



## Quality of Service in Mobile Adhoc Networks with Non-Saturation Conditions

Harith Yas<sup>1,\*</sup>, Manal M. Nasir<sup>2</sup>

<sup>1</sup>Faculty of Management, Universiti Teknologi Malaysia, Johor Bahru, Johor, Malaysia

<sup>2</sup>Gwinnett Technical College, 5150 Sugarloaf Pkwy, Lawrenceville, GA 30043, USA

Email: [Harith.albayati@yahoo.com](mailto:Harith.albayati@yahoo.com); [mnasir@gwinnetttech.edu](mailto:mnasir@gwinnetttech.edu)

### Abstract

Numerous research has been conducted in order to investigate the performance of IEEE 802.11LEACH for a single-cell Wireless Local Area Network (WLAN) under saturation conditions. Saturation conditions are those in which it is anticipated that the queues of nodes will never be empty. To put it another way, there is always a packet waiting to be sent out from each and every node in the network. The term "infinite load" refers to the condition of saturation, which is a situation that may be regarded as having an endless load. Even though conducting an analysis under saturated conditions may provide some insight into how well the network operates in a high-pressure setting, this strategy does not appear to be practical because there is a possibility that the network will not always be at capacity. Even though conducting such an analysis under saturation circumstances may provide some insight into how well the network operates in a high-pressure setting, it is still not practical. When using CQSR, the source is aware of the correlation that exists between the many different paths that go to the destination. When it comes to the provision of quality service in an ad hoc network, having several pathways among a specific cause and an endpoint may be of assistance in the following scenarios. Having multiple pathways between a source and a destination may also be of assistance when it comes to the provision of quality service. It is feasible that a single channel will not be able to deliver adequate resources to meet the desired quality of service if the resources of mobile nodes are limited. This scenario might occur if mobile nodes are subject to resource limitations. The requirements of the application in terms of the quality of service might, however, be satisfied by the resources located along any one of the many possible paths that could exist between the specified pair of nodes. It seems likely that this will turn out to be the situation. The task force may be dispersed over a number of different routes if there are adequate resources available along each route. To put it another way, data packets are sent along each path that satisfies the criteria for acceptable quality-of-service levels. If you use many routes instead of just one, you may be able to obtain a throughput that is far higher than you would with a single route. In the previous proposed work, we did an analysis of IEEE 802.11 LEACH for an ad hoc network under saturation conditions. Saturation circumstances refer to scenarios in which it is believed that the queues of nodes are never empty. On the other hand, it is likely that the nodes that make up an ad hoc network will not always be totally filled.

**Keywords:** Adhoc network; Quality of Service; Wireless Local Area Network; IEEE 802.11; mobile nodes.

## 1. Introduction

It is possible to construct an ad hoc network on the spot and on the go without the participation of any centralized infrastructure or access point [1]. This is possible because of the rise of VoIP technology [2]. People who do this might end up saving both time and money. As a consequence of this, making use of an ad hoc network to transmit data across a large number of mobile hosts [3] could turn out to be a solution that is both more effective and more cost-effective.

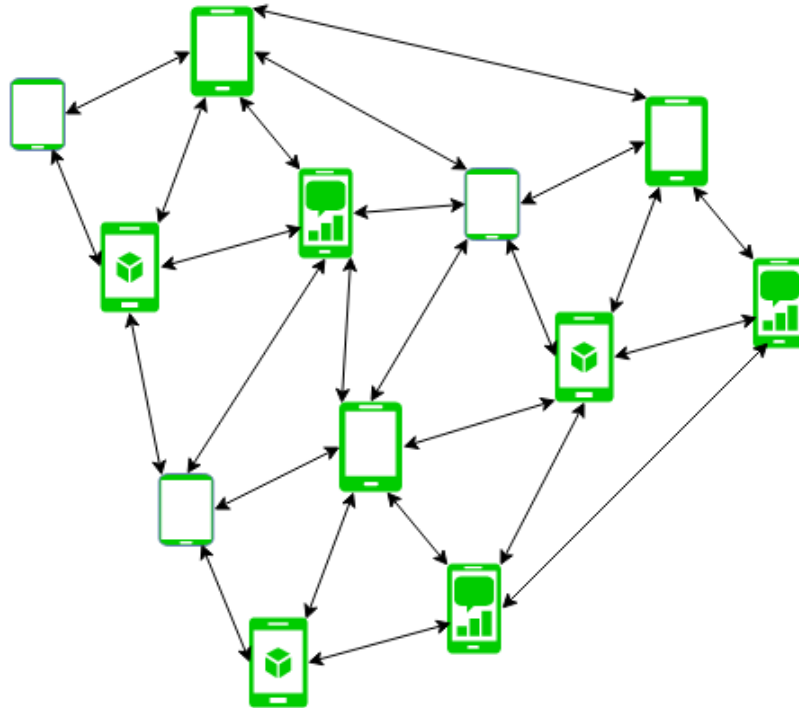


Figure 1: Wireless Network [geeks for geeks]

[4] Because the devices that are used to set up an ad hoc network have a limited transmission range; the routes have different values. In recent years, there has been a rise in the use of ad hoc networks.[5] Packets are sent from one another in order to arrive at their final destinations without traffic in the system. This is necessary in order for the packets to be able to reach their final destinations. Since the devices are often powered by batteries, the depletion of the battery power might result in the failure of nodes as well as the linkages that are coupled with those nodes. As a result of the fact that there is a chance for random movement among the nodes, the topology of the network is susceptible to consistent and ongoing modification.

