ESAM - Energy Saving Slot Allocation Based Multicast Routing in Wireless Mesh Network

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Abstract

The wireless mesh network is an emerging technology, offering innovative and efficient solutions typically used for last-mile broadband access. Multicasting is a mode of communication that delivers data from a sender to a set of receivers simultaneously in an effective way. This article deals with the problem of assigning synchronized time slots among the forwarded nodes in the multicast group of a wireless mesh network. To solve this problem, we propose a MAC layer solution that developed with snoozing and awaken slot durations for each node to pick the channel at a specific time and during the remaining period, the node will be in an idle state to listen for the packet arrival using Galois estimation. This mechanism divides the available time into slots depends on the demand of the node transmissions and channel availability. During transmission, each node comes to the awaken state and once the transmission completed the node goes to the snoozing state to preserve the energy. The slot allocation is assigned to each node based on the binary track of the span duration and transmission demands. The slot allocation based on multicast packet forwarding technique reduces the energy expense among nodes and supports to balance network communication duration. This shared slot allocation also minimizes the congestion on the network and healthier channel usage during communication. The Simulation results show that the proposed approach has achieved a better outcome than previous works in terms of minimum delay and high throughput.

1. Introduction

A wireless mesh network (WMN) is an infrastructure of nodes that are wirelessly connected to each other [1]. Figure 1 depicts the architectural diagram for WMN. The WMN built with mesh routers, client nodes, and a gateway joined to an internet server. The mesh router act as a forwarding node among the clients and the internet servers to serve the internet benefits to the clients and the gateways enable the integration of WMNs with other networks. A huge gain of mesh connection is connecting clients in global communication and each client can reach the routers depends on the protocol structure. If one device can no longer work, the remaining nodes can still connect to the other routers, directly or through the intermediate devices. The advantages of WMN's are completely connected, healthy and strong connection, and fewer chances for network loss.
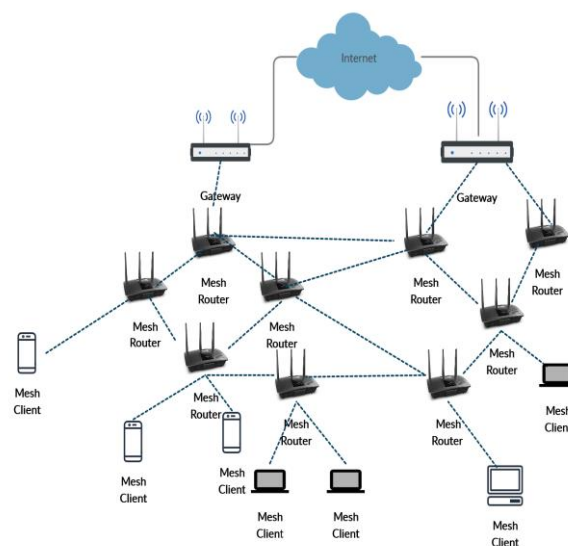

Figure 1. A wireless mesh network

Multicast [2] is the communication system that spreads the datagram's to a set of devices, the device groups are known

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from the receiver group identifications. In multicast, the sending packets are distributed to all of the group receivers as the destination. The multicast communication minimizes the routing costs and channel bandwidth usage during transmission by delivering the same data to several receivers. Upon receiving the packets from the source node, the receiving router retransmits that to all the attached interfaces in the group. This mode of data sharing method is known as the multicast transmission as shown in Figure 1. In the tree-based multicast protocol, initially, each receiver is connected to the multicast group by openly sending the *CONNECT* message and the node connected to a group based on the data request. Various sources send the dissimilar data packets to the different group receivers. Once the *CONNECT* message reaches group receivers, the receivers replied with a *CONNECT-REPLY* message to the source to build the multicast network.
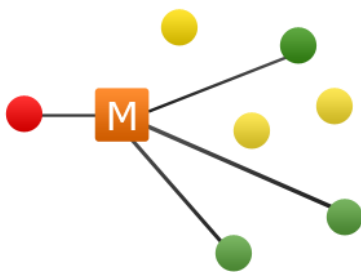

Figure 2. Multicasting

Despite the above-mentioned benefits, the restricted capacity is the most exciting problem in WMN. This leads, many of the nodes lying down in the same communication range may use the identical channel and transmit the packets to a destination simultaneously which emerges interference among transmissions in the network. Hence it is important to handle such a problem using the MAC layer solution that determines the time slot of accessing the wireless medium for every device in the network.

Besides, many real-time multimedia applications such as patient health monitoring system, public safety and disaster recovery applications etc. require that data be sent immediately [3, 4] and communication has to be done without interruption and delay [5-7]. This leads to developing a time slot allocation mechanism under the multicast scenario in WMN.

