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Privacy Preserving in Opportunistic Routing for Wireless Sensor Networks

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***Abstract*—** There are large numbers of sensor nodes deployed within wireless sensor networks. These nodes contain batteries of extremely small size. Moreover, these nodes are generally deployed at distant locations. Therefore, replacing these batteries is not a good option. Hence, in WSN, the efficient use of battery is a main challenge. The base paper proposes a novel routing algorithm called opportunistic routing. This algorithm is used to route data packets in wireless sensor networks. The source node stores the data on the intermediate node in this sort of routing. The source node will move close to the sink node or base station. This node delivers data to the sink node. The priority is assigned to the data stored on the intermediate node. The data with higher priority is transmitted first to the sink node. A simulation tool named NS2 is used for the simulation of proposed algorithm. It has been analyzed that proposed algorithm gives better performance in terms of different performance metrics.

***Keywords*—** WSN, Opportunistic, priority queue, gateway

I. INTRODUCTION

The manufacturing of small and inexpensive sensors has become possible in technical as well as economical manner due to the recent advances in the field of technology. These sensors measure distributed environmental conditions. After sensing, these sensors transform these measurements into signals. The processing of these signals is possible to identify some features about the surrounding environment in that region [1]. Massive amount of these sensors can be deployed in various applications that need unattended operations. This phenomenon generates a wireless sensor network (WSN). Wireless Sensor Networks (WSNs) contain several hundreds or thousands of small sensor nodes. These nodes use limited energy to communicate with each other. In order to sense various ecological effects, the deployment of these wireless sensors is done in a real-world environment. Sensor nodes have limited energy. Therefore, the data gathered from target environment is sent straight to the base station (BS) or sink. Base Station is a node that receives data from sensor nodes. The gathered data is analyzed by the base station [2]. Base station or sink node decreases the similarities between the data obtained from various nodes. Then, this data is utilized for decision-making. Moreover, BS has not just the ability to utilize this data in local manner but it can send these data to other remotely deployed networks. Nevertheless, this would result in high communication overhead [3]. Sensor nodes do not have the ability to tolerate this. Data aggregation is known as the procedures of data collection from all sensors and its delivery to BS in wireless sensor networks. There are various application fields in which the technology of WSNs has been used. These applications may include military applications, survival monitoring, traffic control, intelligent buildings and object tracking. Over the years, comprehensive research works were performed to meet up the potential of cooperation among sensor nodes in data collection and processing, and coordination and management of the sensing behavior [4]. There are various 4pplications in which sensor nodes face some issues related to communication bandwidth and energy supply. Therefore, there is a huge need of pioneering approaches to remove energy limitations. These limitations reduce the life span of the network. Also, it is very important to use limited bandwidth in extremely effective manner. These limitations merged with a usual deployment of massive amount of sensor nodes cause various challenges to the design and management of WSNs. Therefore, it is highly required to maintain energy at all layers of the networking protocol stack. For instance, it is extremely required to develop methods for energy-efficient route discovery and delivery of data from the sensor nodes to the sink at the network layer [5]. This is done to maximize the life span of wireless sensor network. In wireless sensor network, routing is a difficult task. There is a lot of difference to design a routing protocol for wireless sensor network and the conventional networks. Wireless sensor networks have a limitation related to energy consumption. It is imperative to provide a solution of this issue to increase the life span of wireless sensor network. Thus, the resources should be managed properly during designing the routing protocol for WSN. Route selection and data forwarding are the main tasks of routing. Choosing the optimum route between two nodes is included in route selection process. The subsequent node or hop is selected for data forwarding in data transmission task. In the conventional routing algorithms, the node was selected proactively at the sender side for sending data packet prior to broadcasting in multi-hop wireless networks [6]. The conventional multi-hop routing algorithms used Automatic Repeat Request [ARQ] or Forward Error Control [FEC] Data link methods and limited the transmission ability of the wireless networks. A routing algorithm which uses the broadcasting nature of the wireless network to forward packet is called "Opportunistic Routing (OR)". This approach is based on the principal of the broadcasting nature of wireless network. Thus, multiple nodes overhear transmission from one node. The Opportunistic Routing delivers a data packet to adjoining nodes rather than following fixed sequence of nodes to forward data. Afterward, the nodes being successful in receiving packet coordinate with each other another and choose the optimum node for forwarding data packet. At last, data packet is further delivered and same process is replicated till the arrival of all data packets packet to the destination. This process uses the transferring potential of existing neighboring nodes [7]. Thus, the Opportunistic Routing (OR) is different from conventional routing. In traditional routing, fixed path can be followed for the forwarding of data packets. It has been analyzed that OR performs better as compared to conventional routing. Selecting the forwarder set and prioritizing the nodes within the set is the main task of opportunistic routing. EEFORT is an important opportunistic routing protocol in WSN. In contrast to previous works in opportunistic routing which were focused on designing the metric to improve network throughput and minimize the end-to-end delay, EEFORT is the first routing algorithm that investigated a metric for opportunistic routing to extend the life span of a wireless sensor network. There are the two segments in which this routing algorithm has been divided [8]. Energy Efficient Opportunistic Routing (EEOR) is a one more example of opportunistic routing. This algorithm chooses and assigns priority to the forwarder list for minimizing the overall energy cost of transmitting data to the base station.

