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Performance Analysis of Optimum Retransmission Based Multipath Routing Protocol in WSN Using OMNET++ Simulator

Laveena Mahajan[1], Avani Chopra[2], Robin Chadha[3]
[1] *(Research Scholar, Department of Computer Science & Engineering, DAVIET, India)*
[2] *(Assistant Professor, Department of Information Technology, DAVIET, India)*
[3] *(Assistant Professor, Department of Electronics, KMV College, India)*

Abstract: Designing an efficient and reliable routing protocol for Wireless Sensor network is a challenging issue. Multipath routing technique plays a vital role to improve the reliability of WSN by creating several transmission paths from the source to the sink node. In this paper, multipath routing protocol is designed for WSN using OMNET++4.5 simulator. The simulation is based on the proper selection of sensor nodes, number of dropped frames, and other important parameters. This paper presents a comprehensive analysis of how MIXIM framework can be used to simulate multipath wireless environment. The methodology is discussed to improve the Quality of Service (QoS) of the network using the concept of optimum retransmission in which only the dropped frames are retransmitted. The results are analyzed for the simple scenario of multipath wireless environment on the basis of latency, number of dropped frames and backoff duration.

Keywords: MIXIM, Multipath Routing, OMNET++, Optimum Retransmission, Wireless Sensor Network

I. Introduction

A wireless sensor network (WSN) consists of densely distributed sensor nodes that are capable of sensing, signal processing, computing, and connectivity. The main purpose of a WSN is information gathering and transmits it from source to the sink node, but the problem is to deliver information correctly with minimum energy consumption. A wireless network can generally be used in many application areas including industrial process monitoring and control, healthcare applications, disaster management system, vehicular networking and battlefield communication or traffic control [1].

Routing in WSN is a process of determining a path from a source node to its destination for data transmission. In recent times, routing protocols use a single path for data transmission. It is a simple routing technique by selecting an optimal path and sending the data through that path. But, due to the limitations of single path routing protocols, multipath routing protocols has been introduced which uses an alternate path between sources and sink node to evenly distribute the traffic load over the network [2]. Most of the multipath routing protocols focus on energy efficiency, load balance, fault tolerance, and thus, extending the network lifetime.

The primary objective of the proposed work is to improve the Quality of Service (QoS) of the wireless network by using the concept of retransmission. This shows that only the number of packets dropped can be easily retransmitted to the sink node instead of sending all packets again to the sink node. The rest of paper is organized as follows: section II shows the related work. Section III describes multipath modeling techniques. The proposed multipath routing protocol is discussed in section IV. OMNET++ model and simulation parameters are described in section V. Section VI describes Simulation Results and Analysis. Conclusion is provided in section VII.

II. RELATED WORK

Multipath routing techniques provide reliability, higher throughput, improved load balancing, Quality of service (QoS) and lower delay. The authors in [1] [2] [4], discussed a comprehensive analysis of various multi-path routing techniques in WSN and discuss its benefits over single path routing protocols. It shows the detailed operational characteristics of existing multipath routing techniques on basis of different categories. It also explains taxonomy of different multipath routing protocols. Energy-aware node-disjoint multipath routing protocol (EANDMRP) have been discussed in [3] which is sink initiated routing protocol having node-disjoint paths between the source and sink nodes. This protocol maximizes the network lifetime, provides better reliability, improves end to end delay, packet delivery fraction, and enhances the energy efficiency.

The paper [6] [7] [9], emphasis on OMNET++ Simulator and MIXIM framework for modeling the multipath routing protocols. IM2PR (Interference-Minimized Multipath routing protocol) for Wireless Sensor Networks is proposed in paper [8] that provides event-driven packet forwarding and discovers minimum interfering paths in WSN to improve transmission quality between an event and sink area. This protocol

constructs minimum interfering paths towards the sink, selects the path which includes a minimum number of packets to be transmitted in a single path delivery. Other multipath routing protocols have been discussed in the paper [10] [12]. The overview of the network simulators for designing the multipath wireless environment is shown in [13] [14] [16] and optimum retransmission multipath routing algorithm is proposed by using OMNET++ simulator.