To solve the above said problems, the ESAM presents the snoozing and awaken based slot allocation between the source and the forwarders in a wireless mesh-based multicast network using Galois estimation. In the design of node scheduling in wireless mesh networks, it is appropriate to construct mathematical models which is simpler and better understood. In, mathematics, Galois Theory named after Evariste Galois [8], provides a connection between field theory and group theory.

The proposed protocol provides the knowledge to the mesh nodes to pick the uninterrupted and overlapping

slots until the end of a communication. Besides, to avoid the packet expiry due to the long delay, a data preference-based forwarding technique is applied in ESAM. The forwarder selection based on slot allocation helps to reduce the packet loss and buffer overflow because of the network load.

The rest of the article is organized as follows: Section 2 presents the literature review; Section 3 discusses the detailed working of the proposed protocol. Results and discussions are explained in section 4, the conclusion is specified in section 5.

2. Related Works

For wireless mesh networks, it is important to develop an effective slot allocation system to completely fulfill the QoS requirements of multimedia applications. This section presents an overview of the existing slot allocation methods for wireless mesh networks. Over the past few years, the problem of time-slot allocation schemes in WMN has been studied in the literature [9-11].

The most recent works of the same problem are described in [12-18]. The Time Division Multiplexing (TDM) method [12] deals with an out of conflict time slot allocation system which consider the time slot allocation among various nodes of a fully connected mesh network. It works on the principle of the least and extreme requirement of time-slot number on each node is fairly allocated and the slot allocations of nodes are assessed for every system with shared bandwidth information. The algorithm using TDM ensures that the output of the algorithm is the same for each node which leads to a collision-free solution with low delay. The local voting [13] method focuses on the issue of node scheduling in multi-hop wireless networks. The goal of this approach is to almost balance the ratio of the number of slots allocated to each node versus the buffer length of the device. The local routing algorithm schedules node transmissions in such a way that the minimum maximal node-level delay is attained. The algorithm also ensures that the lowest delivery time is attained when the load is nearly equalized across the network.

Reference [14] deals with a systematic approach for the evaluation of wireless mesh networks that uses a collision-free TDMA. This method proposes a queuing model based on a Markov chain that deals with forwarding the network traffic based on accurate slot allocation using mathematical models. This approach ensures better accuracy and emphasizes the result of a finite queue by presenting the queue level handling. The authors in [15] deals with a scheduling scheme with an energetic time slot allocation mechanism in a fog networking for a real-time patient monitoring applications. To improve the performance of the network, an efficient least cost parent selection algorithm has been proposed while transmitting data packets. Besides, to improve the consistency of

transmissions, a fuzzy-based energetic slot allocation has been offered.

The fuzzy logic uses input variables of packet arrival rate, buffer ratio, and energy ratio. This technique eradicates the time slot wastage and excess delay in the network and also ensures the reliability of the network with fullest channel utilization.

The authors in [16] propose a slot allocation scheme to transmit real-time data over wireless networks. This approach proposes an enhanced time division multiple access MAC protocol which dynamically allocates the time slots for body sensor nodes. In this method, the whole channels are partitioned into several time slots in such a way that devices can send their data packets over a dedicated time slot. Also, the enhanced packet scheduling algorithm is used to ensure that the nodes which are waiting for a long time before data transmission has to get the specified time slots in the given time frame.

In [17], the authors focused to improve the performance of the packet transmission of every node in a particular period by changing the sending order and the sending time of each node. The greedy strategy is used as a model for the time slot allocation mechanism. In this scheme, nodes with greater priority are permitted to send data items during healthier channel conditions, which successfully decreases the time complexity of the algorithm.

Askari et.al [18] investigates the problem of combined routing, scheduling and call admission control in multi-radio multi-channel wireless mesh networks. The algorithm improves the wireless resources utilization by choosing the route which reduces the collision and scheduling multiple collision-free transmissions in the same time slot. Additionally, the algorithm fulfills the QoS of each path tree by checking the possibility of its data transmissions depending on the interference.

The proposed ESAM protocol uses a multicast-based routing technique with accurate slot allocation to eliminate channel collision in the network using Galois estimation.

3 Proposed ESAM Protocol

In this section, we briefly present detailed working of ESAM protocol including the network model, multicast tree construction, slot allocation system in detail.

3.1 Network Model

The wireless mesh network is modeled as an undirected unique graph $G = (D, N)$, where D is a set of vertices expressed as devices or nodes, and N is a collection of neighbors among the vertices. Any two nodes location, coordinated points can be nearer to each other as $(X, Y) \in$

N called neighbors provided they can listen to each one's communication range as depicted in figure 2. Each device in the mesh network works in full-duplex form, which means the device can send and receive packets simultaneously. Further, according to the periodic time standard, all the devices are coordinated in time. Besides, as per the device knowledge each device in the network region has an exclusive device address (D_A) and all the nodes are placed randomly.

