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Research Article

An Energy-Efficient Event Reliability Protocol for Wireless Communication Networks

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Nowadays, WSN (wireless sensor networks) are used in every aspect of life. It consists of tiny sensor nodes that are capable of sensing, aggregating, dispensation, and sending data for end-user queries. Two major constraints in WSN are power consumption and reliability. As we know, power is limited per sensor node, so efficient utilization of power is needed all the way. Another constraint is reliability. Both constraints are in conflict with each other. If we try to increase reliability by sending the same packet on a different path, then it will increase power consumption. Many algorithms have been defined in the past to reduce power consumption and have reliable transmission. Basically, there are two types of reliability mechanisms: packet reliability and occurrence reliability. Package reliability explains about all packages must be reached at the destination. Event reliability ensures that at least one event should be successful in a specific region. This paper proposes an analysis model to evaluate the reliability of wireless sensor networks. In addition, this paper has proposed a reliability technique for events. The proposed algorithm has been simulated, analyzed, and compared with the already-published algorithms, namely BaseModel, SWIA, and ERP techniques.

1. Introduction

WSN influences every movement of human life. These are used to provide solutions for our daily life problems in a very efficient and effective manner. The applications of wireless sensor networks are almost everywhere. It is used in the defense area, weather forecasting, forest fire detection to have knowledge about forest animals, sensing natural disasters, etc. Apart from these advantages, sensors are also used in home appliances and in the healthcare environment and are useful for developing Internet of things (IoT)-based applications. Furthermore, sensor networks are also used in the sensing of underwater environments. As we all know, 70% of the Earth is covered with water, so sensing the underwater environment is again a big challenge and a big achievement in the field of WSN. Underwater sensing contains various applications for detecting the underwater environment for a large number of applications. These applications include the study of marine creatures, and monitoring chemical waste, monitoring natural disasters such as earthquakes and tsunamis.

The wireless sensor network (WSN) [1–15] consists of a large number of tiny sensor devices and a sink node. All sensor nodes have to sense the data; these sensed statistics will be sent collectively to the sink node. The sink node will forward this data to the base station for end-user queries. It is always required to reduce the power consumption of nodes. In the case of densely deployed nodes, sometimes the same information could be carried by the same nodes, resulting in larger power consumption by the nodes. In this scenario, we must have some algorithm by which the sensor nodes can identify the event. So, those nodes will not waste their energy carrying and sending the same data. In this scenario, reliability must be maintained to ensure that at least one copy of the event will be successfully delivered to the sink node.

(i) In this paper, we propose an energy-efficient event reliability protocol for wireless communication networks.
(ii) Reliability has been maintained by sending data packets through multiple routes.
(iii) same events have been identified by applying the proposed algorithm, and only one copy of similar events will be forwarded.
(iv) Reduce the power consumption.
(v) Compared the proposed algorithm in terms of unique events, duplicate events, power consumption, and total packets received at the sink node.

2. Problem Statement

Wireless sensor networks (WSN) influence every movement of human life. These are used to provide solutions for our daily life problems in a very efficient and effective manner. The applications of wireless sensor networks are almost everywhere. It is used in defense areas, weather forecasting, forest fire detection, knowing about forest animals, sensing natural disasters, etc. Apart from these advantages, sensors are also used in home appliances, in the health care environment, and to develop Internet of things (IoT)-based applications. Furthermore, sensor networks are also used in the sensing of underwater environments. As we know, 70% of the Earth is covered with water, so sensing the underwater environment is again a big challenge and a big achievement in the field of WSN. Underwater sensing contains various applications for detecting the underwater environment for a large number of applications. These applications include the study of marine creatures, monitoring chemical waste, and monitoring natural disasters such as earthquakes and tsunamis.

Till now, most of the research [5–8] has been conducted for reliable data transmission. Traditional packet reliability was concerned with reliable data delivery at the sink node. End-to-end reliability ensures that all the packets must reach their destination. Since network links are error-prone, end-to-end reliability requires that all packets, when received at the receiver's side, be sent an acknowledgement. If acknowledgement is not received for any packet, then retransmission will be carried out.

Some papers[9, 10, 16] in the past have proposed an event reliability model, in which at least one packet containing information about a specified event is received at the sink node. This results in a reduction of congestion and packet transmission overhead.