[6] To provide a little more clarity, the requirements for these applications often include a certain minimum bandwidth, and they are also sensitive to latency issues. As a consequence of this, the network has to be able to deliver a high quality of service in terms of both its bandwidth and its latency in order for them to operate correctly. Because multimedia applications need a high degree of performance, it is very desirable for an ad hoc network to contain a source of quality of service (QoS) in order to support these applications.

### 1.1 Main Aim of the proposed work

No infrastructure that is centralized: Since an ad hoc network may operate without the necessary participation of a centrally located infrastructure or an access point, any scheme or protocol that is used to give quality of service (QoS) should not rely on a centralized infrastructure. Transmission that is only capable of reaching certain areas: Because the devices that are used to build an ad hoc network have a limited transmission range, the paths that connect a particular source and a destination often consist of a number of hops. This is because the devices that are used to form an ad hoc network have a restricted transmission range, which is the reason why this problem occurs. Each hop along the route

has a role in determining the quality of service (QoS) [7] that is provided by the network. Because there are no unique routers, the nodes in the network are required to send the packets that belong to one another to the computers that will finally receive them.

Modeling the end-to-delay requires cutting a one-dimensional network or line topology up into individual nodes, and then treating each node as if it were a GI/Geo/1 queuing system. The modeling of the end-to-delay is the next step as a result of this.

Analytical formulas for determining end-to-end delays along a multihop route from a given source to a destination are not provided by the bulk of the models of IEEE 802.11 LEACH and IEEE 802.11e EDCA [8] that were presented before in this section. These models were mentioned above. This is due to the fact that the total delay from beginning to finish is determined by the total number of hops taken along the journey. In addition to this, these models do not take into consideration the influence that the transmission and carrier sense ranges of nodes have on the end-to-end latency and throughput of the network. In this proposed work, our major purpose is to discuss the many ways in which quality of service may be given via the use of an ad hoc network. In order to build a protocol for the provision of quality service, we are doing research on the IEEE 802.11 LEACH and IEEE 802.11e EDCA standards (QoS) [9].

## **2. Related Study**

the Media Access Control (MAC) layer in order to provide the user the option of using any alternate queuing model of their choosing. In order to achieve this goal, the only adjustment that needs to be performed is for the phrases to be included. A Time That Is Never Stopping In the presentation of a model that analyses the performance of an IEEE 802.11LEACH network when it is saturated, the Markov Chain is one of the tools that is employed (CTMC). The model has attracted the attention of a sizeable number of academics and is generally recognized as valid. In the formulation of the probability of transmission, it resulted in the production of transition probabilities, and in order to calculate the delays, one has to fill in the equation for the average waiting time in the queue. This laid the groundwork for subsequent studies' evaluations of the performance of IEEE 802.11 LEACH [10], which were conducted by other researchers.

However, since it makes the assumption that the number of tries may be repeated an infinite number of times, it does not take into account a particular cap on the maximum number of times an attempt can be made. New understandings for modeling the performance of single-cell WLANs are presented in reference [11], which may be found here. Among these realizations is the one-time multiplication of the probability of packet transmission when the network is saturated. On the other hand, it cannot be used as a model for a network that does not have all of its nodes in use. In addition, the packets, and as a direct consequence, the throughput, is decreased. In addition, we would like to point out that the models presented in [12] and [13] focus on the throughput rather than the delays. This is something that has been shown to us. A decrease in the standard throughput is brought about by an increase in the number of tries made to transmit the data. In each of these models, a network consisting of a single hop is taken into account. In addition to that, these models reason this is due to the fact that an increase in the number of transmission attempts per unit of time results in an increase in both the probability of a collision and the probability of a number of nodes wishing to transmit at the same time, which in turn results in an increase in the total number of collisions [14]. This in turn results in an increase in the total number of collisions. There is a relationship between the number of a node's neighbors who are within its transmission range and/or carrier sense range and the amount of data that is being sent by that node.

A mean-field Markov model for WLANs is described in reference number [16]. In the case of throughput, on the other hand, it would seem that there is a discrepancy between the results of the simulation and the method used to calculate the likelihood of packet transmission. In the context of Euclidean geometry, this mismatch may be explained by the boundary effect. However, the model that is described in [17] does not offer any information on what are the distance metrics [18] that should be employed in the formula for the steady-state probability area. [20] This is due to the fact that nodes that are situated on the perimeters of the deployment zone have a much lower number of neighbors in comparison to nodes that are situated more centrally inside the region. In point of fact, we have accounted for the number of contentious neighbors in the area under the topic of non saturation in our analysis of the mission.

