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# Investigation of failed node method to support healthy communication for linear wireless sensor networks

**Musa Çıbuk*[1], Davut Arı [2], Fikri Ağgün [3], Ümit Budak [4]**

[1]*Bitlis Eren University, Engineering and Architecture, Computer Engineering, Bitlis, Turkey, mcibuk@beu.edu.tr*
[2]*Bitlis Eren University, Engineering and Architecture, Computer Engineering, Bitlis, Turkey, dari@beu.edu.tr*
[3]*Bitlis Eren University, Adilcevaz Vocational School Department Of Computer Technology, Bitlis, Turkey, faggun@beu.edu.tr*
[4]*Bitlis Eren University, Engineering and Architecture, Electricity - Electronic Engineering, Bitlis, Turkey, ubudak@beu.edu.tr*

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**Keywords**
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LWSN
MAC Protocol
Linear Topology
Failed Node

**ABSTRACT**

Wireless Sensor Networks (WSNs) are used extensively in many natural environment research and observation applications in the world, and their popularity is increasing day by day. In parallel with these studies, Linear Wireless Sensor Network (LWSN), which is a type of WSNs application, is frequently encountered for reasons such as meeting the security requirements of highways, bridges, pipelines, and border lengths, determining and observing the needs. For this purpose, within the scope of a project, a new MAC protocol has been designed by us, which is effective in minimizing LWSN problems and can ensure the continuity of the network's connection in difficult physical conditions. With the failed node method, which is the main subject of our article and introduced in the protocol in question, an important study has been put forward to avoid situations that will disrupt the data transmission of the network.

## Introduction

Recently, possibilities have emerged that allow the implementation of Linear Wireless Sensor Network (LWSN) applications with ease, which can consist of many sensor nodes and be used along linear lines. As seen in Fig. 1, LWSN is a specialized type for WSN applications that require linear topology characteristics. Thanks to its linear array feature, operations such as installation, maintenance, and routing are effortless. However, there are difficulties to be solved in such networks such as end-to-end latency, excessive data traffic at end nodes, network reliability, node failure, and link failure [1]. The linear nature of such networks can be an important motivation for designing custom protocols to increase reliability, efficiency, energy savings, and network lifetime [2-3].

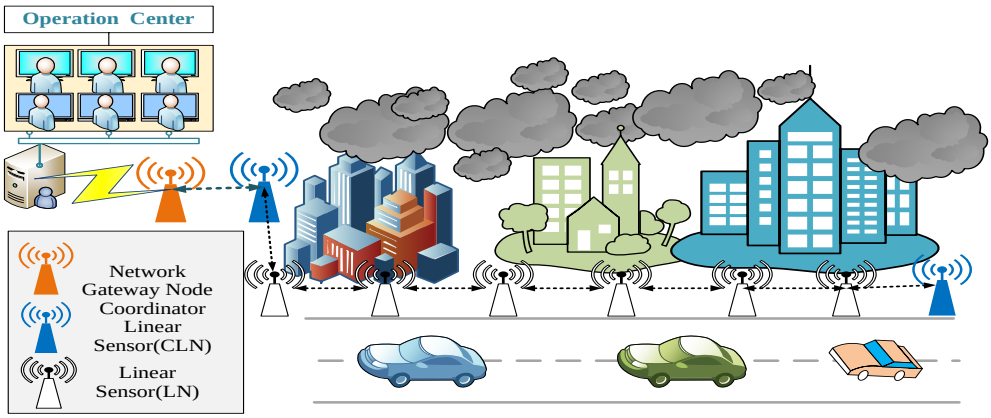


**Figure 1.** An example LWSN structure

Unlike traditional networks, sensor networks work on dense distribution and coordination. It has been seen that sensor network applications have many advantages over traditional networks, primarily in military applications, detection and surveillance of enemy activities [2].

LWSNs have been used in many applications such as pipeline [4-5], mine tunnel monitoring [6], traffic monitoring, and road safety [2,7].

Operations such as network setup and routing, which are difficult for most WSN types, are quite easy with LWSNs. Intensive studies are carried out on the development of MAC protocols, and they provide effective communication in networks. We have proposed a new MAC protocol that can be used in LWSNs, providing efficient, healthy, and lossless communication. In this protocol, a method is proposed that aims to prevent the communication between the nodes in the network from being interrupted. This method steps in when a node is disconnected from the network and contributes to the continuity of the network even if a node on the transmission line is disconnected from the network. The success of the proposed method has been demonstrated by the simulation and the performance analysis has been made. The results show that the method activated in the node failure scenario in the proposed MAC protocol is a highly effective method that can eliminate the disconnection in the network and maintain communication smoothly.