The nodes in the wireless mesh network communicate in synchronous time slots. In each time slot, every node in the network plays the role of either as a sender or as a receiver. When the node acting as a sender transmit data, it is possible that it can travel to all of its neighbours. Hence if two or more neighbours transmit simultaneously in a particular time slot, none of the data is received in that time slot. This situation is called a collision.
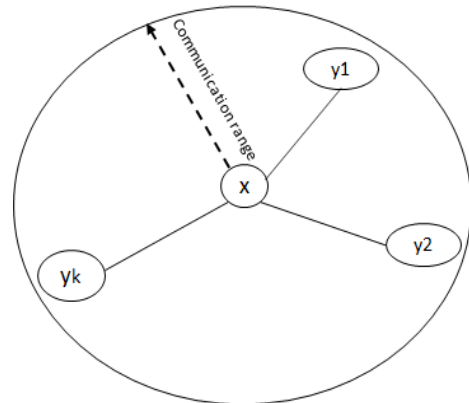

Figure 3. Neighbors and communication range

3.2 Multicast Tree construction

Constructing the best multicast tree is important to the performance of scheduling transmissions among nodes in WMN. We have developed a multicast tree formation technique [21] for constructing an optimal route between a data source (D_S) to set of receivers (D_R) in a multicast group. In this technique, the fuzzy logic is used at the sender side to find the best neighbor in the network considering the network metrics viz. communication delay, channel utilization, and hop count. Additionally, at the receiver side, the protocol ranks the nodes and links using the TOPSIS method using another set of network parameters viz, ETX, ETT and buffer occupancy. Using the above two techniques, the protocol selects the best forwarder and optimal path to send the data with the highest packet delivery ratio and with minimized control overhead. The sample multicast tree is depicted in figure 3. Once the multicast tree is constructed, the ESAM ensures that synchronized timeslots are assigned among the forwarder nodes in a multicast path from a source to multicast receivers.
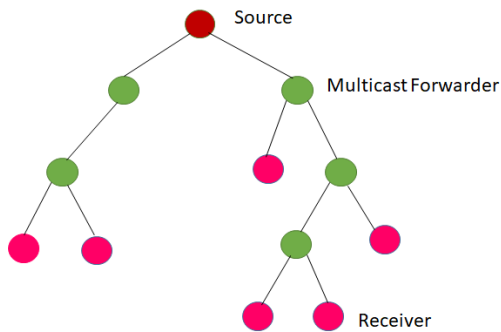
Figure 4. Example Multicast Tree

3.3 Network Metrics Computation

To ensure energy-saving multicast path from source to set of receivers, the proposed protocol uses following network metrics by considering the energy factor.

3.2.1 $Cost\ (C)$

To find the minimum cost of a path of devices. The cost is computed as given in the following Eq. (1).

$$C = \frac{Pr_{1,2} + Pr_{2,3} + \cdots Pr_{i,j}}{TR1 \ldots TRn} \quad (1)$$

Where, Pr_{ij} is the power needed for transmitting a packet from node i to node j is known as the receiving signal strength and TRi is the number of free transceivers accessible on the network as nodes i and j.

3.2.2 $Energy\ Expensed\ based\ Distance\ (DE)$

To find the energy usage cost of a node is to identify the energy expensed based distance between devices as shown in Eq. (2).

$$DE_{ij} = \frac{RE_{ij}}{IE_{ij}} \quad (2)$$

Where, RE_{ij} is the remaining energy of devices and IE_{ij} is the initial energy of devices. Then the ultimate total path distance between the initial device and final destination receivers which are defined in Eq. (3) as follows,

$$D_{ist} = \sum_{i=0}^{n} D_{D=1}; D_{A+1}; \quad (3)$$

Where $i = 0$ is the D_A of the initial device and D_D is the address of the final destination receivers.

3.4 Snoozing Setting up System

Each device in D knows awakening and the snoozing configuration system, hence the node switches from the snoozing(S_N)
to awaken(A_N) slot modes, often depend on the data availability and load of the nodes. A Snoozing setting up system is a binary track of span (B_T) calculations. The slot awareness schedule of a device (S_{Di}) defined as follows,
$$S_{Di} = \begin{cases} 1, & if\ the\ current\ slot\ is\ an\ awaken\ time\ slot; \\ 0, & otherwise, n^{th}\ slot\ is\ a\ snoozing\ slot, where\ 1 \le n \le B_T; \end{cases} \quad (4)$$