On the other hand, we modify and broaden the phrase, which fills the void that was discussed before in this paragraph. One technique to decrease the influence that boundary effects have on the chance of transferring the value in terms of shifting from a steady state to an unstable one is to make use of a toroidal distance metric.

### 3. Proposed Work

Because they were developed for use with single-hop networks, the models that we have been discussing so far are only capable of providing an indirect application to multi-hop ad hoc networks. A CIMC model for IEEE 802.11 LEACH operating under finite load conditions is presented in the aforementioned paper. This model pertains to an ad hoc network. An M/G/1 model is utilized for the modeling of queueing delays within this model.

Algorithm 1: Proposed work

1. If the packet that was received was an RREP, then
2. Arrange the pathways in decreasing order of the amount of time it takes from beginning to finish
3. Send the  $i$ th packet along the route indicated by  $(i \% k)$ .
- 4: otherwise, if the packet that was received was a RERR, then step
- 5: mark the pathways that were indicated by RERR as "invalid"
6. Route the subsequent packets via the available pathways.
- 7: If there is no viable way, go to step
- 8: Start the route-finding process.
- 9: end if 10: end if

It is impossible to consider this model to be practical since it is based on the implausible assumption that the queue contains an infinite number of buffers. The point backoff state is another thing that the model is going to assume, and the model will base this state on whether or not the queue is empty.

The remainder of the proposed work is divided up into the following sections: In the next portion of this article, we will provide an analysis of a network with a single hop in the context of nonsaturated conditions. In the next section, we will broaden the focus of our analysis to encompass multihop networks. The discussion of the results will take place in the next section (section 4). Section 5 presents a comparative appraisal of the work that is pertinent to the topic at hand. The conclusion is discussed in the very last part of the essay.

#### 3.1 Single-Hop Analysis Under Non-saturation

In this part of the article, we will examine the single-hop delays in situations that are not saturated. A mean-field Markov model for WLA is described. Within this model, the formula for the probability of packet transmission under non-saturation is supposed to be as follows:

$$\tau' = \frac{1+p+p^2+\dots+p^N}{\frac{W_u}{2} + p \frac{W_A}{2} + p^2 \frac{W_2}{2} + \dots + p^3 \frac{W_M}{2} + (1-q)/r} \quad (1)$$

consequently,  $r$  equals 1 minus  $K$ . Putting these values in (2), we obtain,

$$\tau' = \frac{\sum_{i=0}^M p^i}{\frac{W_0}{2} \left( \sum_{i=0}^{m-1} 2^i p^{k+2m} p^m \sum_{i=0}^{M-t-m} p^i \right) + \frac{\pi_0}{1-MK}} \quad (2)$$

$$\tau' = \frac{\frac{1-p^{N+1}}{1-p^N}}{\frac{W_0}{2} \left( \frac{1-(2p)^m}{1-2p} + 2m p^{m-1-p^{N-m+1}} \right) + \frac{m_0}{1-\pi_N}} \quad (3)$$

Simplifying (4), we have,

$$\tau' = \frac{1-p^{M+1}}{\frac{W_0}{2} \left( \frac{1-(2pp^m)(1-p)}{1-2p} + 2m p^m (1-p^{M-m+1}) \right) + \frac{m_0}{1-T_K}} \quad (4)$$

In Lemma 4, (see Appendix), we have shown that,

$$\frac{\pi_a}{1-\pi_K} = \begin{cases} \frac{1-\mu_K}{1-\sigma_K} & \text{if } 0 \leq \rho < 1 \\ \frac{1}{K} & \text{if } \rho = 1. \end{cases} \quad (5)$$

which can be used to compute  $\gamma'$  as given by (5).

### 3.2 Multihop Analysis

For a single-hop network, the delays can be written as follows.

$$\delta = \delta_{MAC} + \delta_{quese} \quad (6)$$

$$= \delta_{MAC} + \frac{1}{\mu} \left( \frac{1}{1-\rho} - \frac{\kappa \rho^K}{1-\rho^K} \right). \quad (7)$$

Let us say that we want to calculate the end-to-end delay while going from a given source to a destination, and let us also say that there is h hope between a given source and a destination. It would seem that all that is required to calculate the total delay along a multi-hop route is to multiply the number of hops by the delay that is connected with a single hop and then multiply that total by the delay associated with the single hop. However, keep in mind that this is just a rough estimate. On the other hand, it's likely that the findings will only be an estimate and not actual numbers.

$$v'_{ex} = v_{co}(1-x) \quad (8)$$

$$x = \frac{2.1521}{\pi} \left( 1 - \frac{1}{h} \right) \quad (9)$$

$$\Delta = h \left[ \delta'_{SAAC} + \frac{1}{\mu} \left( \frac{1}{1-\mu} - \frac{K^K \rho^K}{1-\rho^K} \right) \right]. \quad (10)$$