Many redundancy-based reliability schemes have been proposed in past, Kim et al. [17] proposed a famous technique for reliability transferring the data over the wireless sensor networks, and the authors also validated this by the use of erasure codes on sensor test environments. This reliable transfer for wireless networks is considering reliability in terms of packets. It uses a systematic code where decoding is simple and does not involve any complex recompilation in order to get the original message. This coding scheme introduced systematic codes, which labelled the packets either as originals or as duplicates. So, in that case, the receiving node will receive and decode only that node that is labelled as the original and discard all other duplicate packets, likewise reducing the power consumption. Reduce the cost of decoding the redundant packets.

Wen et al. [18] propose another algorithm named transmission reliability in sensor networks (TRSN). This algorithm also considers packet reliability; in this technique, the packet arrival probability is evaluated against the required probability, whereas energy efficiency is evaluated in terms of the total power consumed in successfully receiving data packets. The authors consider the Gilbert model for analysis purposes. This model is suited for one-hop communication. So, for multihop network behavior, this model is used independently. Cost and power estimation are carried out using this Gilbert model independently for all hops, and power calculation in transferring data from one hop to another is used to calculate the whole data network's power consumption. The packet receiving probability is calculated based on the packet loss probability that the next packet will be lost if the previous packet is lost.

Another author in the series proposed the OREC (Optimum Reed–Solomon Erasure Coding). Ali et al. [19] propose an error coding scheme to achieve reliability in a distributed deployment of the wireless sensor network. In this technique, the source node creates the fragments of packets using Reed–Solomon codes and then these fragments are sent over multiple paths and then it is reconstructed. The cost of preparing the fragments and then reconstructing them is calculated, and to find the optimized number of fragments to be transmitted is calculated using a genetic algorithm. This is based on a query-based WSN in which a sink node is sending the queries to the hop before the sink node. This scheme assumed a query-based WSN where the sink sends the query to the prongs, which are nodes one hop from the sink. The prongs further broadcast the queries throughout the network, and the relay nodes keep track of the path through which they received the queries.

Marchi et al. [20] proposed a routing technique known as distributed transport for sensor networks (DTSN). This technique provides a technique that is energy efficient as well as not centric on the sink. It also provides end-to-end packet reliability. In some cases where full reliability is not needed, there differential reliability technique is used by using forward error correction (FEC).

Most recently, the event reliability protocol (ERP) was proposed by Mahmood and Seah [21]. In this paper, the author discusses how the event reliability protocol depends on hop-by-hop data transfer. It ignores the redundant data transfer. It is best suited to a spatial environment when similar types of events occur. Instead of forwarding all the events to the sink node, ERP considers only different events and forwards those to the sink node, deleting the same events that occurred due to spatial correlation. This type of reliable transmission is carried out with the help of region-based selective retransmission, through which unique events are sent to the sink node.

Table 1 describes the comparison among the retransmission-based reliability scheme. In the existing literature algorithm for identifying the same event information is missing. One decentralized process was required for the same. For correct event reliability, this is the most important factor. Once packets containing information about the same event can be identified in a distributed fashion, the next challenge is to reliably transport the event information in resource-constrained WSNs. In WSNs, hop-by-hop event reliability is sufficient for event-driven applications, rather than end-to-end packet reliability [21, 32]. The traditional approach to end-to-end reliability is inefficient as it introduces long delays, increased traffic, and packet loss, all of which cause energy wastage, which has been the primary concern for resource-constrained WSNs. The node-by-node mechanism that performs packet loss identification and recovery at each node is a more efficient approach. The challenge is to integrate the node-by-node approach with an event identification method to create a node-by-node event reliability mechanism that reliably delivers sufficient event information while minimizing the traffic overhead.

Table 2 describes the reliability schemes at the packet level.

