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Infrastructure-Less Wireless Networks Employ Reactive Routing with Knapsack-Based Buffer Management

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Abstract: Wireless infrastructure-less networks provide network resources independent of location. These networks are mobile, resource heterogeneous, peer-to-peer, self-forming, and adaptable. Health management, military, and disaster aid use such networks for reliable communication. These networks use routing to connect source and destination nodes and forward data packets. Network nodes' buffer sizes hinder efficient routing. We present a buffer-aware route-finding system that optimises nodes' packet processing based on their residual buffer size using the knapsack algorithm. Our buffer overflow-prevention method improves network performance. Using the NS-2 simulator, the suggested mechanism reduces packet loss, improving network performance. Our work proposes an effective routing protocol for wireless infrastructure-less networks that takes into account nodes' restricted buffer sizes. The proposed system could be used where efficient and reliable communication is needed.

Introduction

With the use of wireless devices that contain a variety of resources and dispersed through radio communication, the purpose of wireless infrastructure-less networks is to make internet connectivity available everywhere. If two devices are within radio range of one another, they are able to communicate with one another directly. If they are not, communication must be enabled by intermediate nodes. The network is dynamic and unpredictable, and as a result, it is possible for devices to join or depart at any time. Because the network is capable of self-formation, adaptability, and autonomy, it is not only simple but also economical and straightforward to put into action.[1] However, due to the one-of-a-kind qualities of these networks, it is difficult to design optimal routing methods inside them; hence, this is a topic that is currently being researched.

The process of processing and forwarding packets is known as routing. Routing is an essential component in facilitating communication inside a network. In wireless infrastructure-less networks, routing protocols are required to incorporate some level of quality of service in order to meet the demands of various applications.[2] Due to the absence of a central coordinator and the limitation of heterogeneous resources, it is difficult to achieve efficient routing, which is why buffer awareness is such an important consideration during the route calculation process. Before forwarding packets, intermediate nodes store them in a buffer for a brief period of time.

However, if the buffer reaches its maximum capacity, the packets are lost, and the storage space is squandered. Therefore, selecting proper intermediary nodes is absolutely necessary.[3]

In this research, we present an effective routing protocol with the goal of reducing the amount of data that is dropped from wireless infrastructure-less networks as a result of buffer space constraints. This problem of packet loss caused by buffer overflow is addressed by the route-finding metric, which is based on the optimised packet processing ability of the node in residual buffer size. The following outline constitutes the paper's structure: The second section discusses the use of buffer-aware routing in wireless networks that lack infrastructure. In the third section, we will examine the method of assessing the node's capabilities to process packets in a buffer-specific optimised manner. In the fourth section, the criteria and outcomes for the performance review are discussed. In the last part of the article, we will provide a summary as well as some recommendations for the future.[4]

Efficient Buffer-Aware Routing Protocol for Wireless Infrastructure-Less Networks

This section explain the stages involved in determining the optimal packet processing capacity (OPPC) of a network node for a specific residual buffer size.

To begin, let's take into consideration a wireless infrastructure-less multi-hop network with mobile nodes that are equipped with buffers of size Q bytes each. We are working under the assumption that data is transferred over a network in the form of packets, and that these packets must travel through an intermediary node that has buffers of size Q bytes. There are three requirements that must be met before communication can take place on a network without experiencing loss of packets as a result of a crowded buffer:[5]

It is important that the overall volume of a node's communication packets not exceed Q bytes.

It is necessary to complete as many packets as the node is capable of processing.

It is necessary for the node to disregard a sizeable fraction of the packets.

It is necessary to select the subset of packets that maximises the total of their sizes in order to calculate the optimal number of packets to process through an intermediate node within the confines of the available buffer (Q). This requires us to choose the subset of packets that meets the constraint that the sum of their sizes does not exceed Q. [5,6,7]

To estimate the network node's optimal packet processing capacity (OPPC) for a particular residual buffer size, one way that can be used in practise is to carry out all conceivable procedures while keeping them under Q bytes. This can be achieved with the help of the knapsack algorithm, which produces two arrays with multiple dimensions.[9]