III. MULTIPATH MODELING TECHNIQUES

In WSN, routing is a technique to transmit the data from the source to sink node. Multipath routing technique either uses alternate path or concurrent paths for data transmission. Alternate path routing uses primary path for transmitting data and make the other paths to be as a backup which is to be used in case of any node failure or in the case when primary path consumes more energy than other paths.

On the other hand, using concurrent path routing, protocol uses multiple concurrent paths and evenly distributes the traffic load over the network, thus extending the network lifetime [2].

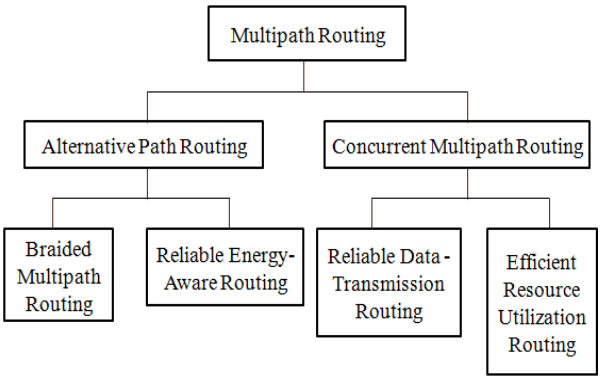

Fig. 1: Multipath Routing Protocols

3.1 Alternative Path Routing

Alternative path routing discovers multiple paths one at a time for transmitting data between the source node and sink node [4]. Thus, in the network, each node maintains information about alternative next-hop neighbors towards the sink.

In alternative path routing, the source node discovers the multiple paths during the route discovery phase. Then, the source node chooses a single path to route data towards the sink node but the other discovered multiple paths are not discarded and are kept as back-up paths [2]. These back-up paths are used to switch traffic between them when the primary path fails. It includes:

3.1.1 Braided Multipath Routing:

Braided Multipath Routing constructs several partially disjoint paths and provides fault tolerant routing in WSN [3].

Firstly, the primary path is computed to construct the braided multipath. Then, for each node on the primary path, the best path is determined while it does not include that node. Those best alternate paths are not necessarily disjoint from the primary path and are called idealized braided multi-paths [4].

3.1.2 Reliable and Energy-Aware Multipath Routing:

This multipath routing is designed to construct energy efficient wireless sensor networks, while provides reliable data transmission through maintaining a backup path from each source node towards the sink node [3] and increases the lifetime of the network.

3.2 Concurrent Multipath Routing:

After the source node discovers the path, multiple paths can also be used simultaneously to route data towards the sink node. Concurrent multipath routing uses several multiple paths simultaneously to route data from source towards the sink node. It was used to distribute the load across the network and reduce the number of transmission delays [2]. It includes:

3.3 Reliable Data-Transmission Routing:

This concurrent multipath routing can be used to support reliable communication over unreliable low-power wireless links and introduces data redundancy during the data transmission process [3].

3.3.1 Energy-Efficient Routing:

With respect to the limitations of tiny sensor nodes, this energy-efficient routing is developed to balance network traffic and resource utilization throughout the network.

IV. Proposed Multipath Routing Protocol Technique

Multipath Routing Protocol based on optimum retransmission is proposed to increase the lifetime of nodes present in the multipath environment. The lifetime of the nodes directly depends on the efficient use of energy stored in the on-board battery of sensor node. All the processes such as sensing, coordination, communication performed by the sensor node require energy.

Moreover, more energy is required during the communication process where total energy consumption depends on the energy consumed in transmitting the packets and the energy required during retransmission of packets, in case of a collision. The collision of packets increases with increase in the number of the transmitted packets which leads to frequent retransmissions of the dropped packets.

The proposed multipath protocol uses an alternate path routing technique to improve the energy efficiency of multipath routing protocols using optimum retransmission as shown in the fig 2.

Thus, each node in the network maintains information about alternative next-hop neighbors towards the sink on the basis of the shortest distance between the hops. The primary path switches to another backup path on the basis of shortest distance in case of node failure.

