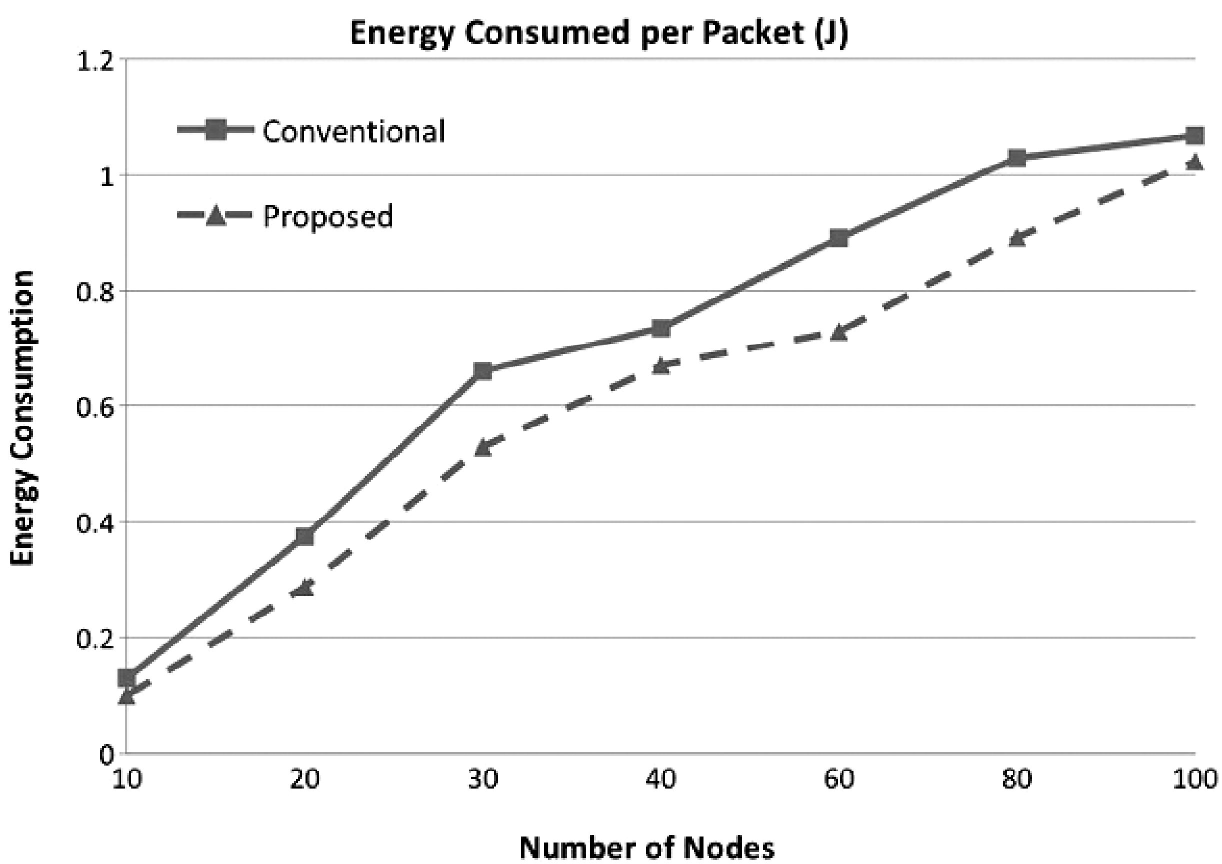

Figure 6: Energy Consumed per Packet

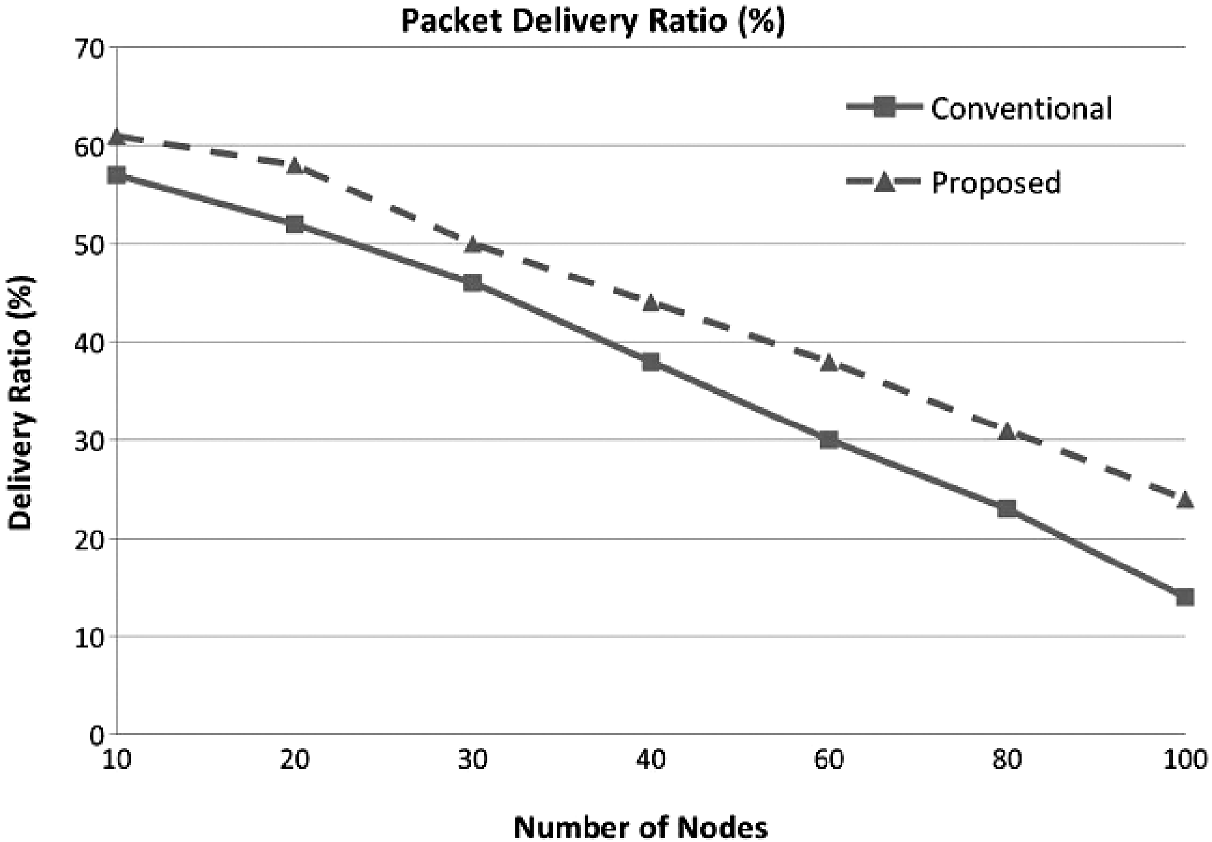

Figure 7: Packet Delivery Ratio

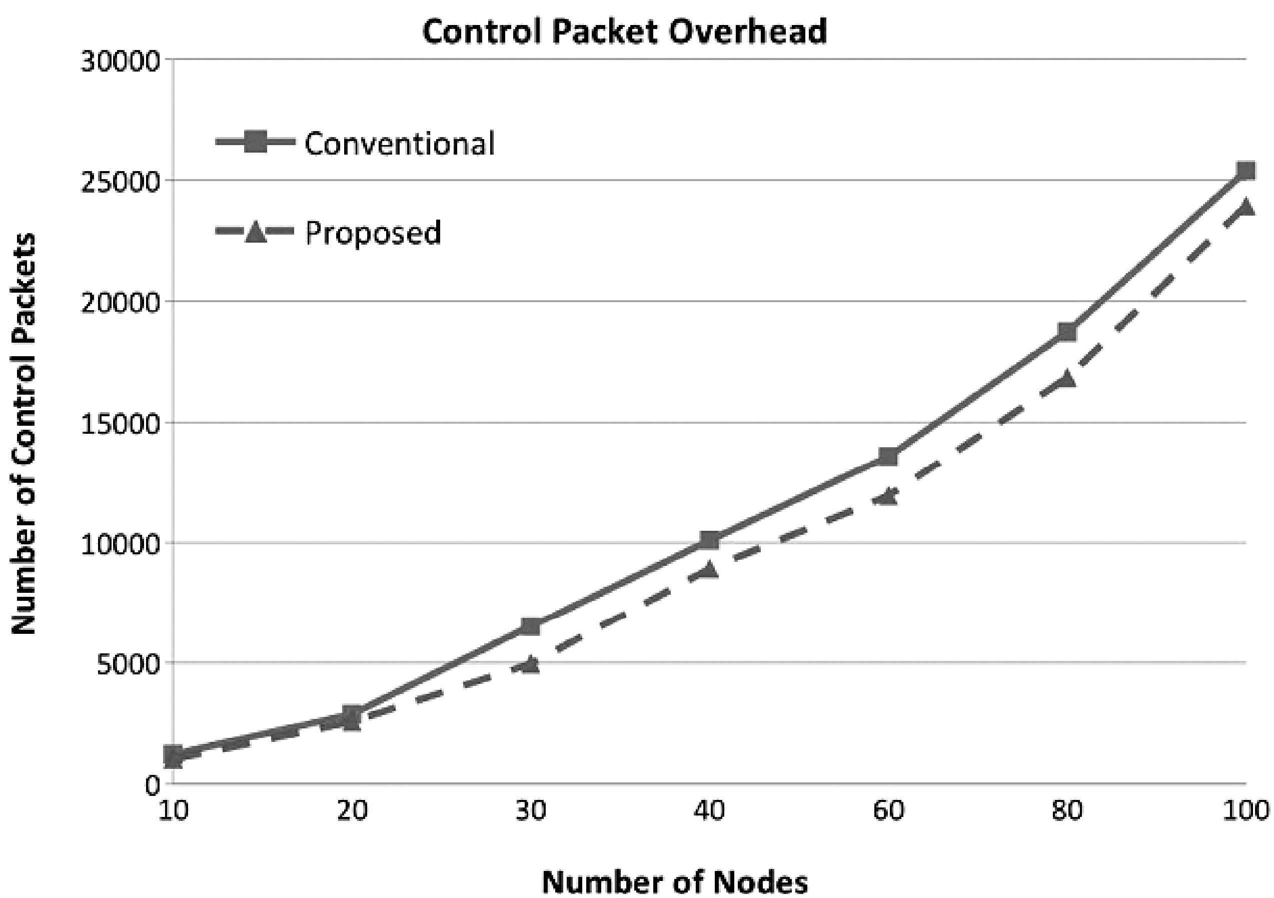

Figure 8: Control Packet Overhead

bottleneck problem. The proposed radio propagation model implemented in the evaluation process is the Two Ray Ground model in which the LOS is present and obstacles are absent between the nodes. It has been regularly used to evaluating mobile wireless sensor network operation. The energy model consists of few states as follows: transmission state, reception state, sleep state, idle/listening state and transition state.

5. RESULTS & DISCUSSIONS

To evaluate the performance characteristics of the XLN (Cross Layer Network) operation approach, extensive simulations have been estimated and performed using NS-II simulation. The proposed model also uses the cross layer approach but the difference when compared to the conventional model is that, a mobility aware protocol has been introduced in the efficient proposed model to determine the speed of the nodes from which we can observe the fast mobility nodes through which we can update the NB-List to only those nodes so that energy utilization can be minimized leading to efficient network lifetime. The remaining details are being shown in Figure (4).