3. Proposed Architecture

In this WSN environment, three types of nodes are deployed. Sink nodes are used to collect the information from all the sensor nodes and are arranged at the water surface. Cluster head nodes (anchor nodes) are dispersed, one per cluster, and ordinary sensor nodes are used to sense the real environment. The sink node is the node that is responsible for gathering the information from all sensor nodes and cluster head nodes and transmitting that information to the base station. These nodes are equipped with a GPS system knowing their exact location all the time. Cluster heads (CH) are the nodes that can directly talk to the sink node. CH nodes can contact sink nodes to get their exact locations. These CH nodes can assist ordinary sensor nodes in knowing their locations. Ordinary sensor nodes are those with less transmission power and low energy, through which they cannot directly communicate with a sink node because of limited power and high cost. Further sections define the work within a cluster.

In this, the whole system is divided into three tiers. The first-tier distance is stated from the base station up to distance $d1$. The second tier starts from $d1$ up to distance $d2$. The third tier is the $d2$ to the end of the network convergence area. Now, the nodes are assigned a tier ID based on their distance from the base station.

3.1. Data Transmission to BS.

The workings of the architecture are as follows.

The whole network is divided into tiers. Nodes among these tiers are arranged into a spanning tree. Tier 1, which is closest to the base station, has the maximum chance of sending the aggregated data to the base station. Energy has been balanced by defining a threshold value. As soon as the energy of any node reaches the threshold, it will not take part in being the cluster head. Other nodes having the maximum residual energy in a tier will be elected as cluster heads and start aggregating and sending data to the base station. After several intervals, when the energy of all the nodes in tier 1 is below a threshold value, a node in tier 2 will be elected as the cluster head and start aggregating and sending data to the base station. This process continues to tier 3 if all the nodes in tier 2 get exhausted. The process will be terminated if all the nodes in the network have less energy less than the threshold. To save the energy consumption at the node level, we have defined an energy-saving algorithm that identifies the same events and dropsi the same event data packets, saving energy by not transmitting them further.

4. Reliability Models

This section describes the reliability models.

4.1. Reliability Block Diagram.

Suppose a system X consists of a component, $S = \{s_i | 1 \le i \le n\}$, where s_i is the component number i. The value of i will be between 1 and n. The state of system component will be either failed or operational. Suppose t_i indicates the state of any component at a particular interval of time, thus,

$$\begin{aligned} t_i &= 0\{\text{ifcomponentfailed}\},\\ t_i &= 1\{\text{ifcomponentisoperational}\}, \end{aligned} \tag{1}$$

where t_i represents the state vector, which defines the condition of each part of the system. The system state is represented by a discrete random variable x_i.

$$\begin{aligned} x_i &= 0\{if component failed\},\\ x_i &= 1\{\text{ifcomponentisoperational}\}, \end{aligned} \tag{2}$$

where x represents the organization function of the organization.

$$\varnothing(X) = X_i \varnothing(1_i, X) + (1 - X_i)\varnothing(0_i, X), \tag{3}$$

where $\varnothing(1_i, X) = \varnothing(X_1, X_2, \cdots, 1_i, \cdots X_n)$ and $\varnothing(0_i, X) = \varnothing(X_1, X_2, \cdots, 1_i, \cdots X_n)$.

In equation (1), two equations are defined. The first equation explains that all components are working and the states of other apparatus are arbitrary. The second equation is defined as all components are failed and states of other components are random.

The reliability block diagram is used to explain the reliability of the system. The reliability block diagram enables us to describe and examine the reliability of an organization's system by considering all the components of the system.

Table 1: Retransmission-based reliability schemes comparison.

Protocol	Traffic flow	Loss recovery	ACK-mechanism	Sink centric	Coding scheme
ERP [21]	Up	Hop-by-hop	iACK	No	No
ESRT [22]	Up	End-to-end	—	Yes	No
DST [23]	Up	End-to-end	—	Yes	No
PORT [24]	Up	End-to-end	—	Yes	No
ART [25]	Up	End-to-end	ACK/NACK	Yes	No
STCP [26]	Up	End-to-end	ACK/NACK	Yes	No
RBC [27]	Up	Hop-by-hop	iACK	Yes	No
DTSN [20]	Up	End-to-end	ACK/SACK	Yes	No
PSFQ [28]	Up	Hop-by-hop	NACK	Yes	No
GARUDA [29]	Up	Hop-by-hop	NACK	Yes	No
SWIA [29]	Up	Hop-by-hop	iACK	No	No
ERTP [30]	Up	Hop-by-hop	iACK/ACK	Yes	No
RMST [31]	Up	Hop-by-hop	NACK	Yes	No

Table 2: Comparison table of packet-level reliability schemes.