The first array, denoted by the letter L, is comprised of the elements L[0 to n, 0 to Q], where n refers to the total number of packets and Q specifies the size of the buffer. We compute the optimal packets that should be processed over an intermediate node in a particular residual buffer for each and every element L[i, Q_s(P_i)]. We steer clear of the following possibilities: L[0, Q_s(P_i)0]=0, which indicates that no packet is currently being processed, and L[0, Q_s(P_i)>0]=-, which indicates that the current state of the system is illegal.[8,9,10]

The second array is a Boolean auxiliary array that is referred to as Keep. It contains the elements Keep[i, Q_s(P_i)], where i is the number of the packet and Q_s(P_i) is the size of the packet. The appropriate knapsack method can be determined based on the values contained in

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this array. If an active node sends the ith packet from a communication array Keep[i, Q_s(P_i),] the array will change to one; if an active node does not send the ith packet, the array will change to zero. [1,11]

Following are some formulae that can be used to compute the optimal packet processing capacity (OPPC) for a particular residual buffer size:

L[i, Q_s(P_i)] = max(L[i-1, Q_s(P_i)], L[i-1, Q-Q_s(P_i)]+P_i) Keep[i, Q_s(P_i)] = 1 if L[i, Q_s(P_i)] > L[i-1, Q_s(P_i)] else 0 [11,12,14]

In this context, the size of the ith packet is denoted by P_i, while the size of the buffer is denoted by Q. The first equation determines, in a particular residual buffer, the maximum value that may be reached by the optimal packets that have been processed through an intermediary node. If an active node delivers the ith packet from a communication array Keep[i, Q_s(P_i),] the value of the Boolean auxiliary array is changed from zero to one by the second equation. If an active node does not send the ith packet, the value is changed to zero.

For the purpose of computing the optimal packet processing capacity (OPPC) for a particular residual buffer size, the knapsack algorithm is utilised. The technique generates two multi-dimensional arrays called L and Keep. These arrays are then used to estimate the maximum value of the optimal packets that were processed across an intermediate node in a certain residual buffer. While the second array modifies the value of the Boolean auxiliary array, the first array determines the highest possible value and computes it. [13,14,15]

Performance Analysis

To evaluate the proposed algorithm, a network simulator such as NS-2 used to simulate a network. We generate various categories of network traffic, including voice and data packets of varying sizes, and vary the network load to observe the algorithm's performance under various conditions. During the simulation, numerous performance metrics, including packet loss rate, end-to-end delay, and throughput, will be measured. The efficacy of the proposed algorithm will be compared to a baseline scenario in which packet-dropping nodes are not removed from the route. To further evaluate the proposed algorithm, we can also undertake experiments with different threshold parameter values OPPC_max and OPPC_min and observe how the algorithm performs under various threshold settings. Finally, we can compare the proposed algorithm to other existing routing algorithms, such as the shortest path algorithm, to determine its efficacy in reducing packet loss and enhancing network performance as a whole.

Using a discrete-event network simulator, the efficacy of a proposed routing algorithm is assessed. The simulation includes 100 nodes randomly distributed across a 500m 500m area. The nodes have distinct transmission and processing capabilities. The protocol used for routing is AODV (Ad-hoc On Demand Distance Vector). Table 1 displayss the simulation's parameters. [16,17]

Several metrics, such as throughput, end-to-end delay, and packet delivery ratio, are used to evaluate the efficacy of an algorithm. The throughput is defined as the number of effectively delivered packets per unit of time. The end-to-end latency is the amount of time a packet takes to travel from the source node to the destination node. The packet delivery ratio is the

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proportion of packets delivered to the destination node out of the total number of packets transmitted.

The results of the simulation are depicted in figures 1-4. A comparison is made between the proposed algorithm and a conventional AODV algorithm. The results indicate that the proposed algorithm outperforms the conventional AODV in terms of throughput and packet delivery ratio, while the end-to-end delay is marginally higher. However, the difference in delay is not substantial, and the proposed algorithm is a better option for the network due to its increased throughput and packet delivery ratio.