After M times of trying to retransmit the packet, there is a chance that it will not be sent to a particular node that is equal to (M+1). Because of the buffer overflow, there is a risk that the packet will be lost at one of the nodes that make up the network. This likelihood is equal to K percent. The data packet will only make it to the MAC layer if there is a chance that the buffer overflow won't cause it to be lost. The MAC layer will then make an effort to deliver the packet if there is a chance that it won't be lost. If a packet did not get lost because of buffer overflow, the chance that it would be lost due to MAC layer collisions at a node is equal to (1-K)p(M+1). This is assuming that the packet did not get lost due to any other cause. There are currently two distinct scenarios: I either the packet is lost as a result of the buffer overflow, or (ii) the packet that is not lost as a result of the buffer overflow is lost at the MAC layer as a result of collisions. Both of these scenarios are possible at present moment. Because it is impossible for these two things to take place at the same time, the likelihood that a packet will be lost at a node may be computed as follows.

$$\psi' = \pi_K + (1-\pi_K)p^{MM+1}. \quad (11)$$

1-' represents the probability that the packet will be successfully transmitted by the node. The formula (1-v'n) can be used to calculate the probability that the packet will be transmitted by all of the nodes along a path that has h hops. There is a chance that the package will not be delivered to its intended location.

$$\Psi = 1 - (1-\epsilon')^h = 1 - [1 - \{\pi_K + (1-\pi_K)p^{MM+1}\}]^h \quad (12)$$

Using (13), we have,

$$W' = \begin{cases} 1 - \left[ 1 - \left\{ \frac{e^N(1-p)}{1-p^{K+1}} + \left( \frac{1-p^K}{1-p^{K+1}} \right) p^{MM+1} \right\} \right]^h & \text{if } 0 \leq \rho < 1 \\ 1 - \left[ 1 - \left\{ \frac{1}{K+1} + \left( \frac{\kappa}{K+1} \right) p^{M+1} \right\} \right]^A & \text{if } \rho = 1 \end{cases} \quad (13)$$

The average end-to-end throughput of a path from a given source to a destination is

$$\Phi' = (1 - \Psi')\phi'$$

where  $\Psi'$  is given by (13).

#### 4. Results and Discussion

Let's imagine there are 100 nodes, and they are dispersed in a way that is completely random throughout an area that is 1000 meters by 1000 meters.

It is generally accepted that the carrier detecting range will be the same as the transmission range, which will be 250 meters for each node. We are proceeding on the basis that each node is equipped with an antenna that can receive signals in any direction. A constant bit rate is used by the traffic, and the size of each individual packet is 1024 bytes. Our calculations show that this equals 0.1. In the scenario of IEEE 802.11LEACH, it is assumed that the data channel has a rate of 11Mbps and that the control channel has a rate of 1Mbps. The contention window sides for FHSS are as follows: CW min = W 0 = 16; C max = 1024; and the slot duration is either less than or equal to fifty seconds. CW min equals W 0 equals 32, CW max equals 1024, and equals 20 microseconds in DSSS notation. We have a total of M=12 chances to complete each scenario, with m=6 for the FHSS and m=5 for the DSSS (because the specification states that CW max equals 2m CW min). We ran simulations by constructing a topologic map of the network, and each point on the graph represents an average that was derived from one hundred distinct runs of the simulation.

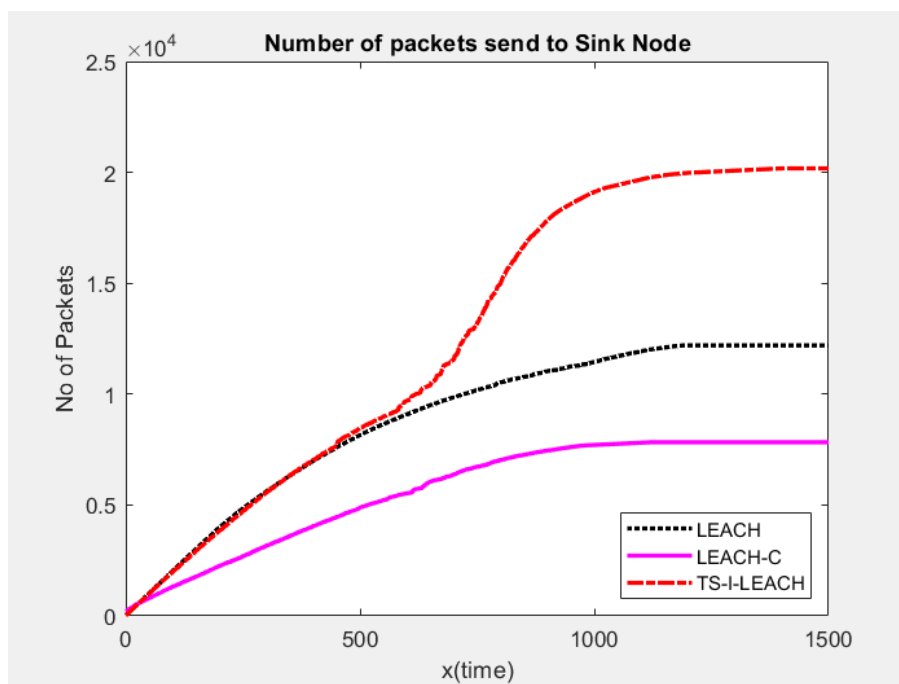


Figure 2: Number of packets to sink node

Figure 2 depicts the average end-to-end latency as a function of the collision probability for the number of hops along the route from a specific source to a destination, with  $h = 1$  and  $h = 5$  respectively. This function is shown as a function of the collision probability. We have demonstrated that there is a link between an increase in the collision probability and an increase in the end-to-end latency. This is the case by showing a correlation between the two. This is because there was an increase in the collision probability, which led to an increase in the number of packets that collided with the transmissions over a distance of 150 m.