3.5 Creation of Snoozing Agenda

During multicast routing in a mesh network, time slot (T_S) for the data transmissions between nodes and the snoozing (S_N) forecast to inform the channel usage among the nodes are computed by using Galois estimation (G_E) with the binary forecast track pattern (B_T). The creation of the S_N agenda is based on the mathematical resources of the restricted fields. In computations, G_E gives a relationship between the communication range and the group of nodes. Using G_E, the problem related to scheduling of nodes in a communication range are simplified and which is computed based on the polynomial degree (P_D) and it is represented by the polynomial statements which helps to solve the variations of their inheritance while changing the node locations. The Galois system is computed as $G_E(P_N\ P_I)$ where, P_I is a positive integer and P_N is a prime number of an arithmetical configuration with a limited count of elements, where summation, division, multiplication, and subtraction are distinct on that.
- The elements of $G_E(P_N\ P_I)$ is represented by the set z ={(a_0), (a_1), …, (a_{z-1})}. Initially, G_E is created by the restricted number of essentials and polynomial degree(P_D). Hence, each device needs to discover a polynomial degree (P_D) over $G_E(z)$ used to build the T_S.
- The P_D be $f_D(k) = (a_i) + (a_j)$, here a_i and a_j are the essential inputs of $G_E(z)$, in sequence to get the suitable i and j and assign T_S between them using the following estimations.
- Then, $i = \frac{D_A}{P_N}$, $j = d\ \%\ P_N$; $\quad (5)$
  Where D_A is a unique device address of D.
Employing the polynomial $f_D(k)$ each device generates the T_S as shown below:
$$T_{SD} = [\theta\ (\ f_D\ (a_0))\ \theta(\ f_D\ (a_1))\ldots\ldots\theta(\ f_D\ (a_{z-1})),\theta(\alpha_n)] \quad (6)$$

Where θ is a task which plots a z-array value into a binary time-span z and T_{SD} is the time slot for the device. For instance,
$\theta([a_0])$=1000 … 00: $\theta([a_0])$=0100 … 00: $\theta([a_0])$=0010 … 00: $\theta([a_0])$ =0000 … 01

While estimating the $f_D(k)$, the addition and multiplication functions must be complete in $G_E(z)$. Figure 3 describes the Galois estimation based slot allocation algorithm.

Let the values of G_E $(z= P_N\ P_I)$ be $([a_0]),.... ([a_1]).. ([a_{z-1}])$.

Create G_E track$(P_N\ P_I)$

{

$z \leftarrow P_N\ P_I$;

for $i \leftarrow 0$ to $z - 1$

  for $j \leftarrow 0$ to $z - 1$

    for $k \leftarrow 0$ to n

     if $(n == z)$

        $f_D \leftarrow [a_i]$;

     else $f_D \leftarrow (([a_0] \times [a_n]) + [a_j])$;

for $l \leftarrow 0$ to z

 if $(f_D == [a_j])$ then

    evaluate 1;

 else

    evaluate 0;

}

Figure 5. Slot allocation using Galois Estimation

The nodes were configured to compute the T_S from the initial stage of communication. At each communication, if the node has sufficient buffer space, it need not figure out the slot duration for the transmissions. It starts the time slot estimates when the node becomes overloaded and when the channel affected by the traffic jam known as congestion because of overcrowded traffic. Here P_N and P_I taken as inputs and those values produced the complete set of forecast vectors about the future nodes load position so that a set of T_S generated according to the buffer load on each device. During transmission, each node conscious of its time slot to communicate with its neighbours. To discover the T_S of neighbouring devices, each device updates adjacent 'j' address periodically.

3.6 Data Transmission

After constructing the T_S each device then schedules the packets on its awaken period as per the T_S notification. If $([a_1]) = 1$, the 1st T_S is a live awaken slot where the device must continue in the wake-up state. If $([a_1]) = 0$, the slot is an energy saving snoozing slot where the device can sleep to retain the energy until the next reversal occurs. If there is no awaiting critical data to send through the channel, the wakeup state node can extend the snoozing state, if not, the node desired to continue the awaken era until the communication is ended as depicted below in figure 4.
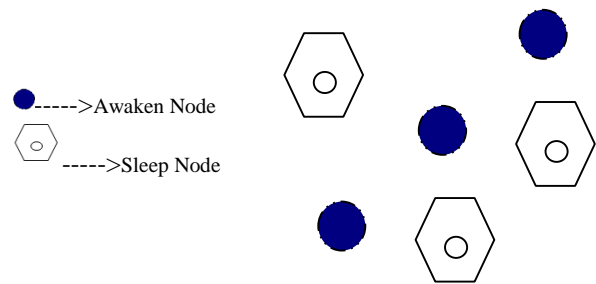

