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Design and Evaluation of a New 802.11KT MAC Protocol for ADHOC Network

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***Abstract*—The main thrust of this research paper is to propose and design a new MAC 802.11KT protocol to overcome the limits of the IEEE 802.11 MAC protocol and improve the system performance in multi-hop adhoc networks. Proposed 1.5TDDIbackoff algorithm and proposed small RTS and CTS frame format of control fields are implemented in newly designed 802.11KT MAC protocol. The effect of proposed backoff algorithm and proposed control frame of new 802.11KT mac protocol would be examined and the results and insights obtained would be used to maximize the network packet delivery ratio, reduce end to end delay and reduce power consumption of the ad-hoc wireless network. The simulation analysis of existing IEEE 802.11 MAC protocol and newly proposed and designed 802.11KT MAC protocol is done using network simulator NS-2.Simulation results observed that proposed 802.11KT Mac protocol is superior in performance than existing IEEE 802.11 Mac protocol.**

***Keywords*—IEEE 802.11 mac, Adhoc network, NS-2.**

I. INTRODUCTION

Basically IEEE 802.11 MAC protocol is used for wireless communication in adhoc network. In [17], demonstrated that the performance of this protocol depend on various characteristics of the network, including the type of network topology, channel rates, contention window size and traffic patterns and signal propagation environment. However, the performance of IEEE 802.11 MAC protocol degrades due to overheads added to it. These overheads reduces the overall packet delivery ratio of the system and increases end to end delay for data packet transmission between source node and destination node resulting in more power consumption of the system. However achieving maximum system packet delivery ratio with minimum end to end delay and minimum power consumption would need an ideal MAC protocol that gives a better system performance. Hence, a new MAC protocol known as MAC 802.11KT protocol is designed. This protocol maintains the optimize values of parameters of mac layer and physical layer with new proposed backoff phenomena and proposed frame format of RTS and CTS control frame. Adhoc nodes of the proposed 802.11KT MAC protocol uses propose carrier sensing and propose backoff phenomena with proposed frame format of RTS and CTS control fields to determine if the shared channel is idle before attempting to transmit and prevent packet collisions. The goal of this paper is to carry out a systematic simulation performance analysis of a newly designed and proposed 802.11 KT Mac protocol and existing IEEE802.11 Mac protocol for adhoc networks. Moreover the simulation analysis is based on varying the mobility of nodes in the Mobile adhoc Network in random topology. The rest of the paper is organized as follows: The work contributed in this area is provided in section II. The existing IEEE 802.11 MAC protocol description is summarised in section III. The proposed 802.11KT protocol is explained in section IV. The simulation environment is described in Section V. The simulation results and observation are described in section VI and the conclusion is presented in section VII.

II. RELATED WORK

This section presents some of the researches that is done in the field of IEEE 802.11Medium Access Control protocol (MAC protocol) in adhoc networks. The earliest IEEE 802.11 MAC protocol proposed for wireless networks is ALOHA, known as random-access mode. In ALOHA [1], the nodes were transmits whenever they have to send data, without knowing the current status of the medium and the positive Acknowledgement (ACK) is used to decide a successful transmission of data. If ACK is not received by the sender node, a collision is assumed to have takes place. The extension to ALOHA is slotted ALOHA. In this, the time is divided into number of slots, whose duration is exactly equal to the transmission time of a single packet. The nodes are permitted to transmit only at the beginning of a slot. For further enhancement of channel utilisation, the Carrier Sense Multiple Access (CSMA) mode [2] is used but there is hidden-terminals problem. In [3], Tobagi and

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Kleinrockindicates that the existence of hidden terminals significantly degrades the performance of CSMA. In [4], Karn suggested a new type of scheme, Multiple Access with Collision Avoidance (MACA) to overcome the shortcomings of CSMA and it was inspired by the CSMA/CA method [5] that uses two signalling packets: Request-to-Send (RTS) and Clear-to-Send (CTS).In this, the RTS/CTS exchange between source and destination before the data transmission. In MACA, the node uses the Binary Exponential Backoff (BEB) algorithm to backoff for some time before retrying to avoid the collision between transmitting and receiving nodes. According to [6] the Binary Exponential Backoff (BEB) algorithm used in MACA, it does not allocate the bandwidth of the channel in fair manner, because it adjusts the back-off counter value very rapidly.