LWSN networks continue to increase in popularity day by day. Well-designed MAC protocols and the methods used in them have a salient place among the chief factors affecting the efficient use of resources by sensor nodes with low features and limited sources.

LWSN is created by arranging sensor nodes one after another along a line. In fact, as the number of nodes increases, many network parameters such as end-to-end latency, network connection success, energy savings, and network lifetime are adversely affected.

Energy-efficient node placement research is among the main design considerations for all WSNs and especially for LWSNs spread over large areas [3].

In our study, it is thought that the proposed method to optimize the topology and feel the network disconnection as little as possible will support the topology optimization approach. With these aspects, it is thought that the method in the proposed protocol will make an effective contribution to the literature.

## Material and Method

The Node Failure method in the developed MAC protocol, which ensures the continuity of the network by maintaining the communication in the network despite the nodes disconnected from the network, and significantly affects the protocol performance in this respect, has the mechanism whose diagram is given in Fig. 2.

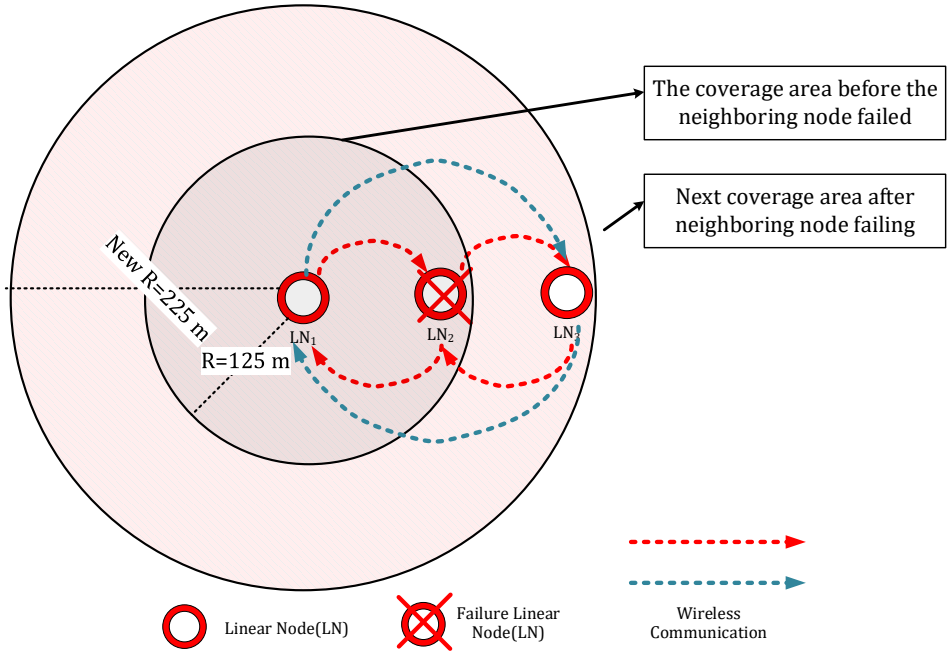


**Figure 2.** Behavior of Failed Node Mechanism

Thanks to this structure defined in the MAC protocol, the node, which decides that its neighbor has dropped from the network, increases its coverage area, scans the distance of two hops instead of one hop, and communicates with its neighbor at two hops distance and can ensure the continuation of the network over themselves. Thus, this

mechanism ensures the continuity of the communication line. In the example simulation scenarios, in the first case, neighboring nodes communicate in the area with a radius of 125m. However, depending on the disconnection from the network, the communication distance radius increases up to 225m.
The Riverbed Modeler program was preferred for the performance evaluation of the proposed MAC protocol within the scope of this study. There are three types of nodes in the prepared Network Project environment: Sensor (LN), Coordinator (CLN) and Sink. The simulation parameters are given in Table 1.

**Table 1.** Simulation parameters

| Parameter | Value(s) |
|---|---|
| Radio propagation delay model | dra_propdel |
| Modulation | qam64_ber_snr |
| Radio propagation Range | 125m & 225m |
| Transmit Power | SR_tx = 0.027w |
| Receive Power | Sr_rx = 0.0366w |
| LN Count | 10, 20, 30, 40, 50 |
| CLN Count | 2 |
| Sink Count | 1 |
| Node Layout | Linear |
| Used Channel Count | 1 |
| Distance Between Nodes | 100m |
| Simulation time | 25sn |

Connecting LWSN nodes to the network and performing their duties without disconnecting from the network is of great importance in terms of network performance. Under this title, the responsiveness and behavior of the protocol, due to the relevant method, in case a node disconnects from the network for any reason, is examined.