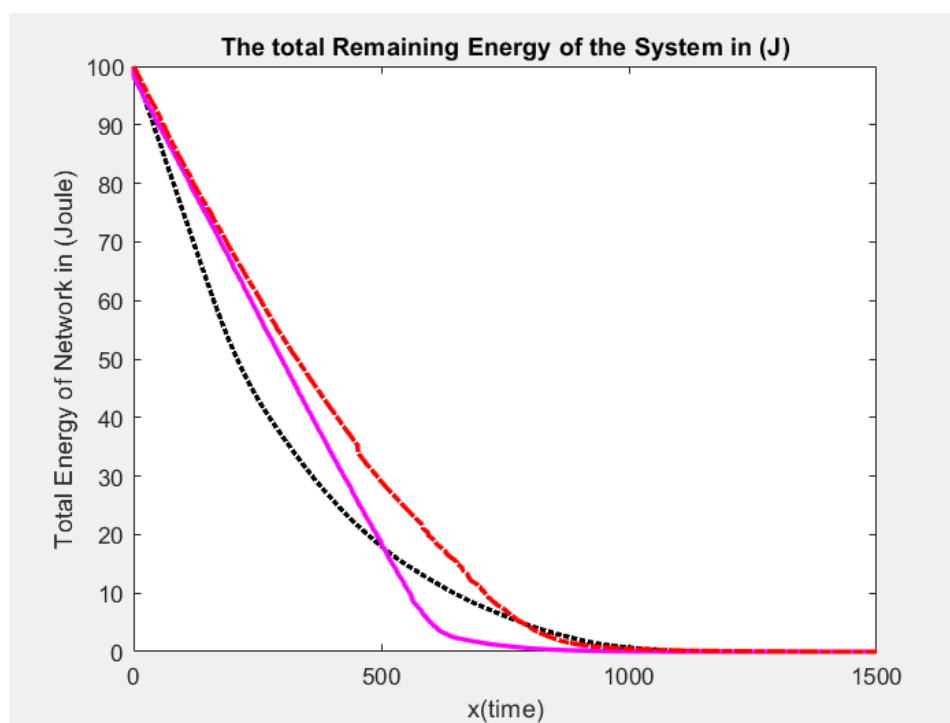


Figure 3: Total Remaining Energy to System

Because of this, there is an increase in the back-of delays at each node along the line, which in turn causes there to be a delay in the transmission of data at each node. This is a direct result of the situation. Because of this, packets experience proportionally considerable levels of average end-to-end delays throughout a broader range of transmission values. These delays may be rather frustrating for users.

Let's see how the outcomes of simulations stack up against the numbers of the average end-to-end latency that were calculated using analytical techniques. When the transmission range is equal to 150" " m and when the collision probability is 0.01, the analytical value of the average end-to-end latency is found to be 12.6192% longer than the simulated value.

When the transmission range is equal to 250" " m and when the collision probability is 0.01, the difference between the analytical and simulation estimates of the average end-to-end delay is 0.1484%. When the collision probability is 0.02, the gap grows to 0.1640%.

This is the case for both of these methods. The graphic illustrates both of these different types of processes. The discrepancy between the values of the average end-to-end latency determined analytically and by simulation for the Basic access method is 0.1484% when the collision probability is 0.01, and it climbs to 0.1610% when the collision probability is 0.02. There is a difference of 0.1825% in the values of the average end-to-end latency that are calculated analytically and through simulations. This is predicated on the premise that there is a 0.10 percent chance of a collision occurring. When the collision probability is 0.02, the difference in percentage is 14.9568%, and when the collision probability is 0.010, the difference in percentage is 16.8930%.

RTS/CTS is significantly lower than the average end-to-end delays for mechanisms that do not incorporate RTS/CTS. Because neighboring nodes are informed of the forthcoming packet transmission by means of the RTS/CTS packets, the chance of collisions and the backoff delays that result from retransmissions caused by collisions are reduced. This is because the RTS/CTS packets are sent out. As a direct result of this, the typical amount of time it takes for a delay to occur from the beginning to the end has been cut down. This points to the fact that the RTS/CTS method ought to be utilized.

Figure 4 presents the typical end-to-end lag time for both the FHSS and DSSS systems as a function of the collision probability. For FHSS, the difference between the values derived analytically and by simulation for the average end-to-end latency is 0.1484% when the collision probability is 0.01, and the difference increases to 0.1640% when the collision probability is 0.02.