At the initialization phase, a wireless network is designed and the source node, as well as sink node, is selected. The selected source node discovers the primary route on basis of minimum hop count from its neighbor nodes. At the time of primary path creation, every node selected during route discovery is checked before the data transmission. In case of any node failure, an alternative intermediate node gets selected to transmit data to the sink node. But, if there is no node failure on the route, then, data is directly transmitted to the sink node from that primary path.

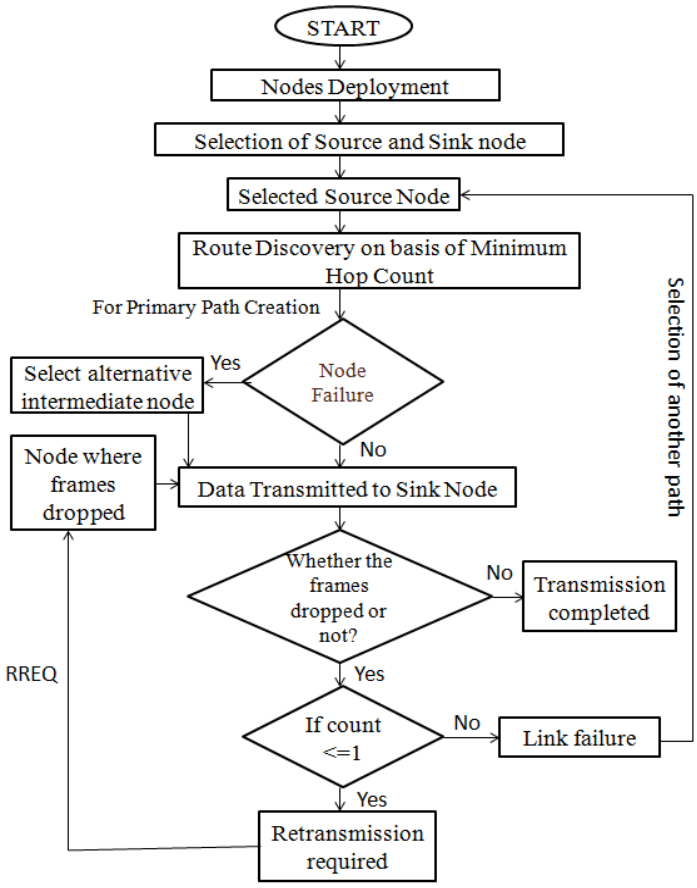

Fig 2: Flowchart of Proposed Multipath Routing Protocol

When the data received at the sink node, the frames have been checked that whether the frames have been dropped during transmission or not. If no frames dropped then the transmission is completed. But if frames dropped, then the counter counts the number of the frames dropped. If it is only the first time the frames dropped, then, retransmission of the dropped frames is required. The retransmission of packets is optimally done from the node where the frames get dropped instead of creating the whole path or from the first sensor node of the path. This will decrease the energy consumption and increase the Quality of service (QoS) of the entire network. But if the frames dropped more than once, then, in that case, no retransmission is required. This leads to the link failure and another path is selected for transmitting the data.

V. OMNET++ MODEL

To establish the simulation model, the OMNET++ network simulator, and MIXIM framework is used. MIXIM (mixed simulator) is an OMNET++ modeling framework created for fixed wireless networks.

5.1 System Model

We executed the proposed optimum retransmission based model using MIXIM framework version2.3 and OMNET++ 4.5 network simulator. We presented multipath wireless environment comprising the features of static nodes with limited battery, processing, and storage. Sensor node uses multiple channels for communication, which required the establishment of MAC (Medium Access Control) protocol [12].

The multipath design developments are slightly complicated as it requires in-depth knowledge to present a broad analysis. We demonstrate multipath wireless environment consisting of a total of 50 sensor nodes as shown in fig 3. In this model, the nodes are responsible for establishing the connection between the nodes, gathering the data, and then, transferring information.