Energy Consumption Results: The energy consumed of the network is shown in Figure (5). The energy consumed per packet is shown is Figure (6). As per the results is concerned, the energy consumption per network as well as per data packet with respect to proposed model is efficient when compared to the conventional model performance.

Packet Delivery Ratio (%): The PDR is high in the proposed model as due to the control packet minimization is also high when compared to the PDR of the conventional model. Figure (7) shows the PDR (%) of the IEEE 802.15.4 with respect to the cross layer model. The control packet overhead is the problem occurs in the link between sensor nodes and sink node which is due to the more number of packets at the bottleneck of the sink node. This implies the bottleneck problem. Figure (8) shows the control packet overhead is better in the proposed system.

6. CONCLUSION & FUTURE SCOPE

The proposed model determines two major clockworks: Firstly, is the controlling the number of control packets being transmitted in the network to contribute the assistance for the communication channel between the nodes. The minimization and reduction mechanism of the control packets has the impact on the transmitted packets, NB discovery packets (hello packets) at the routing layer. Secondly, is the transmission power control mechanism which is almost proportional to the location of the nodes. This mechanism is active only after the route discovery process or else only after the establishment of the route. Combining the above two major mechanisms results in energy efficiency, large throughput, minimum end to end delay and high packet delivery ratio. Apart from the above, the mobility aware protocol has been implemented in this proposed model which calculates the distance between the nodes at regular intervals of time due to which the fast mobility nodes can be identified. This implies that NB-list will be updated only to those fast mobility nodes so that the energy consumption at each and every node reduces and therefore enhancing the efficiency of the cross layer network including which the problem of bottleneck which occurs due to multiple sources has also been resolved to some extent as by scheduling those fast mobility which results in reduction of control overhead. Future scope for the efficient proposed model is to reduce more control packet overhead as well bottleneck problem. This can be done by using more efficient scheduling algorithm to minimize the above problem.

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