-----> Awaken Node

-----> Sleep Node

Figure 6. Time Slot Path

The device goes behind the allotted T_S from the left end to the next right end-time cycle and it returns once again from the beginning of the T_S to continue. The total snoozing and awakening slot is the one complete time frame for the communication. The node sends the data during the assigned T_S between two nodes and devices can contact only during the synchronized awaken overlapping slot as shown in Figure 5. According to Figure 5, both devices 1 and 4 are awakened at the particular time slot and they can share the data among themselves in that period. If a source node has the data packets to send, it waits for the awakening slots as per the notification from neighbours in a normal state, in the meantime, it searches the synchronized slot neighbour and updates the path neighbour list. Later, both the nodes share the packets to reach the destination. This process goes on until the end of the communication.
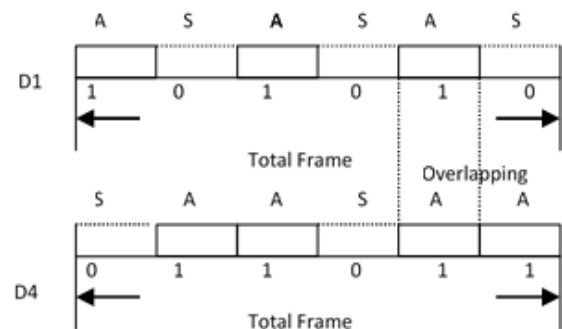

Figure 7. Slot Allocation and Overlapping

3.7 Data Preference Allocation

When a source node needs to deliver a packet through multicast, it selects one if it's neighbour as a forwarder at that time both the sender and forwarder nodes are in awaken state. If not, the data packets will remain in the source buffer until the neighbour selection process ends.

To solve the delay issue and to avoid the packet expiry due to the long delay, a data preference forwarding technique is applied in ESAM. The setback packets and the

longer buffered packets are reviewed with privileged preference at each node. The highest preference, longer delayed data packet needs to send on the next awakening period. In this way, ESAM minimized the delay and reduced packet loss.

The properties of the T_S are generally depends upon the input parameters of the P_N and P_I.

- *The total number of T_S is computed as $(P_N \times P_I) = P_{NI}$*
- *The duration of a T_S is computed as $P_N \times (P_I+1)$*

For instance, the obtained T_S shown in table 1 are computed from ESAM. From table 1, it is noticeable that neighbour nodes can communicate based on identical time slot notification using Galois estimation as per the regular time standard.

Table 1.a Slot Allocation table at the various time period

Time	Node Id	Binary Track Span	Slot(in seconds)
0.5	42	1100	0.0416667
0.5	85	1100	0.0625
0.5	81	0100	0.0625
0.5	93	0100	0.0555556
0.5	55	0010	0.0714286
0.5	7	0010	0.0833333
0.5	24	1000	0.0555556
0.5	48	1000	0.25

Table 1.b Slot Allocation table at the various time period

Time	Node Id	Binary Track Span	Slot(in seconds)
20.5	54	0000	0.0277778
20.5	57	0000	0.0294118
20.5	41	0011	0.0294118
20.5	44	0011	0.0416667
20.5	12	0010	0.0294118
20.5	76	0010	0.0277778
20.5	25	0001	0.03125
20.5	89	0001	0.0238095

The Timeslot computation adjust during the communication as described below,

- Compute the binary vector weight $B_W = (b_{W\,1}, b_{W\,0}, ..., b_{W\,x})$ where $b_{W\,i} \in \{0,1\}$, defined by $\omega(B_W)$, is the value of 1s in B_W.

- The T_S provides the percentage of the awakening period to the complete the data processing, the T_S of a device D computed as $T_{SD} = (d_1, d_2, ..., d_k)$ is known as $\dfrac{\left(\omega T_{SD}\right)}{k}$, where k is the total number of timeslot.

- Note that (ωT_{SD}) is considered from $(PN^{PI} +1)$ because, $k \leftarrow 0\ to\ z$, and for each k, there is precisely 1. So that the T_S of T_{SD} for all d$\in$ D is $\dfrac{1}{P_N\,PI}$.

- For two forecast vectors, $T_{S\,1} = (d_1, d_2 ..., d_{n-1})$ and $T_{S\,2} = (d_1, d_2 ..., d_{n-n})$ here, both $T_{S\,1}$ and $T_{S\,2}$ are consecutive time slots, for $1 \leq PN^{PI} \leq k$, is known a awaken slot of T_{SD}.

One of the prime concerns of the time slot assignment among the nodes is, the synchronization between the $T_S 1$ and $T_S 2$ to follow the overlapped slots at the same time of the communication viz. $T_S 1 = T_S 2 = 1$ to receive the continuous slots if the node desires more time to send the data packets. So that the nodes can extend the awaken time to complete the transmissions at the same time it can choose that path node as a forwarder. So, the ESAM provides the knowledge to pick the uninterrupted overlapping slots until the end of the communication.