Protocols	Traffic flow	Reliability level	Encoding/decoding	Evaluation	Supportive mechanism
TRSN [18]	Up	Packet	Hop-by-hop	Theoretical analysis	ULP
OREC [19]	Up	Packet	End-to-end	Theoretical analysis	Genetic algorithms
DTSN [20]	Up	Packet	End-to-end	Simulations	Enhancement flow
RTSN [17]	Up	Packet	End-to-end	Theoretical analysis	Alternate route-fix
RDTS [33]	Up	Packet	Hop-by-hop	Theoretical analysis	Partial coding
FBcast [34]	Down	Packet	Hop-by-hop	Theoretical analysis	FB cast

4.2. Reliability Model. In this section, we are representing the models in which WSN can be arranged. With the use of reliability models, we can describe how the routing algorithms reflect on the reliability of the system.

4.2.1. Basic Definitions. A WSN consists of simple, tiny sensor nodes, communication links, and destination sink nodes. WSN nodes are arranged in a specified region. All WSN nodes follow a specific path called WSN Path that represents the connections of sensor nodes with sink nodes. Likewise, several paths exist between sensor nodes and sink nodes. For reliability purposes, the reliability of each region is calculated independently. Reliability is affected by various 4 factors: location of the nodes, reliability of the nodes, reliability of links, and routing algorithm. So, each element will be associated with a reliability model, which leads to the models for nodes and links, models for region, and model for Path.

WSN configuration has been defined initially. After that, all other steps will be performed automatically. Paths are formed in this region. Path models are applied to all paths. Then, in step 3, the final region model will be applied.

(i) Basic Model [25]: Node reliability is described by the following blocks: operating system, middleware, radio, and battery level. Node reliability depends on the dependability of all these components; if any one of these fails, then the whole node will fail. Node simulation is used to determine the status of the node. Simulation is carried out based on battery level and radio status (active/inactive). If the battery level is low, then the node's reliability will be less. Same as if a radio is inactive then data packets sent in that time will be lost. Reliability will be greater than 0.0 if a radio is active, and it will be equal to zero in the case of a radio inactive.

(ii) Path Model: Path contains at least two nodes, where the sender node is the one that starts the data packet and another destination node that terminates the path. If there are more than two nodes in the path, then it will be called a multipath model.

(iii) Region Model: one region will have more than one sensor node. If the area has only one sensor node, then the area model and pathway model will be the same. If the region has more than one path model, then the combination of all the path models will be the region model.

5. Proposed Solution: Enhanced Event Reliability Algorithm

The authors of this paper have proposed an enhanced event reliability algorithm. The author's aim is to design reliable and scalable event-based wireless sensor networks.

5.1. Overview. WSNs consist of a large number of small-sized sensor nodes capable of sensing, aggregating, and sending the sensed data. Sensor nodes usually sense the data, form a packet, and send this data toward the sink node based on the routing algorithm. To ensure reliability, the same packet must be sent from different paths so that a minimum of one packet must be received at the destination. In the event of reliability, it is ensured that at least one packet must be reached at the same time. While improving event reliability, power consumption is also minimized by sensing only one packet of similar events. Only unique data must travel from source to sink. Now consider a scenario in which a data packet is lost due to any reason; then, for reliability, these packets must be retransmitted, which again increases congestion.

Sensor nodes in the same region will produce the same events. The data packets produced by adjacent regions will contain correlated packets. On this basis, ERA has been proposed, explaining the selective retransmission of unique packets. It avoids the retransmission of unnecessary packets with correlated information. The flow chart of the proposed algorithm has been shown in Figure 1.

5.2. Network Deployment. S is the set of sensor nodes in a WSN. Where $S = S_i$ $(i = 1, 2, \ldots, N)$. Sensor nodes are arranged in a network and assumed to be covering all the regions equally in the network. At an instance of time, a sensor node S_i sensed the data, prepares a data packet, and sends this packet of the data toward the sink node.