III. IEEE 802.11 MAC Protocol

A) Distributed Coordination Function

The IEEE 802.11 technology has been widely used in wireless sensor networks and wireless mesh networks. Also, the IEEE 802.11 network has been considered as an important part in the future 4G telecommunication network, where customers may use video communication and voice communication. The great success of the IEEE 802.11 technology also motivates designers and researchers to devote themselves to enhancing the performance of the existing IEEE 802.11 technology. However, it has its own limitations such as efficiently sharing of the medium by adhoc nodes, effective hand shaking between sender node and destination node and effective use of contention window size [11]. The IEEE 802.11 medium access control (MAC) protocol is based on the Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA) principle and the fundamental MAC layer access mechanism of the IEEE 802.11 technology is DCF (Distributed Coordination Function). DCF is based on CSMA/CA backoff mechanism for medium access control, where each node implements its own backoff procedure for medium access. DCF can only offer a best-effort medium access service, where all nodes statistically share the medium effectively. The distributed coordination function (DCF) provides a method for sharing the medium. DCF defines two media access methods to be employed for data frame transmission; they are a two-way handshaking technique and four-way handshaking technique known as Request-To-Send/Clear-To-Send (RTS/CTS) mechanism [12]. Distributed Coordination Function main work is to reduce the collision probability among multiple nodes accessing the same channel. DCF require a slotted binary exponential backoff mechanism to select the random backoff interval. This random backoff interval is selected from a uniform distribution over the interval [0, CW-1], where CW is the contention window size and its initial value is CWmin. When there is an unsuccessful transmission between sender node and destination node, sender node do not receive ACK frame from the destination node, and contention window size get doubled. When contention window reaches to the maximum value, it will remain at this value. On the other hand, after a successful transmission, the contention window value is reset to minimum value, CWmin, before the random backoff interval is selected. Each node decrements its backoff counter every t-Slot Time after the wireless medium is sensed to be idle for DIFS time. If the counter has not reached zero and the channel becomes busy again, the node freezes its counter and when the counter finally reaches to zero, the node starts its transmission. Figure 1 shows RTS/CTS access Exchange scheme.

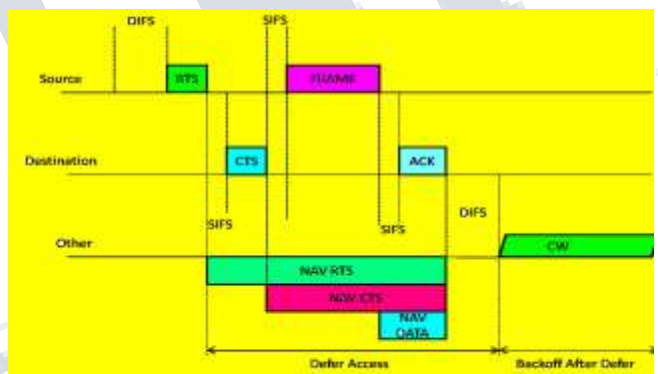

Figure 1: RTS/CTS access Exchange Scheme

B) Binary Exponential Backoff Algorithm

Binary Exponential Backoff algorithm is used to control the size of contention window to minimise the probability collision of data packets between two or more adhoc nodes transmitting simultaneously [13]. It is used in distributed coordination function of a CSMA/CA technique. In binary exponential backoff algorithm, the size of contention window (CW) dynamically controls access of the medium and it is doubled every time when node experiences a packet collision. On the other hand, when a node successfully transmits its data packet, the contention window is reset to the minimum value [14]. The backoff counter for every node depends on the collisions that the packets have experienced in the past. As per the procedure of the collision avoidance protocol, before transmitting a data packet, a