3.8 Polynomial Computation

The polynomial computation of the time slot allocation represented as follows,

- $fD(k) = (a_i) x + (a_j)$; and $fD(k) = (\beta_i)x + (\beta_j)$;

$$(8)$$

Where a_i, a_j, β_i and β_j are the factors of the G_E (PN^{PI}), are used to build the enhanced T_{SD}. In turn to have an overlapped awaken slot, two nodes channel must be connected as $d_1 = d_2$, thus, in sequence to find the time slot k_0, we can discover the solutions of the dissimilarity polynomial $f_{TS1}(k_0) - f_{TS2}(k_0) = 0$, the volume of the overlap slots was precisely similar as the quantity of their

diversification P_D. If $(a_j) \neq (\beta_j)$, the quantity of the dissimilarity P_D is 1, consequently, there will be accurately one awaken slot. If $(a_j) = (\beta_j)$, in any case the last awaken slot of $T_S 1$ and $T_S 2$ have to overlap because of $\theta (a_j) = \theta(\beta_j)$. So that there must be in least case one T_S for any set of views given by the ESAM.

4 Results and Discussions

4.1 Simulation Setup

The performance of the ESAM protocol has been evaluated using the network simulator version 2 (NS-2). A wireless mesh network was designed with the network area of 1000×1000 m^2 with 100 wireless devices. The network uses the IEEE 802.11 MAC protocol. The simulation time of the protocol has been set as 200 to 250 seconds to know the deviations of the network and the packet interval varied from 0.5 to 0.9 seconds. The packet size was also varied from 600 bytes to 1000 bytes, which contain multi-type of packets. Table 2 shows the simulation parameters used for the execution of the protocol.

Table 2. Simulation Parameters

Simulation Parameters	Values
Radio-propagation model	Propagation/Two Ray Ground
MAC type	Mac/802_11
Antenna model	Antenna /Omni Antenna
Routing protocol	ESAM
Nodes	100
X dimension of topography	1000
Y dimension of topography	1000
Simulation Time	200-250 sec
Node transmission range	250m
Initial energy in Joules	100
Packet Interval	0.5 - 0.9
Packet Size	600 bytes-1000 bytes

4.2 Performance metrics and Simulation Results

The performance of the proposed protocol has been compared with Rank based forwarder selection in multicast routing (RFSMPF)[19], fuzzy based multi-constraint multicast routing (EFM)[20] and Multi-criteria routing metric for supporting data-differentiated service (MCM)[21] routing protocols using performance metrics such as goodput, packet delivery delay, packet delivery ratio and throughput and they are defined as follows.

- **Goodput**

The goodput is similar to throughput except that it is the average amount of packet received by the receiver per unit of time that is not retransmissions, delayed packets, and other discardable data.

- **Packet delivery delay (PDD)**

It is measured as the average time taken to transmit the data packets from a source to a group of multicast receivers. It is calculated as follows,

$$PDD = \sum_{i=1}^{n} \frac{received\ time\ of\ packet - sending\ time\ of\ packet}{number\ of\ connection}$$

- **Packet delivery ratio (PDR)**

The PDR is the total number of packets that are received to a receiver versus the number of packets that have been sent by the originator and is denoted as follows,

$$PDR = \sum_{i=1}^{n} \frac{No.\ of\ data\ packet\ recived}{No.\ of\ data\ packet\ sent}$$

- **Throughput**

Throughput is the average number of packets received by the receiver during a time frame regardless of whether the data is retransmission or not.

$$Throughput = \sum_{i=1}^{n} \frac{Number\ of\ data\ Packets * Average\ Packetsize}{Total\ time\ in\ sending\ of\ packets}$$

Figures 8-11 depict the comparative results of packet delivery delay, good put, packet delivery ratio and throughput of existing and proposed protocols.
Figure 8 shows the average packet delivery delay from a source node to the set of receivers in a multicast

group. It has been observed that ESAM shows minimum delay result than the other compared protocols as it deals with the channel interruption-less accurate slot allocation among the multicast forwarder devices using a binary track of span based calculations. Therefore, the devices were able to send several packets in short duration to the receivers from the source. The delay time also