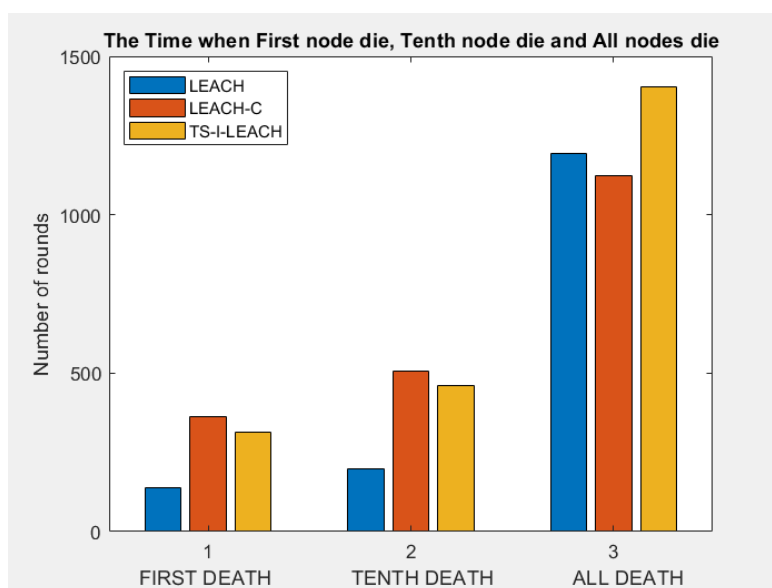


Figure 4: All Nodes Die Time

When the two approaches are contrasted, it is possible to see this disparity. When the collision probability is set to 0.01, the values of the average end-to-end latency that were calculated analytically and via simulations differ by 4.6219 percent. This is the case with DSSS. When the collision probability is 0.02, there is a difference of 4.7401%, and when the collision probability is 0.10, there is a difference of 4.8566%.

This is because simulations are used to get these results. In order to arrive at these values, a comparison was carried out between the simulated values and the real ones. We have discovered that the average end-to-end delays that are encountered by the packets in the case of FHSS are considerably smaller than those that are experienced in the case of DSSS. This was the finding that we came to after doing research on the topic.

This is due to the fact that the minimum contention window size necessary for DSSS is required to be twice as big as the minimum contention window size required for FHSS.

Figure 3 illustrates the transmission attempt rate as a function of the collision probability for both FHSS and DSSS, which both employ RTS/CTS as their mechanism. This is demonstrated for both of these systems. The following is what we see in Figure 3.6: Transmission attempt rate for FHSS and DSSS seen as a function of the collision probability reveals that the transmission attempt rate decreases as the collision probability increases. This is the case for both FHSS and DSSS. This is the situation with both of the procedures. Because an increase in the collision probability leads to an increase in the frequency of collisions, which in turn reduces the possibility that a packet will be successfully delivered, this is the explanation for this phenomenon.

According to our research and findings, a greater average throughput may be achieved by increasing the total number of buffers in use. However, the amount of gain in the average throughput does not become much more meaningful after you have more than five buffers.

This is due to the fact that there is insufficient storage capacity to accommodate all of the packets that are now awaiting servicing. This is due to the fact that an increase in the chance of collisions at the beginning of the process leads to greater channel utilization and, therefore, a higher throughput. On the other hand, a rise in the collision probability leads to an increase in the number of collisions, which in turn leads to an increase in the delays that are incurred in the backoff stages, which in turn leads to a drop in the throughput. It has also been seen that the throughput for FHSS is much greater compared to that of DSSS. This is one more item that has been noted.

However, after a certain threshold has been exceeded, the likelihood of arrival in the collision probability, the utilization of the channel, and the length of time a customer must wait in a queue all drop. This, in turn,

causes an increase in the amount of throughput that can be achieved. However, once a threshold has been achieved, the further increase in the collision rate that happens beyond the barrier is relatively low.

We get to the conclusion that since the collision probability for  $r=250$  m is higher than that for  $r=150$  m, a larger amount of time is wasted as a direct consequence of the increased risk of accidents. However, throughout the process of backoff, there is an early improvement in the average throughput, followed by a commencing decline in that throughput. As a direct result of this, the throughput for  $r=250$  m is much lower than the throughput for the fast algorithm. Because the network is capable of broadcasting that for  $r=150$  m, there will initially be an increase in price. This is because why there will be an increase. increased volume of traffic; hence, more than one node is required to broadcast in order to prevent the channel from being congested.