**Results**

The example scenario applied to show the response of the nodes and the continuation status of the network in case of node failure is shown in Fig. 3.

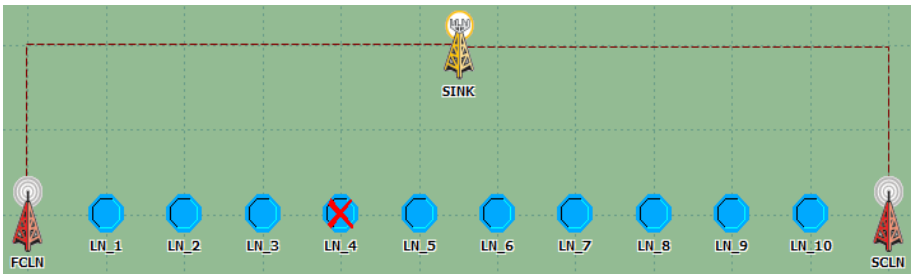


**Figure 3.** Failed node example scenario

A node (LN4) was disconnected from the network in a certain period of time and after a while, the disconnected node was allowed to join the network again. The total number of active nodes in the network is shown in the graph in Fig. 4(a), and the graph showing the number of data packets transmitted in the network in case of a change in the number of nodes is shown in Fig. 4(b).

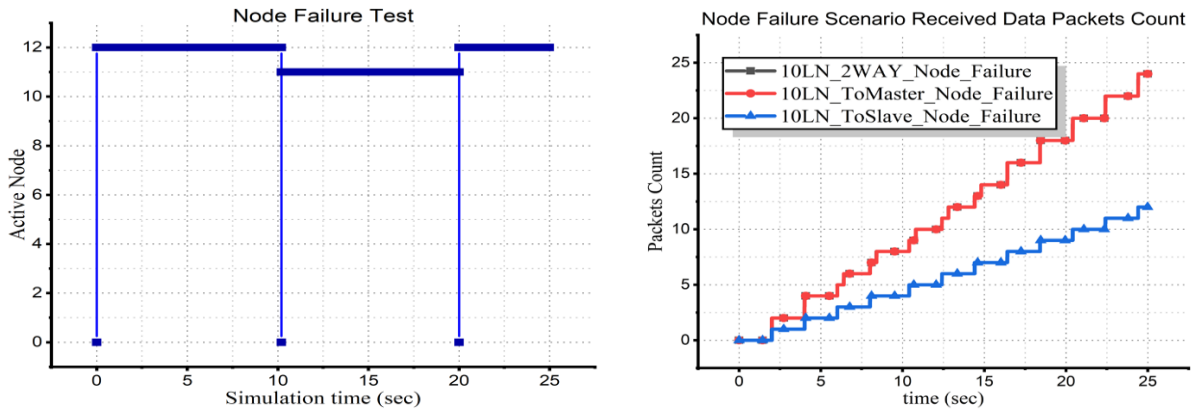


**Figure 4.** Failed node graphic (left), Number of data packets transmitted in case of the failed node (right)

**Discussion**

When Fig. 4(b) is examined, it is seen that although a node is disconnected from the network, data packet communication continues in that process. In this case, with the node falling from the network, the neighboring nodes doubled their coverage area, ensuring continuous communication and connection continuity in the network. It is seen that the same number of packets reached the destination in all three data transmission models. The results show that the failed node method in the proposed protocol works and the transmission continues without packet loss in the network, proving the success of the method.

**Conclusion**

LWSN application simulation shows that the proposed protocol in the simulation environment and the node failure method in the protocol work successfully, and this success also shows that our proposed method has an important place among the precautions to be taken against breaks in the network.

In the node failure method, the neighboring node fulfills the task of the node that has fallen from the network by expanding its coverage area, and the continuity of data communication is ensured without disturbing the communication of the network.

Within the scope of this study, only one node disconnection from the network is studied; the method's behavior in case of disconnection in more than one consecutive node is left to later studies.

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**Author contributions**

**Musa Çibuk and Davut Ari:** Conceptualization, Methodology, Software. **Fikri Ağgun:** Data curation, Writing-Original draft preparation, Software, Validation. **Ümit Budak:** Visualization, Investigation, Writing-Reviewing and Editing.

**Conflicts of interest:**

The authors declare no conflicts of interest.

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