6. Event Reliability Algorithm

6.1. Working at Sensor Node. Whenever an action occurs in the network, nodes will sense this event, detect this event and form a packet for this event, and send this packet towards the sink node. After sending this packet, the node will start its timer and sense the channel to know the status of whether one hop node has forwarded that packet to the next hop. If the node overhears that the next hop has forwarded node to the next hop node, then it will consider this as an implicit acknowledgement. After this acknowledgement, the sensing node will remove that packet from the queue. If it does not hear about data transmission on the next hop, then it will resend the same packet to maintain reliability. A threshold value for the counter is also defined to determine when retransmission can be carried out. If the counter value exceeds this threshold value, then the packet will be removed from the queue and will not retransmit. Here, the node assumes that nodes will retransmit the packets with the same events. Figure 2 shows the event sensing and transmission toward the sink.

6.2. Working at Intermediate Node. The intermediate node maintains three queues: sent data packets, drop data packets, and the current queue.

(a) Drop packets list: this list contains the drop packets list of all the packets, which are dropped from the current list and do not forward the packets.

(b) Sent data packets: this list contains packets that have been successfully sent to the network.

(c) Current queue: this list contains the data packets temporarily saved for transmission decisions.

Figure 3 shows that at the time of the first data packet, when any node receives a data packet from a near node, it will add that data packet to the current queue. The data packet at the front of the current queue will be forwarded to the next hop node as per the routing technique. After transmitting packet, intermediate node will wait for the acknowledgement from the next hop node. If it overhears the acknowledgement from the next hop node, then it confirms that packet has been transmitted successfully, so it will discard the packet from the queue, and all the sent packets will be saved in the sent list.

From the next packet generation onward, whenever an event occurs in any region, it will generate a packet and put it in the queue maintained at the sender node's current list. Now transmission decisions will be carried out by checking whether this data packet contains the event generated from the same region based on the specified range. If it is from the same region, then packets will not be forwarded and will be saved in the drop and discarded from the current queue. If a packet from the same region has been received, then the transmission decision will be carried out by checking whether the event was the same or not. If the same event from the same region is received, then that packet will be discarded and saved into the drop packet list. The same process will be carried out at every intermediate node. In this case intermediate node will send an explicit acknowledgement to the previous node because implicit acknowledgement will not be received by previous node.

If it does not receive any acknowledgement from the next hop node, then it will check the region-based retransmission. For each failed packet, it calculates the spatial correlation and temporal correlation between the current packet and all nodes in the queue. If the event is generated from the same region means their spatial correlation with the current packet is less than twice the range of the sensing range, then it is assumed that the packet contains the information about the same event. So, this packet will not be retransmitted. If there is no correlated data, then it will forward the same packet again until the threshold value is achieved.

6.3. Working at Sink Node. The sink node is the final node, which collects all the information about the actions that occur in the system. After receiving all the packets containing all the events, the sink node will send an unambiguous acknowledgement to the preceding node. This acknowledgement is the confirmation of the reliability of messages received at the end user.

(1) Originator node x senses the event E within its range of sensing.

(2) X now creates a packet P with sensed data along with its coordinates' details.

6.3.1. Pseudo Code for Implementation: At Sink Node. Algorithms1 and 2 are listed as follows:

6.3.2. Implementation: At Intermediate Node

(1) intermediate node will receive a packet to be forwarded to the sink node. It will temporarily store this packet in its queue. Then wait some time and send this to sink nodes through some neighbor's node.