II. RELATED WORK

Ammar Hawbani, et.al (2019) proposed a new protocol in which two major parts were integrated [9]. Initially, a regular geometric shape of four corners was used by each node to define a Candidates Zone (CZ). Through any path in CZ, the packets generated by node would be routed. The nodes in CZ were allowed to be chosen as candidates expressly. The network density controlled the size of CZ. Through the conducted experiments and achieved results it was seen that in comparison to other protocols, the performance of proposed protocol in terms of routing efficiency, energy consumption and network lifetime was better.

Hajer Ben Fradj, et.al (2018) presented a research that aimed to reduce the energy consumption and improve the lifetime of networks [10]. A new opportunistic routing algorithm named as ECS-OR (Energy Candidate Set-opportunistic Routing) was proposed in this research. The objective was to balance the energy consumption and improve the lifetime of WSNs. The conducted experiments and received results showed that the performance of network was improved in terms of energy saving and wireless connectivity.

Hajer Ben Fradj, et.al (2017) proposed an EEOR (Energy Efficient Opportunistic Routing) with the aim of choosing forwarding list [11]. Reducing the energy consumption was the major objective here. Further, this research aimed to improve EEOR by proposed a new opportunistic routing mechanism in which the Range-based Opportunistic Routing (ROR) was represented. The results showed that to reduce the energy and number of packet drops, the proposed approach provided highly efficient results.

Xinguo Wang, et.al (2017) proposed a geographical-based opportunistic routing protocol to be applied in asynchronous WSNs [12]. Multiple relay candidates which make geographical processes of value higher than the threshold value are maintained by every node of the network. To the first candidate node that wakes up, the data packet was forwarded opportunistically. By tuning γ the optimal end-to-end delay performance was achieved. Based on the conducted experiments and achieved results it was seen that a good exchange among single-hop delay and hop count of forwarding path was achieved. Also, for the forwarding path, end-to-end delay was minimized.

Nagesh Kumar, et.al (2016) proposed a new opportunistic routing (OR) metric in this paper [13]. The energy consumption and trustworthiness of sensor node were used to derive this metric. It was possible to detect a malicious activity of the network segment as per the achieved simulation results. The malicious activities were avoided effectively and efficiency and the data integrity were maintained as per the achieved outcomes.

Mayank Sharma, et.al (2015) proposed a new protocol named as Middle Position Dynamic Energy Opportunistic Routing (MDOR) [14]. For WSNs, an efficient multi-hop communication among source and destination was provided through this proposed protocol. When transmitting a packet among nodes, dynamic energy consumption as used by MDOR. The comparative analysis results showed that for proposed protocol the average end-to-end delay was higher. The dynamic energy consumption helped proposed protocol optimize the end-to-end delay and network lifetime.

III. PROBLEM FORMULATION

The wireless sensor network is the self configuring type of network which can be used to sense environmental conditions like temperature, pressure etc. The sink is deployed which act will like the base station and all the sensed information passed to sink. The main issue in wireless sensor network is the battery consumption as it is very difficult to recharge or replace battery of sensor nodes. To increase lifetime of the sensor networks technique of clustering will be applied in which static and dynamic clustering techniques will be applied. In the previous research work, the approach is proposed for the opportunistic routing protocol to ensure data privacy protection. To ensure the data privacy in the opportunistic routing, the history based routing technique is used. The opportunistic routing is the very dynamic in nature due to which it is difficult to do history based routing for the privacy protection.