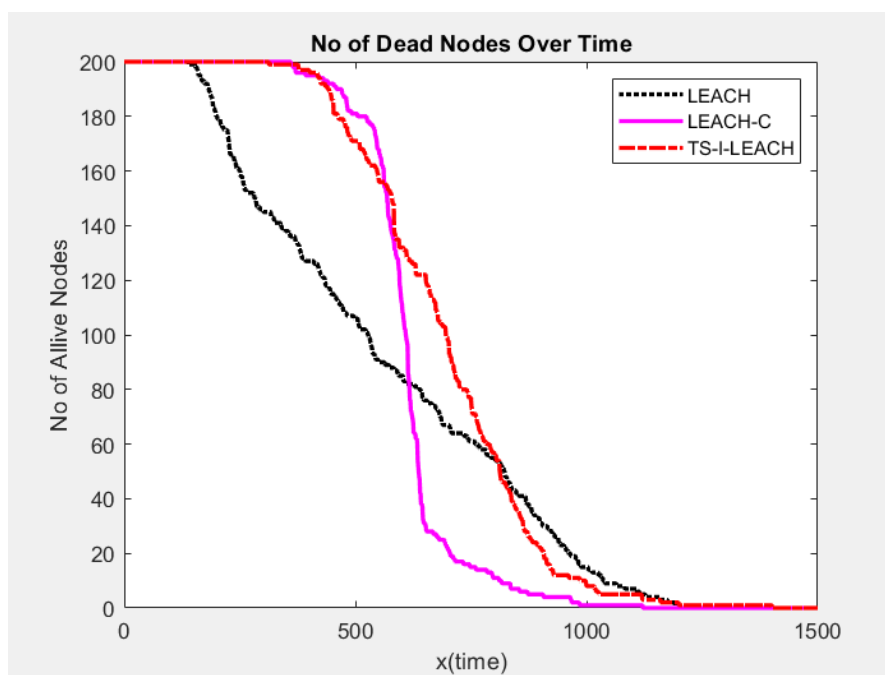


Figure 5: Dead nodes

Figure 5 depicts the average throughput as a function of the number of transmission attempts that were not underutilized. This data may be seen in the figure. On the other hand, there is a larger possibility of an accident if the collision risk is elevated over a certain rate for transmission ranges of 250 m and 150 m. It does not matter how many hops are done before finally reaching the threshold; the amount of time required to go from the origin to the destination is always the same: five seconds. There is evidence to support the hypo-proposed work that the end-to-end average latency is becoming longer. The normal throughput level will thus be reduced as a direct result of this.

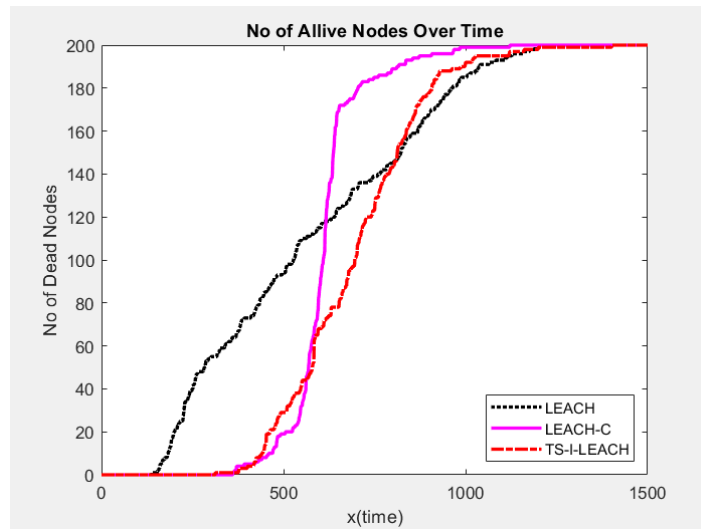


Figure 6: Alive nodes

In figure 6, the typical throughput is shown as a function of the collision frequency. This is due to the fact that increasing the broadcast range will cause an increase in the total number of FHSS and DSSS signals. According to what we have seen, the presence of potentially hostile neighbors is directly correlated to an increase in the total amount of time spent sending packets, which, in turn, is directly correlated to a decrease in the total amount of data that can be moved across the network in a given period of time.

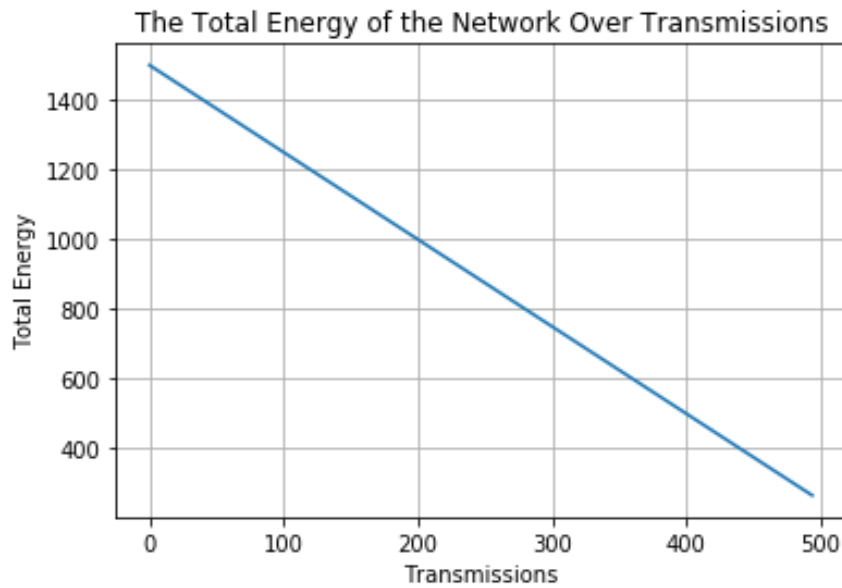


Figure 7: Transmission Rate

A further observation that we have made is that the typical throughput drops as the number of transmission attempts per unit of time increases. The reason for this is that if the pace of transmission attempts is raised, the number of nodes that want to transmit at the same time also rises. This, in turn, results in an increase in the total number of collisions. The throughput has suffered as a direct consequence of this problem.