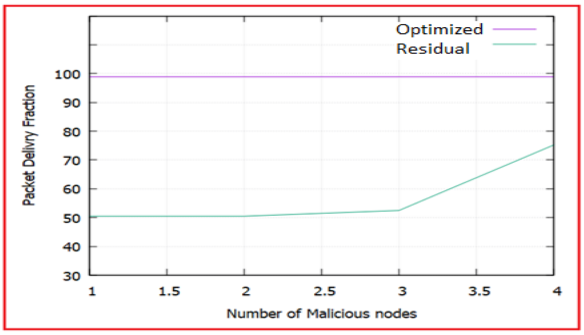

Figure 1 :- Packet Deliver Fraction of the Optimized buffere aware routing in comparison with the Residual Buffer aware routing

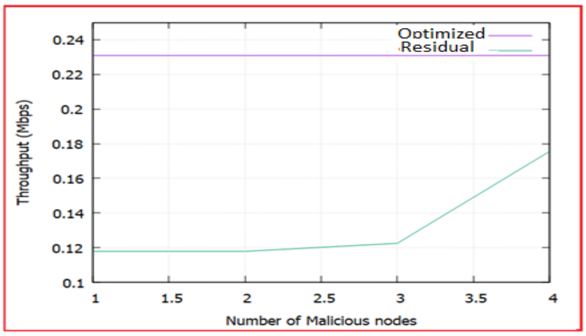

Figure 2 :- Throughput of the Optimized buffere aware routing in comparison with the Residual Buffer aware routing

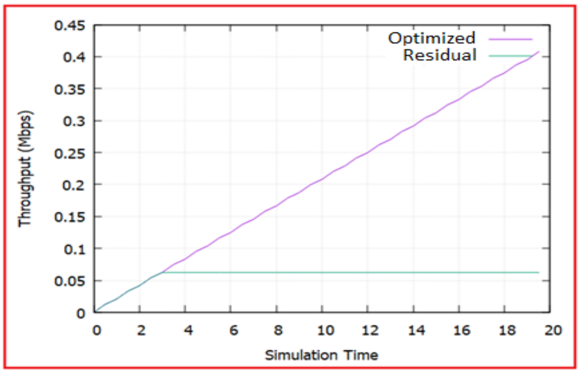

Figure 3 :- Throughput of the Optimized buffere aware routing in comparison with the Residual Buffer aware routing

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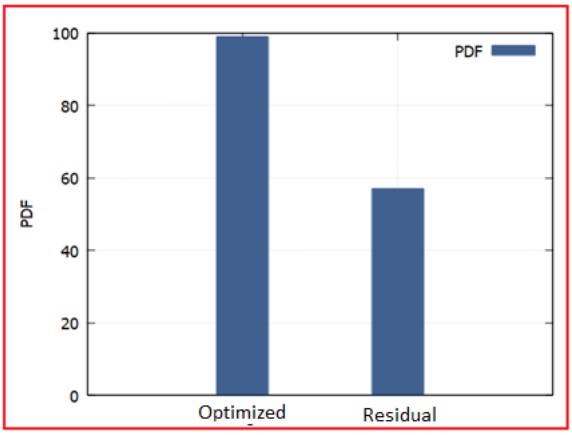

Figure 4 :- Overall packet delivery fraction comparison proposed work with the Residual Buffer aware routing

The results of the performance evaluation indicate that the proposed mechanism effectively reduces packet loss and increases network throughput. The proposed method identifies packet-dropping nodes based on buffer capacity and then excludes them from route computation, thereby preventing future packet loss caused by buffer overflow. The proposed mechanism employs the optimised packet processing capability of nodes to compute the route, thereby effectively avoiding nodes with limited buffer capacity along the routing path. This strategy improves packet delivery and reduces network congestion, which ultimately improves the network's overall performance. The proposed method can be extremely advantageous for infrastructure-free peer-to-peer networks with highly distributed communication nodes and dynamic network topology.[18,19]

Conclusion

With mobility, heterogeneous resources, adaptation, self-forming, and peer-to-peer communication as its defining characteristics, wireless infrastructure-less networks are created to offer network access regardless of location. An effective routing protocol that takes into account the network's limited buffer capacity is essential for the smooth operation of such systems. To combat packet loss caused by overflowing buffers, we offer a new route-finding technique based on the knapsack algorithm. The NS-2 simulator was used to test and validate our suggested technique, and the results showed considerable gains in network performance, most notably a decrease in packet loss. In sum, our study provides a significant addition to the ongoing endeavour to enhance the design and performance of wireless networks that require no underlying physical infrastructure.

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