node buffering delay and channel propagation delay. The ESAM design was concentrated to build the slot based channel selection at each forwarder node and the proposed protocol also focused on the load based priority driven channel allocation to minimize the buffering delay in the network.
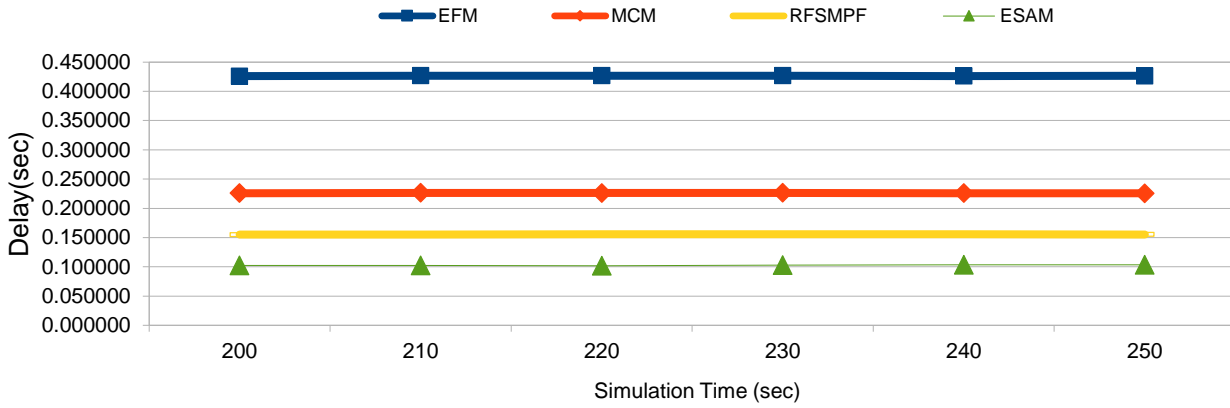

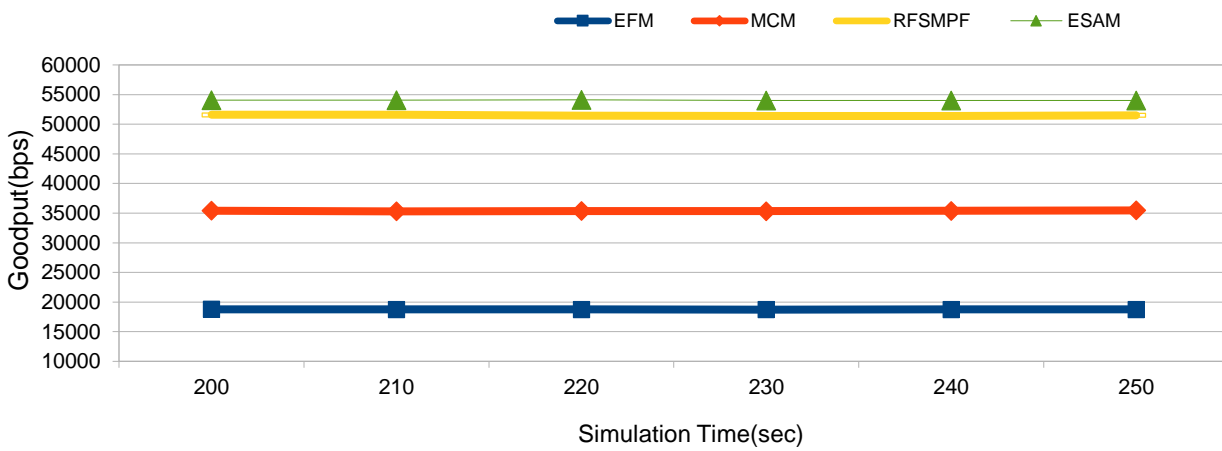**Figure 8**. Packet delivery delay Vs Simulation Time

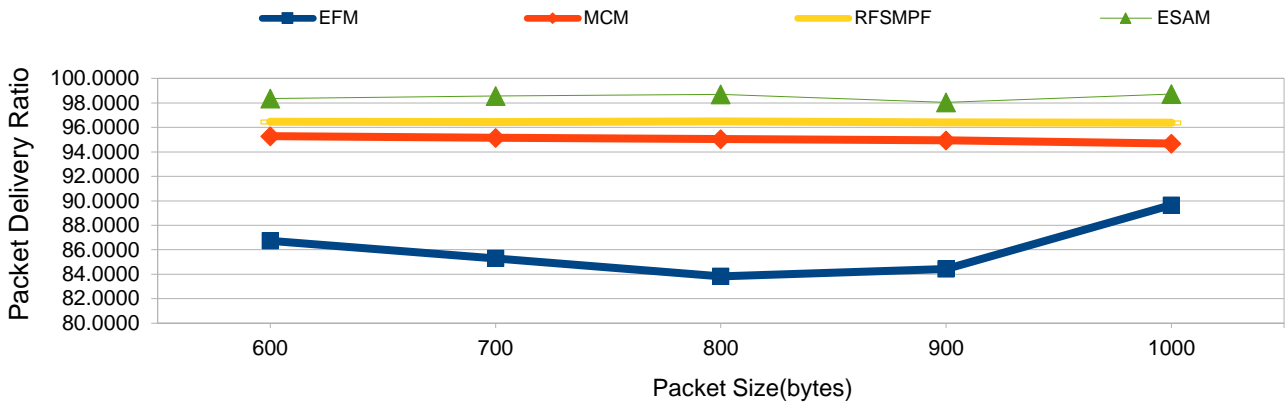**Figure 9.** Good put Vs Simulation Time