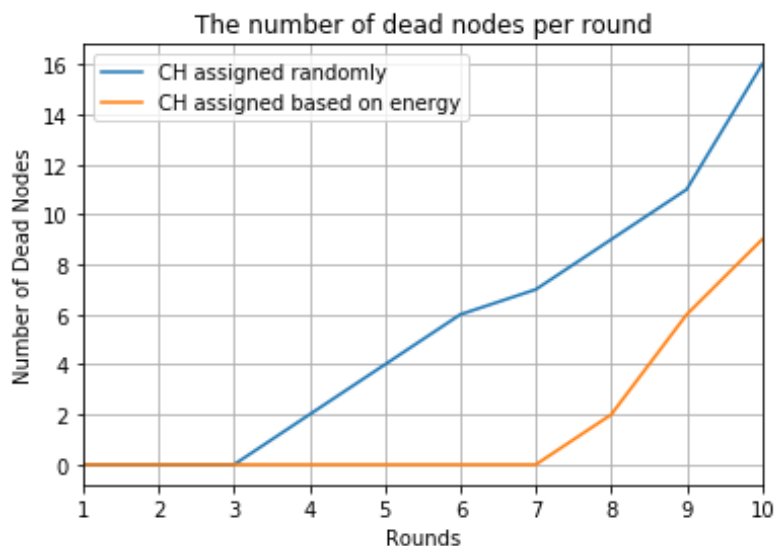


Figure 8: Transmission Rate at dead nodes

In terms of the delay experienced from beginning to finish, the results of the simulation and the analytical data are quite consistent with one another (Figure 5 to Figure 7). On the other hand, when it comes to throughput, there seems to be a disagreement between the findings obtained from the simulation and the results obtained from the analysis (Figure 7 to Figure 9). This distinction is due to a phenomenon known as the boundary effect, which takes place in the context of the Euclidean distance metric.

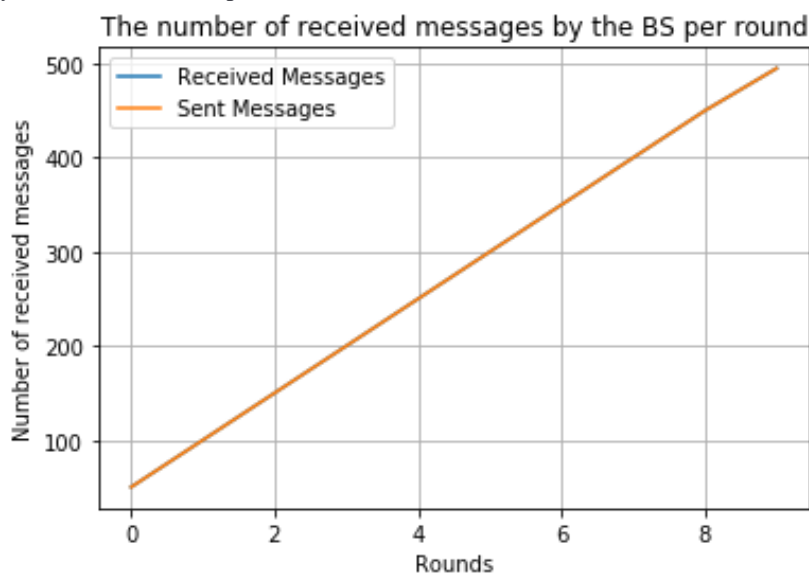


Figure 9: Message to Base Station

This is due to the fact that nodes that are located closer to the perimeter of the deployment zone have a lesser number of neighbors in comparison to nodes that are located further inside the region. In point of fact, we have taken into consideration the number of neighboring competing carriers in the carrier-sense range, which is assumed to be equivalent to twice the transmission range. Even a slight shift in the transmission range brought on by boundary effects can result in a significantly different number of neighbors within the carrier sense range.

## 5. Conclusion

In this proposed work, we carried out an investigation of IEEE 802.11LEACH for an ad hoc network in conditions where there was no saturation. The contributions that were made in this proposed work

are outlined in the following paragraphs. In order to make the study more manageable, we separated the queueing delays that take place at the network layer from the delays that take place at the MAC layer when a HOL packet is traveling through the network. We investigated the total amount of time that was lost across a certain path, beginning at the origin and ending at the destination. Specifically, we took into account how each node along the path from a source to a destination contributes to the overall probability of loss. We analyzed the throughput of two different routes: one that starts at a given source and ends at its destination via any number of hops, and another that starts at the source and ends at its destination via a single hop. The equation that describes the throughput takes into consideration, among other things, the influence of the losses brought on by the buffer. We performed simulations in order to verify the findings of the study, and we discovered that the values of the average end-to-end latency that were derived via simulations were consistent with the analytical values. This led us to conclude that the study was successful. This is something that came to our attention. When looking at the overall pattern of the average throughput, the analytical curves and the simulation curves follow a similar general pattern.

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