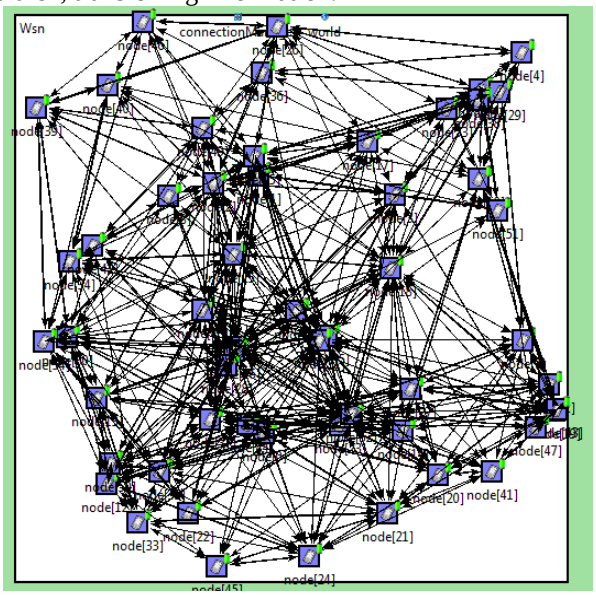

Fig 3: Multi Node WSN

5.2 OMNET ++ (MIXIM) Project Design

For Wireless network, a mixed simulator framework known as MIXIM is used for performing the simulations in OMNET++. This framework reduces the complexity of the model and gives an accurate analysis [10]. The code in OMNET++ is written in C++ language. It consists of various tools such as the NED (network description language), omnet.ini file, MSG file, result analysis tools, simulation launcher, documentation generator and other application modules.

To build an optimum retransmission based model in OMNET++, the following steps are required:

1) Create Project in OMNET+++
2) Design the model including NED file and C++ coding
3) Configure the Project i.e. omnet.ini file
4) Build the Project
5) Analyze the results

The new project is selected in OMNET++ simulator and then MIXIM framework is used for designing the wireless sensor network. We chose the Basic MIXIM network for simulation as it has an ability for selecting the various features.

5.3 Node architecture

The architecture of a node in WSN comprises different layers i.e. application, presentation, session layer, transmission layer, network, and NIC layer as shown in fig 4. The application layer is responsible for sending the request for transmission to the network. Mac layer is a part of a transceiver and special parameter that consumes more energy in WSN. In this paper, CSMA is used for Mac layer. Network layer performs reconfiguration and code reusability by using routing protocols. Each layer has a connection with its upper and lower layer [17].

5.4 Simulation Parameters

The evaluation of optimum retransmission based model consists of 50 sensor nodes as shown in fig 3 in the network size of 100m × 100m. OMNET++ 4.5 with MIXIM 2.3 is used for the designing and computation of the model. IEEE 802.15.4 is the required low cost and low power communication standard between the sink node and other sensor nodes [14].

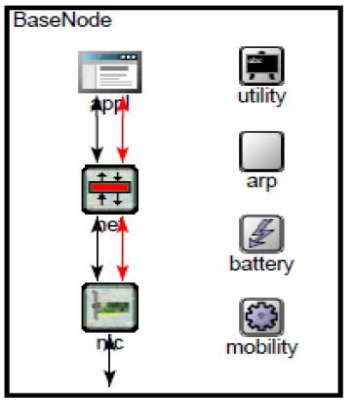

Fig. 4: Node Architecture

TABLE 1: Simulation Parameters

Parameters	Value
Network Size	100m×100m
Node Deployment	Uniform Node Distribution
No. of nodes	50
Carrier Frequency	2.4Ghz
Simulation Time	20ms
Bit rate	256 Kbps
Application layer Header Length	50 bytes
Network Layer Header Length	24 bits
Sink Node Address	Node 0
Mobility type	Static
Medium Access Control Layer	CSMA

VI. Simulation Results and Analysis

This section analysis the performance of proposed multipath routing protocol and simulates the results on the basis of latency, number of dropped frames and backoff duration.