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node uniformly selects a random value for its backoff counter in the interval [0; CW -1] where, CW is the current Contention Window size [103]. For every failed data packet transmission, the value of contention window is equal to CW = 2*CW which depends on the number of failed transmissions of a data packet of a node. At the first transmission attempt of a packet, CW = CWmin. If a data packet collision occurs, contention window size is doubled up to a maximum value (CWmax). Once CW reaches CWmax; it will remain at this value until it is reset to CWmin after a successful packet transmission [15].In the DCF operation, before a node start the transmission process; it has to sense the wireless channel. If the shared channel is found idle for a minimum time equal to DIFS, the MAC frame will be transmitted. Then the node enters into backoff procedure and sets its backoff timer randomly within the range of contention window. When the channel is sensed idle, the backoff timer is decremented by one; when the medium is sensed busy the backoff timer is frozen. When the backoff timer reaches zero, the station starts the data frame transmission as the next consequence. When the transmitted data frame is received correctly, the receiver node is required to send an acknowledgement (ACK) after a time equal to Short Inter Frame Space (SIFS). If ACK frame is not received within stipulated time, the sending node assumes that there is either a collision of frame or frame corruption, and then it doubles its current value of contention window, resetting its backoff timer randomly, and retransmits the previous data frame when the timer reaches zero again [12].

IV. PROPOSED 802.11KT MAC PROTOCOL

A) Objective for Proposed Back off Algorithm

IEEE 802.11 MAC protocol is suitable for adhoc wireless network but still it has some performance degradation due to backoff phenomena it is used. This protocol uses binary exponential backoff phenomena. In this phenomenon, the contention window size of the successful sender node is reset to the minimum value whereas other nodes continue to maintain larger value of contention window. This reduces the chances of other nodes to seize the medium and hence there is medium domination by successful sender node. The small contention window size reduces the chances of collision probability of data packets between nodes and enhances the performance of adhoc network system. It is known that the Binary Exponential Backoff scheme suffers from a fairness problem and quality of service problem because this algorithm have high collision probability of data packets and assume that the data packets were corrupted because of collision only and cannot differentiate it from the corruption caused by the noise. This will lead to poor performance due to overload in the network [12]. Hence it reduces overall packet delivery ratio and increases end to end delay of the adhoc network system. It has more power consumption. Our proposed backoff algorithm overcome these problems by reducing the collision probability and enhances the performance of the adhoc 802.11 network.

B) Proposed 1.5 Times Decrement Double Increment (1.5 TDDI) Algorithm

The function of binary exponential backoff algorithm is to reduce the probability of data packet collisions of nodes but it cannot eliminate collisions data packets completely. Also, it suffers from a low packet delivery ratio and more end to end delay of adhoc network under high traffic load. This is because when there are large numbers of contending nodes and a data packet is transmitted successfully after a number of collisions, the contention window size is reset to the minimum value. This increases the probability of collisions of data packets of nodes [14]. For this problem, the proposed backoff algorithm of 1.5 Times Decrement Double increment (1.5 TDDI) [17],[18] smoothly decreases the value of the contention window to a value CW/1.5 than the minimum value of contention window after successful data packet transmission. Due to proposed algorithm, the node can control the channel with minimum end to end delay and thus enhance packet delivery ratio of the adhoc network with minimum chances of collision of data frames of the node. The working of proposed 1.5 TDDI backoff algorithms along with proposed frame format of RTS and CTS control field of proposed MAC 802.11KT protocol is shown in Figure 2.

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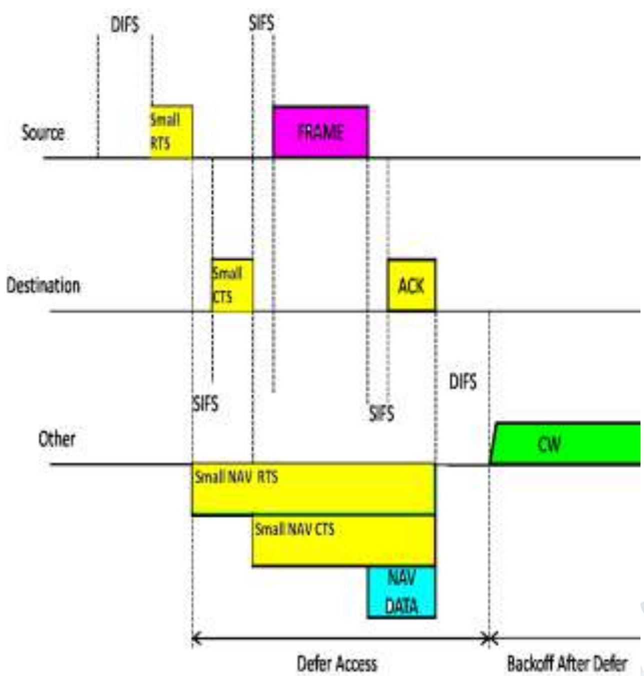