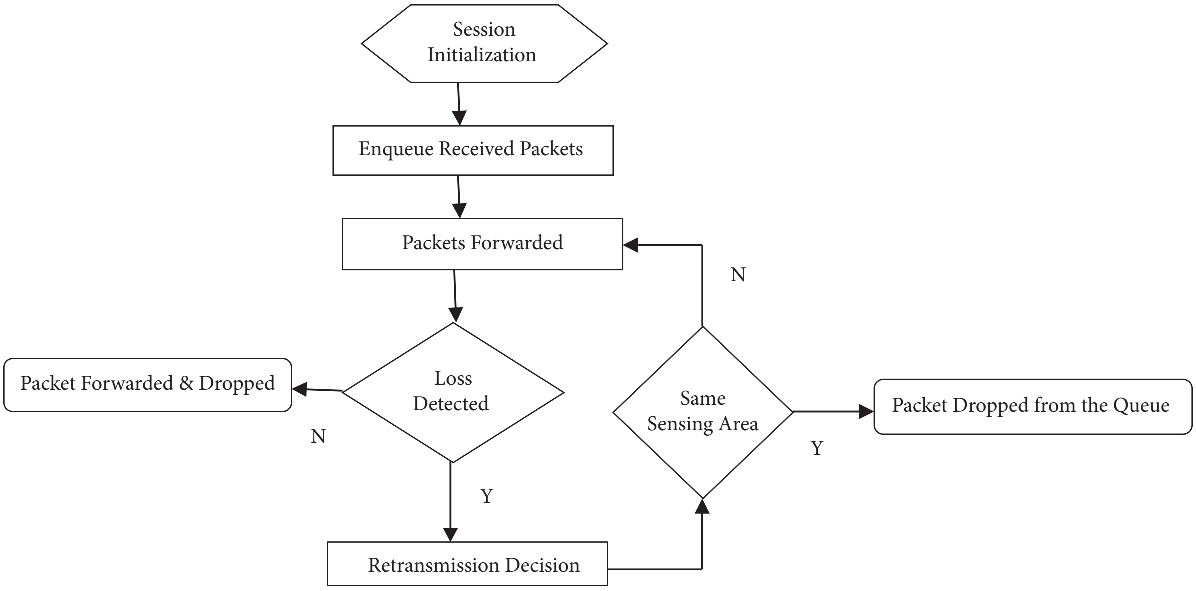

Figure 1: Flow chart of the algorithm operations.

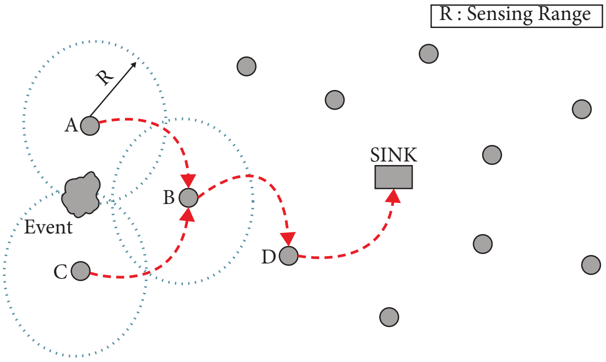

Figure 2: Event sensing and transmission toward the sink.

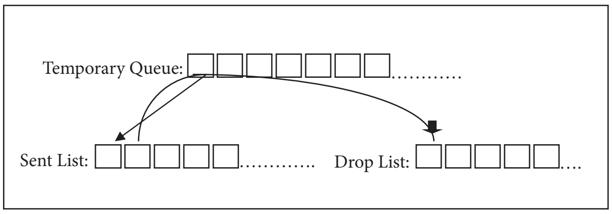

Figure 3: Working at intermediate steps.

Ne1- > Packet (P).

(2) Neighbor node Ne1 will start a timer to wait for an implicit timer if the next hop is not the sink node.

(3) If the channel is free and the timer expires, then Ne1 will send a packet to the next hop node.

(4) If the channel is not free, then the retransmission count has reached its maximum and selective transmission will take place.

6.3.3. Implementation: At Sink Node

(1) sink node will receive the packet, enqueue it, and then send acknowledgements one by one.

7. Performance Evaluation

This section will explain the performance of the design protocol in the case of grid deployment when all nodes have 100% connectivity. This work has been simulated in MATLAB. Sensor nodes are deployed on $100\,\text{m} * 100\,\text{m}$ area. Work has been simulated in comparison to SWIA (Stop and wait implicit acknowledgement) and the base model (with no reliability model).