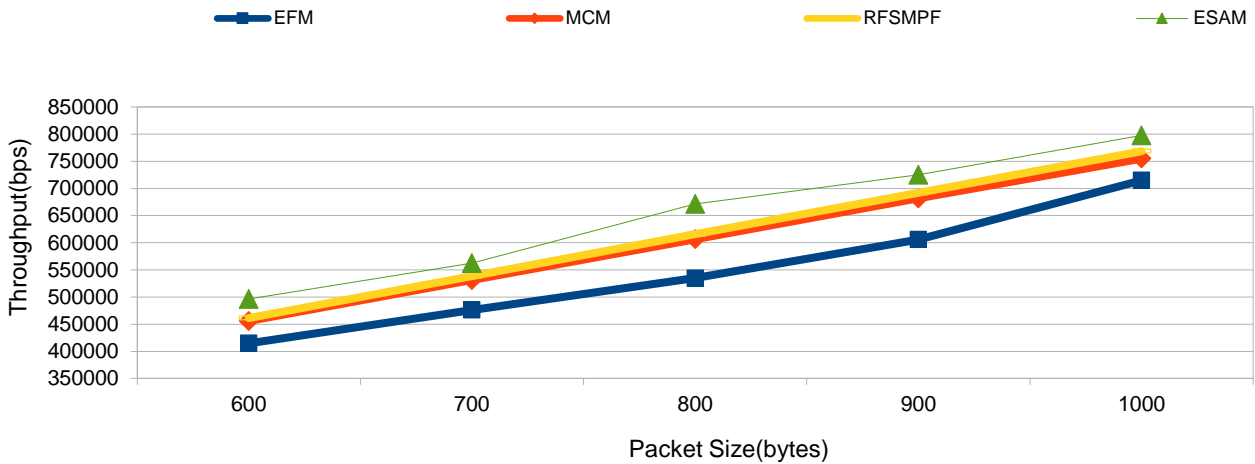**Figure 10**. Packet Delivery Ratio Vs Packet Size

Figure 11. Throughput Vs Packet Size

The good put of the network represents the average received data bit counts at the destination after each communication. The ESAM protocol has shown the highest good put because of the network quality and the stable protocol strength, thus it can send several data packets within the minimum duration as shown in figure 9. This result was drawn after the calculation of the dynamic slot allocation among the devices whenever they send data packets. Thus ESAM reduced the energy expenditure among devices and the design focused to choose the proper overlapping slot allocations from the source to set of destination. So that the output has delivered the highest good put than the other measured protocols.

Figure 10 presents the packet delivery ratio output as the quality of measures of the network. The proposed ESAM remains marked richest packet delivery ratio output

than the compared protocols. The network devices exchanged more data packets from a source to the end devices in mesh networks using multicast routing. So that more receivers received the data packets because of the convenient channel selection technique and the slot was allocated as per the load based priority channel allocation. This computation has enhanced the network life and decreased the channel contentions among the sources and the forwarders. The proposed protocol steadily maintains high delivery ratio even the packet size was increased over the time interval. The ESAM outperformed the compared protocols by 14.5%, 4% and 2.14%.

The figure 11 shows that throughput also increases gradually in ESAM for dynamic packet size. Because of the accurate channel allocation and the energy-preservation based slot allocation, the performance has reinforced more receiving bits per second at the destination

end, as it built the stable path construction without any channel contention and congestion issues. The proposed ESAM protocol marked the highest throughput than the analysed protocols as shown in Figure.9. Using ESAM, the network acquired the proper neighbour node selection to build the route, hence the network can achieve the highest receiving bits per second. It has been inferred that the throughput percentage achieved by ESAM technique over the compared methods is 14.42%, 8.75% and 2%.

5. Conclusion

This paper examines the problem of assigning synchronized time slots among the forwarded nodes in the multicast routing of wireless mesh networks. The ESAM presents a snoozing and awaken slot for wireless mesh networks. By using the parameters of the Galois pattern, the proposed protocol created a collection of binary tracking span with a broader range of slot periods. These computations used to switch channel usage slots between snoozing and awaken states to minimize energy devastation. Moreover, to generate data in a short period of time, ESAM implements the data precedence based forwarding technique to extend the awaken slot duration during burst data arrival, which can assure faster deliverance of packets from device buffer.

This work can be extended for public safety and disaster recovery applications for designing reliable and energy efficient slot allocation systems with an added security feature to preserve the life of the network.

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