Figure 2: Working of proposed 1.5TDDI back off algorithm with proposed frame format

In proposed 1.5 TDDI backoff algorithm, a node uniformly selects a random value for its backoff counter in the interval [CWmin/1.5 to CWmax] where, CWmin is the minimum Contention Window size and CWmax is the maximum contention window size [16].When data packet is transmitted from sender node to the destination node and if the transmission is failed then the size of contention window become double and this phenomena is repeated for every failed data packet transmissions of node and it is depends on the number of failed transmissions of a data packet of a node. In proposedbackoff algorithm, at the first transmission attempt of a data packet, the contention window size is set to CW = CWmin/1.5 whereas in binary backoff algorithm, this value is set at CW=CWmin. If a data packet collision occurs, contention window size is doubled for every failed transmission up to a maximum value of contention window (CWmax). Once contention window size reaches CWmax; it will remain at this value. On the other hand, inr proposed backoff algorithm, the contention window size is reset to CWmin/ 1.5 after a successful packet transmission between nodes whereas in existing binary backoff algorithm, this value is reset to CWmin. For example, if the minimum value of contention window size is CWmin=75,then for binary exponential backoff algorithm in existing IEEE 802.11 MAC protocol, after collision of data packets, the contention window size will reset to 75 with large time duration field of RTS and CTS control field of 802.11 MAC protocol. The time duration set in Network Allocation Vector (NAV) in microsecond is large which specifies that the earliest time the node is permitted to attempt transmission is large. This increases the time delay in data packet communication which increases the chances of collision of packets and reduces packet delivery ratio of IEEE 802.11 MAC protocol and more power consumption. On the contrary, in proposed 1.5 TDDI, backoff algorithm, after collision of data packet, the minimum value of contention window size will become 75/1.5=50 with small time duration field of RTS and CTS control field of proposed MAC 802.11KT protocol. The time duration set in NAV in microsecond in proposed algorithm is small which specifies the earliest time the node is permitted to attempt transmission is small. This decreases the end to end time delay in data packet communication that reduces the chances of collision of packets with increase in the packet delivery ratio and minimum power consumption of proposed MAC 802.11KT protocol. Simulation analysis shows that due to proposed 1.5 TDDI backoff algorithm, the performance of proposed MAC 802.11KT protocol is superior than existing IEEE 802.11 MAC protocol.

C) Flow chart of Proposed 1.5 Times Decrement Double Increment Algorithm (1.5 TDDI)

Figure 3.represent the flow chart of the proposed 1.5 TDDI [14] backoff algorithm. During transmission process, all nodes set the minimum value of contention window to CWmin/1.5.The transmitter node listens to the channel as the persistence strategy. If channel is free, node waits for DIFS time. If the channel is still free, the transmitter node transmits small time duration RTS frame to the destination node and set a timer. If small time duration CTS frame is received from the destination node before time out, sender node wait for SIFS time and after that send a data frame to the destination node and set a timer. If an acknowledgement is received from the destination node before time out, the transmission process is successful. On the other hand, if small duration CTS frame and ACK frame are not received from the destination node, then proposed 1.5 TDDI backoff algorithms start and wait for back off limit. If the backoff limit is reached then abort the transmission of frame. In this proposed protocol contention window do not reach to CWmin value for successful data transmission but reaches to CWmin/1.5 value, thus reducing the end to end delay of the adhoc network system with increase in the packet delivery ratio of the system.