7.1. Unique Event Reported at Sink. Figure 4 shows the events which are uniquely received at the sink node. By comparing it to all SWIA [35], Base model and ERP [21],

```
$E <- (Sense(event)_x)$
Generate Packet $(x - axis_x, y - axis_x, \text{timestam}p_E, id_E)$
$x ->$ add $P$ to Queue at $x$
Transmit data packet from node $x$ to$z$ through$y$
if $X -> NeighbourNode! = z$
    then
    StartTimer $(P)$
do
    Listen $(P)$
    timer < − timer + ticks
    while (Listen$(P)$! = TRUE)&&checkTimer(timer < = ExpireTimer$(P, a)$) == TRUE
```

Algorithm 1: The first part of the procedure.

```
if P == TRUE then
Drop $P$ from queue at $x$
else if $(P == FALSE)$ & & $(Rx < b)$ then//Rx: Retransmission
$Rx = Rx + 1$
ReTransmit $(N_o, \text{Route}(x, z), P)$
else
if $(P = \text{FALSE})\text{and}(Rx\text{Count} > b)$ then,
$N_0 ->$ DeleteQueue$(P)$
end if
end if
end procedure
```

Algorithm 2: The second part of the procedure.

the E3RP algorithm shows better performance. In the base model, events are directly forwarded without considering any reliability mechanisms. In comparison, this SWIA model is simply receiving the packets, storing and forwarding that, as shown in Figure 4. Its x axis is denoted as network density, and its y axis is denoted as unique events received at the sink.

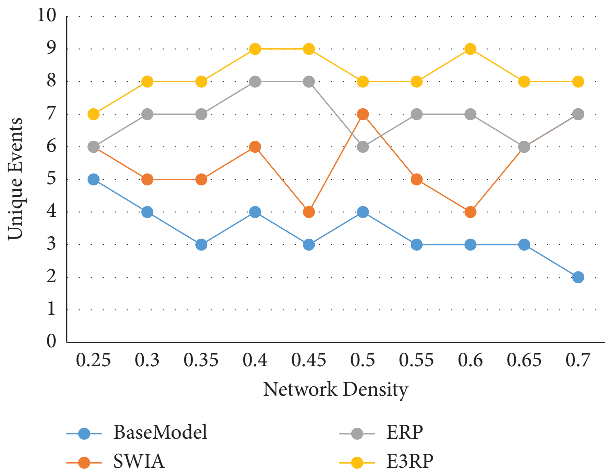

Figure 4: Unique events received at the sink node.

7.2. Percentage of Duplicate Events Reported at the Sink. In this case, stop-and-wait transmissions possess a higher number of duplicate packets at the sink node. Because no checking has been taking place at every node for the repetition of events. In comparison, this proposed algorithm checks the repetition of events at every node. Figure 5's x axis is denoted as network density and the y axis is denoted as the percentage of duplicate events received at the sink.

7.3. Total Packets Received at the Sink. Energy consumption is the main measure of network performance if there are lots of nodes in the network (such a network is named dense network). In a dense network, all nodes are continuously sensing something and forwarding data to the network. Likewise, some duplicate data will be forwarded over the network. A higher number of data packet received at the sink nodes means a higher number of duplicate packets will be there. This will result in higher energy consumption. In this regard, the proposed algorithm has considered this fact and checks for duplication at every node, which results in less energy consumption, as shown in Figure 6. Its x axis denotes a network density, and its Y axis denotes the total number of packets received at the sink.

7.4. Average Battery Consumed by the Nodes. This section describes the average battery consumed by nodes. The battery is used to provide power to the CPU and memory blocks. Energy consumed is the sum of all transmission and receiving energy in all the packets.

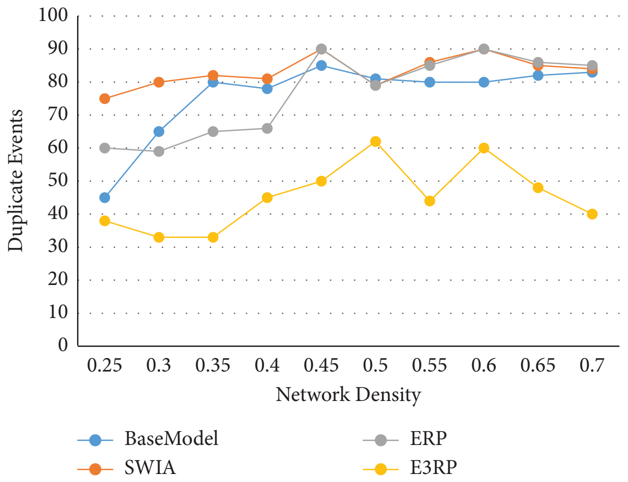

Figure 5: Duplication of events received at the sink node.