IV. METHODOLOGY

Opportunistic routing is performed when a source node stores the data on an intermediate node and then forwards the data to the base station by changing its location. This research is based on opportunistic routing. The data is assigned with priority and the base station first receives the data that is utmost priority. The reliability of WSNs is reduced since the clocks of sensor nodes are not synchronized properly. This research implements the time lay technique due to which strong synchronization among sensor nodes is provided. Clock synchronization is performed in time lay technique. Until the clocks of all nodes are synchronized, clock synchronization process is performed. The gateway nodes are placed near the base station and based on the priority, the data is forwarded to base station by these gateway nodes. The priority of packets stored closer to gateway nodes is higher. This research proposed a new mechanism through which the clocks of sensor nodes are synchronized. Based on MAC time, the clock synchronization is performed by proposed technique. Current time header is sent by the node that aggregates the data to gateway. The time header is checker when gateway receives the packet. The node in which data is stored will adjust the clock depending upon the current time of gateway once the packet is received at the gateway and the time of sensor node and gateway are mismatched. The clocks of data storage node are adjusted as per the gateway node time in the final step. The nodes applied on each node work efficiently when the clocks of sensor nodes are synchronized. There is reduction in energy consumption and a steady increase in throughput. Thus, there is improvement in energy consumption, network lifetime and network throughput which leads to improvement in overall network performance.

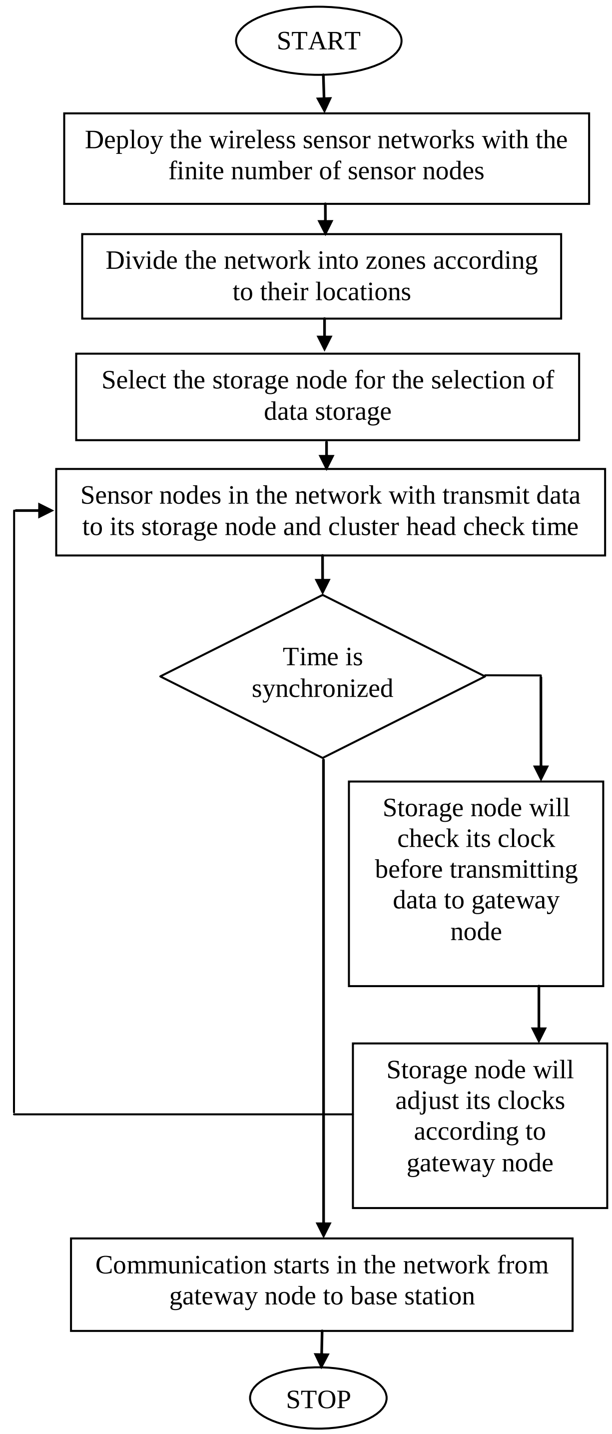

Figure 1. Proposed Flowchart

V. RESULTS AND DISCUSSION

The proposed research is implemented in NS2 and the results are evaluated by comparing them with the outcomes of existing technique in terms of different performance measures.

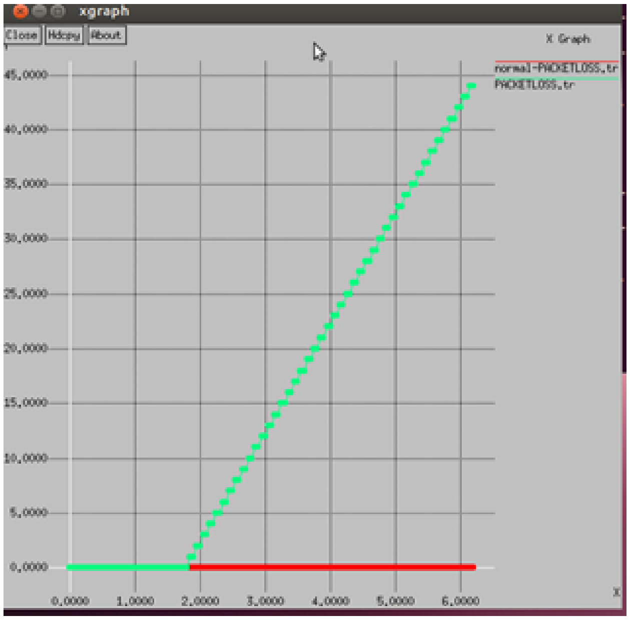

Figure 2. Packet loss without gateway

Figure 2 shows the no. of packets loss during packet delivery. Loss of some packets occurs during the transmission of data to the base station.