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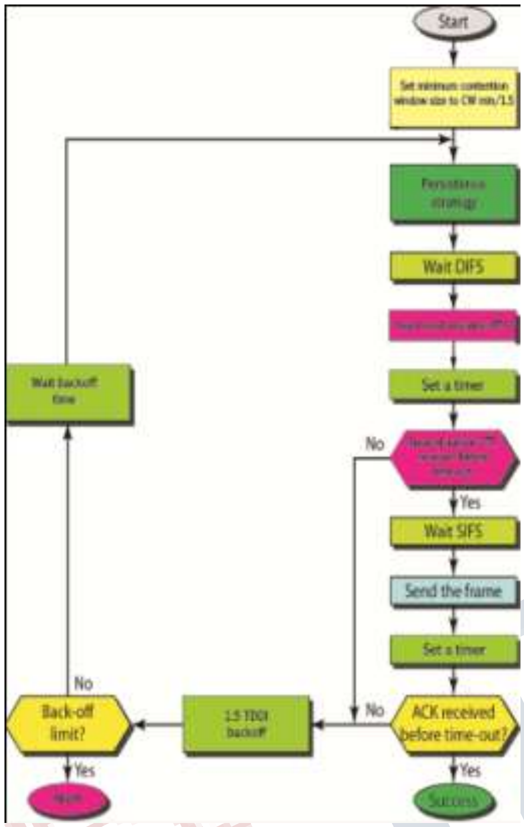

Figure 3: Flow chart of proposed 1.5 TDDI backoff algorithms

V. SIMULATION ENVIRONMENT

A) Simulation Model

This section have given the emphasis for the simulation of performance of IEEE 802.11 MAC protocol and 802.11KT MAC protocol with proposed 1.5 TDDI algorithm by varying the mobility of mobile nodes. The simulations have been performed using network simulator NS-2 [16][17][19][20]. The network simulator NS-2 is discrete event simulation software for network simulations which means it simulates events such as sending, receiving, forwarding and dropping packets. Ns-2 is written in C++ programming language and Object Tool Common Language (OTCL). Although ns-2.34 can be built on various platforms, a Linux platform [FEDORA 7] is used for this paper, as Linux offers a number of programming development tools that can be used along with the simulation process. To run a simulation with NS-2.34,the simulation script is written in OTCL, got the simulation results in an output trace file. The performance metrics are calculated using AWK file and the result graphically visualized. NS-2 also offers a visual representation of the simulated network by tracing nodes movements and events and writing them in a network animator (NAM) file.

B) Simulation Parameters

A network of adhoc nodes placing within a 2200m X 500m area is considered for simulation . The simulation of IEEE 802.11 MAC protocol and proposed 802.11KT MAC protocol are evaluated by keeping the network payload constant and varying the mobility of mobile nodes. Table 1 shows the simulation parameters used in this simulation.

TABLE 1
PARAMETERS VALUES FOR SIMULATION

Simulation Parameters	
Network Simulator	NS-2.34
MAC Protocols	IEEE 802.11,802.11KT
Simulation duration	150 seconds
Simulation area	2200 m x 500 m
Number of nodes	50
Transmission range	250 m
Movement model	Random topology
Maximum speed	5,10,15,20,25,30m/s
Packet rate	4 packets/sec
Traffic type	CBR (UDP)
Data payload	512 bytes/packet

VI. SIMULATION RESULTS & OBESRVATION

The simulation results of IEEE 802.11 MAC protocol and 802.11KT MAC protocol are shown in the following section in the form of line graphs. The performance of IEEE 802.11 MAC and proposed 802.11KT MAC protocol are done based on the mobility of the adhoc nodes. The perform matrix consists of parameters like Total packets generated, Packets dropped, Packets Delivery ratio & Average End to End delay with respect to the mobility of the adhoc nodes. “Fig. 4” shows the creation of 50 numbers of mobile adhoc nodes in random topology.

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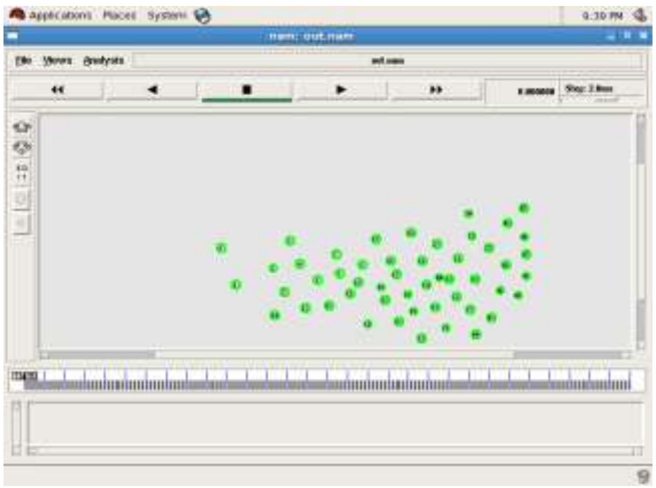