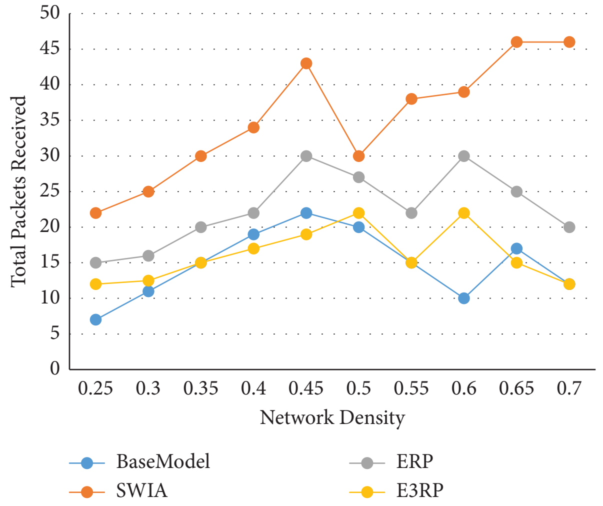

Figure 6: Average number of total packets received at the sink node.

Figure 7 shows the stop-and-wait for implicit acknowledgement, consuming maximum energy. This is because of the retransmission of packets until the node stops detecting the acknowledgement. In contrast to this proposed algorithm, we have applied a more sophisticated algorithm to reduce the retransmissions. Also, the base model is just sending the packets; it is not considering their reliability. The x axis of Figure 7 is denoted as network density, and the y axis is denoted as the average battery consumed by the node.

8. Discussion

Wireless sensor networks work for many applications in the field of control systems and monitoring. All of these applications need reliable transmission because they are all used for some specific purpose. Reliability is one of the major concerns in wireless data transfer. To address this issue, we did a literature survey of existing protocols.

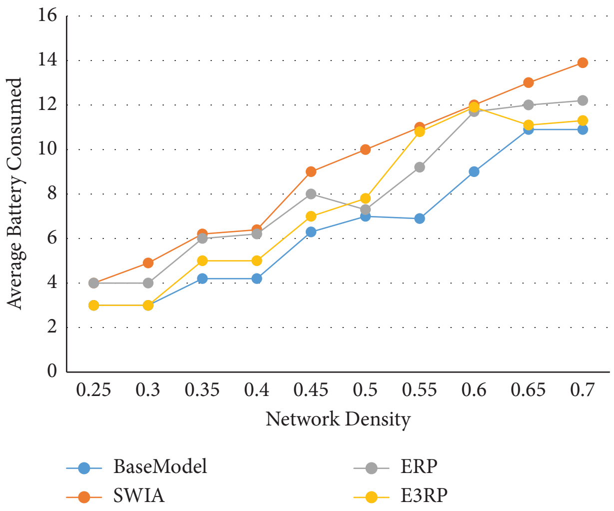

Figure 7: Average power consumption by the nodes.

Event identification is another major challenge in ensuring event reliability. Many algorithms have been defined to ensure event detection. But the concern is not only to detect the event. Event identification is important. Only then can one identify whether two packets are carrying the same data or different data. In this paper, we have addressed the abovementioned problems and proposed an energy-efficient event reliability protocol for wireless sensor networks.

9. Conclusion

This paper proposes the energy efficient event reliability protocol, which improves the event identification process with less power consumption. It uses the condition of spatial locality, which employs selective retransmissions. It also ensures that the redundant packets received at the sink node are minimized. All the packets are preprocessed before forwarding to the next hop node. The proposed work has been compared with a few other algorithms like BaseModel, SWIA, and ERP. E3RP performs the analysis of identifying the same events at the node end, which reduces the retransmission of the same events. Simulation has been carried out in MATLAB. Four different performance metrics have been used for performance analysis: unique events received, identifying events, average power consumption, and the total number of packets received. E3RP confirms the unique events at the node level; by doing this, it results in less communication, a reduction in congestion caused by retransmissions, and ultimately, an improvement in system efficiency through a reduction in power consumption.

Data Availability

Data will be made available upon reasonable request to the first author and subject to copyright permissions (email: gulista.khan@gmail.com).

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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