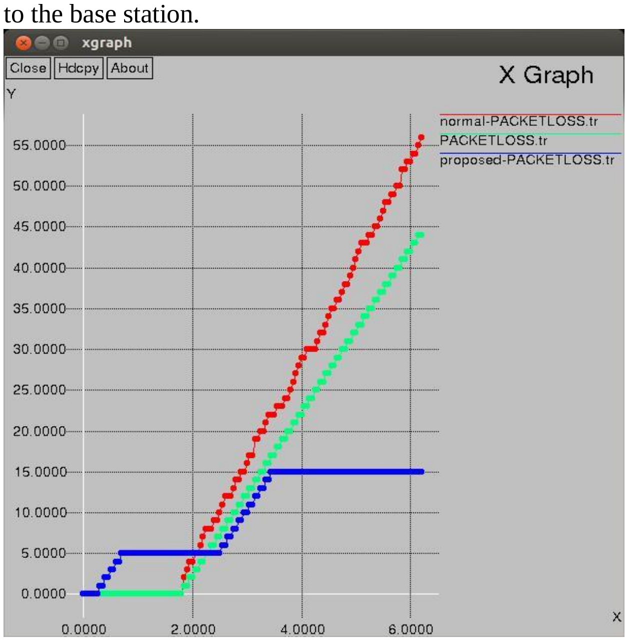

Figure 3. Packet loss comparison

Figure 3 shows the comparison of normal situation, packet loss situation and proposed situation in terms of packet loss. In contrast to other situations, the proposed algorithm performs better in terms of less packet loss as per the analysis.

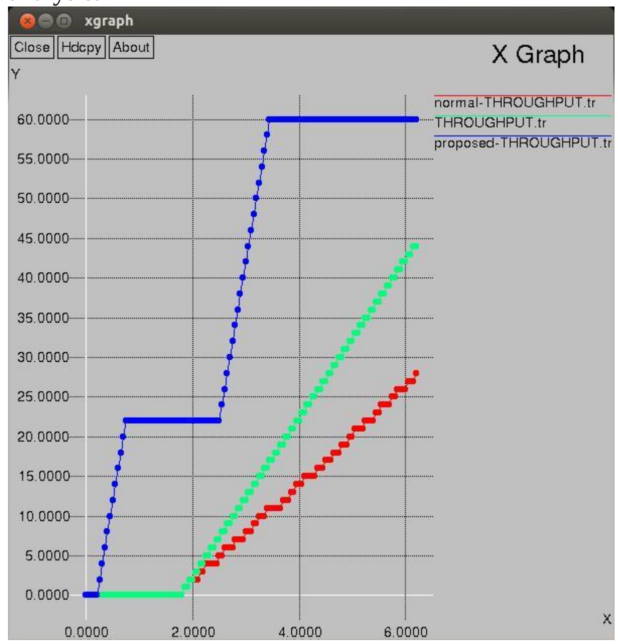

Figure 4. Throughput Comparison

Figure 4 shows the comparison of proposed algorithm, normal algorithm and base paper algorithm in terms of network throughput. In contrast to existing algorithm, the proposed algorithm gives better performance as per the analysis.

VI. CONCLUSION

A large number of sensor nodes have been deployed within the wireless sensor network. These nodes establish communication all over the network. The sensors hubs occur in these networks. These sensor hubs provide support in the collection of useful information by sensor nodes. The sensor nodes contain batteries. These batteries are extremely small in size. The proposed algorithm depends on the MAC time to synchronize clock within the network. The node that aggregate data to cluster head will also deliver data to the current time header. The gateway node after receiving packet verifies the time header. The data storing node will adjust the clock as per the current time, the time at which sensor node and cluster head gets mismatched. The cluster heads will adjust its clocks as per the received time from their neighboring cluster heads in the last stage of clock synchronization. After the synchronization of sensor nodes, the modes implemented on every node will work competently. This process reduces energy consumption and increases network throughput at steady rate. The main motive of this research work is to improve network's performance in terms of certain performance metrics. These metrics include network throughput, energy consumption and network life span.

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