Figure 4: 50 numbers of nodes in rural village in random Topology

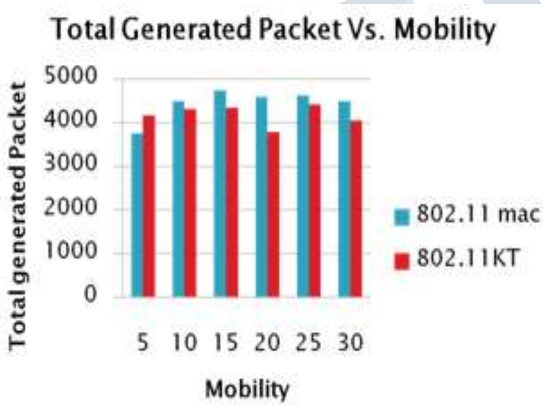

Figure 5:Total Generated Packets vs. Mobility

"Fig. 5" represents the relative simulation analysis of IEEE 802.11 MAC protocol and proposed 802.11KT MAC protocol for Generated Packets with varying mobility of nodes. From analysis, it is observed that data packet required to transfer information from source adhoc mobile node to destination mobile adhoc node is small for 802.11KT MAC protocol than IEEE 802.11 MAC protocol. This saves considerable amount of power of transmitter.

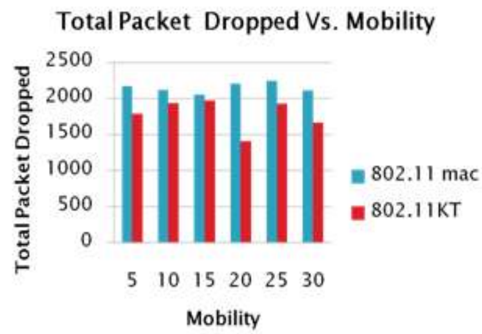

Figure 6:Total Dropped Packets Vs. Mobility

Fig.6 shows the simulation analysis of the relative performance of IEEE 802.11 MAC protocols and 802.11KT MAC protocol for Total Dropped Packet with mobility of nodes. After analysing, it is observed that 802.11KT MAC protocol have better synchronisation between mobile adhoc nodes than IEEE 802.11 MAC protocol. Hence, data packet loss is small for 802.11KT MAC protocol.

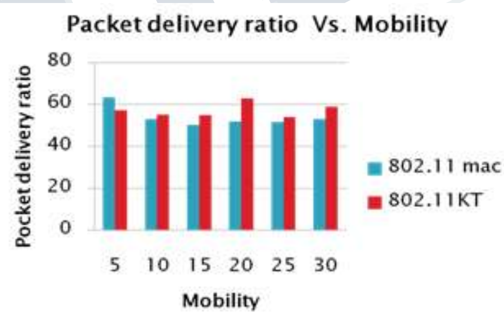

Figure 7:Packet Delivery Ratio Vs. numbers of nodes

The simulation analysis of IEEE 802.11 MAC protocol and 802.11KT MAC protocol for Packet Delivery Ratio with mobility of nodes is shown in fig.7. It shows that 802.11KT protocol have greater packet delivery ratio than IEEE 802.11 MAC protocols. The proposed 802.11KT MAC protocol have better synchronization between nodes,it dropped less number of data packets and delivered more data packets to the destination than IEEE 802.11 MAC protocols. Hence,802.11KT protocol have more packet delivery ratio or throughput than IEEE 802.11 MAC protocol.