6.1 Latency

Latency is defined as the time taken by the data packets to receive the sink node which is transmitted by the source node. With the increase in the number of packets over the network, the latency also increases. The Latency of the proposed multipath protocol over the number of packets is shown in fig 5.

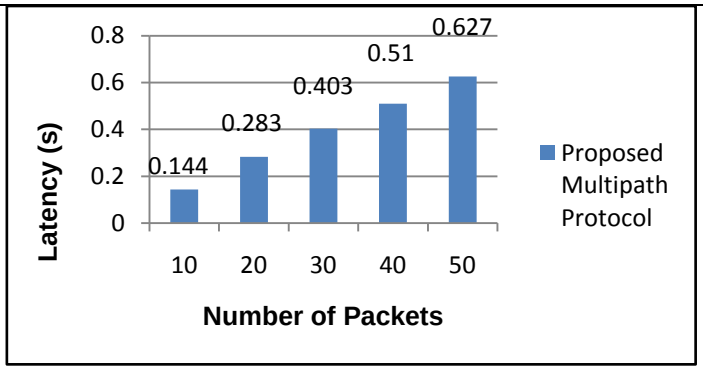

Fig. 5: Latency of Proposed Multipath Protocol

6.2 Number of Dropped Frames

During the data transmission, the number of frames dropped in case of the collision of data over the network. With the increase in the number of the packets, more will be the collisions over the network which leads to the maximum number of the frames dropped. This is shown in fig 6.

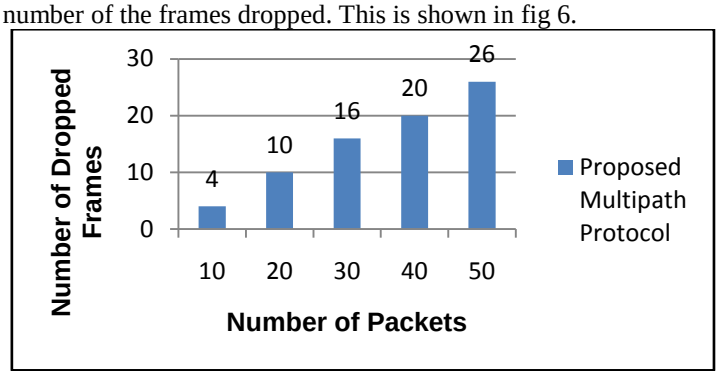

Fig. 6: Number of Dropped Frames of Proposed Multipath Protocol

6.3 Backoff Duration

Backoff Duration describes the time taken in retransmission of the dropped frames. It increases with the number of frames dropped. Fig 7 depicts that more the number of dropped frames more will be the Backoff Duration.

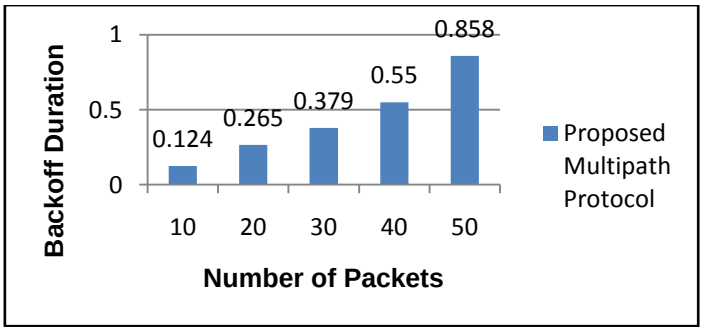

Fig. 7: Backoff Duration of Proposed Multipath Protocol

VII. Conclusion

In this paper, we illustrated the behavior and performance of Multipath routing protocol based on optimum retransmission in which only the dropped frames is retransmitted instead of retransmission of all packets. We considered OMNET++ (MIXIM framework) simulation tool to study the multipath wireless environment. The output graphs that are obtained by using OMNET++ simulator show data transmission i.e. the number of packets to be transmitted and verify the Quality of service (QoS) of the network. Generally, it can be concluded from graphs that QoS of WSN is improved in terms of latency, number of dropped frames and backoff duration in multipath wireless environment.

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