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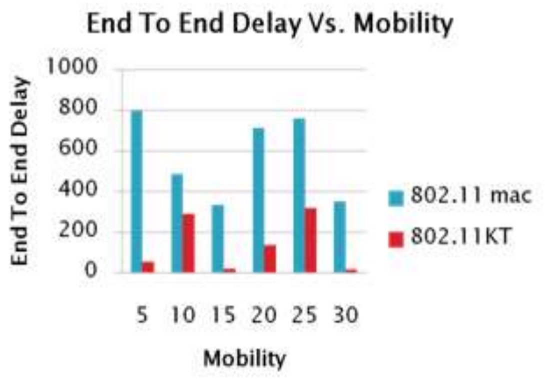

Figure 8:End to End delay Vs. Mobility

Fig.8 highlights the simulation performance of 802.11KT protocol and IEEE 802.11 MAC protocol for Average End To End delay with respect to the mobility of adhoc nodes. Beacon frame of 802.11KT MAC protocol have efficient synchronization among mobile adhoc nodes than IEEE 802.11 MAC protocol. This results in better data transfer with minimum time required and improves the end to end delay. This result in better data transfer with minimum time required and improves the end to end delay .Hence the proposed 802.11KT MAC protocol have better performance over IEEE 802.11 MAC protocol in terms of Average End To End delay.

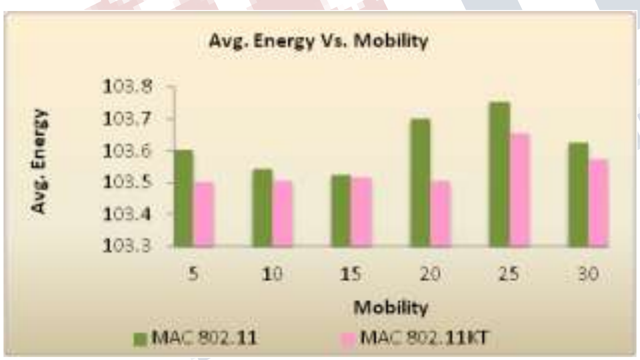

Figure 9:Average Energy vs. Mobility

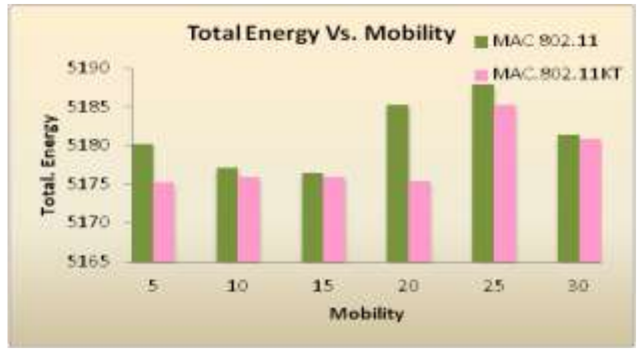

Figure 10:Total energy Vs. Mobility

The graphs shown in Fig9 and Fig.10 represent the relative performance of proposed 802.11KT MAC protocol and IEEE 802.11 MAC protocol for Average energy with mobility of nodes and total energy consumed with mobility of node. These graphics show in the vertical axis the average energy and Total energy for IEEE 802.11MAC protocol (Green column) and for the proposed MAC 802.11KT protocol (Pink column).The horizontal axis show the mobility of nodes. In proposed MAC 802.11KT protocol, to communicate between sender and destination node, it require a less numbers of data packet to generate, hence the average power requires by transmitter of proposed protocol is small as compared to IEEE 802.11 protocol. Due to better synchronisation between nodes, the total power consumption of proposed protocol is also small. From figures, it is observed that 802.11KT MAC protocol have approximately 30% of average energy saving and approximately 15% less power consumption than the IEEE 802.11 MAC protocol.Newly proposed and designed 802.11KT MAC protocol outperforms IEEE 802.11 MAC protocol in terms energy parameters.

CONCLUSSION

The work presented in this paper gave an overview of the proposed and newly designed 802.11KT MAC protocol. It also gave an overview of of the proposed 1.5 TDDI algorithm. This proposed algorithm is implemented into the newly designed 802.11KT mac protocol. The newly designed 802.11KT MAC protocol and existing IEEE 802.11 MAC protocol are simulated and evaluated using network simulator NS-2 for different mobility adhoc nodes. Simulation analysis observed that the newly designed 802.11KT MAC protocol with proposed 1.5TDDI algorithm have superior performance than existing IEEE 802.11 MAC protocol in terms of Total Data Packets generated, Total Packet Dropped, Packet Delivery Ratio and End to End delay,average energy consumption and total energy generated parameters with respect to the mobility of nodes.

The future scope of the newly designed and proposed 802.11KT MAC protocol may be in the application of satellite communication and mobile communication.

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