New Deafness-Aware Mac Protocol for Directional Antennas in WANET'S

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ABSTRACT
A favorable technique is using directional antennas for high – speed wireless personal area networks and local.A new MAC protocol for wireless ad hoc networks which is referred to as New deafness-aware MAC(NDA-MAC) is proposed in this paper. There are many directional MAC protocols which have been proposed, but have not broadly solved the problem of deafness. We are proposing NDA-MAC protocol which can differentiate the deafness problem from collisions by using control channels and logical data.so we are providing a discrete-time Markov chain model for analyzing the deafness impact for both DA-MAC and the current technique. By wide simulations we are showing our NDA-MAC protocol can expressively perform the other current techniques with respect to the duration of deafness , throughput , transmission fairness and energy consumption. Mainly Ad-hoc networks are suffering from hidden nodes(terminals) problem ,leading to the problem of the nodes which are hidden (terminals), which indicates to Spartan degradation in network throughput. A survey of this which will give a basic idea of MAC protocols which will directly or indirectly indicate this problem .The mentioned protocols are set in various for giving the reader a detail understanding for the growth made in types and are discussed in detail. To provide the reader a bottomless understanding for the progress done in enhancing the hidden node problem as well as a detailed comparison of various protocols are shown.

General Terms
Switched Beam Antenna, Ad-hoc networks, Throughput

Keywords
Directional antenna

1. INTRODUCTION
In the coming future, wireless technologies supports greater throughput data than IEEE 802.11n over short distance will arise in order to eliminate wires between multimedia devices like high volume storage ,uncompressed HDTV and HD digital cameras, under fixed topologies [9]. Directional antennas is one of the important technologies in which industries are taking interest, by which benefits will be obtain by consumer , namely range in longer transmission and better spatial reuse. Due to this ,standard organizations such as IEEE 802.11ad,IEEEac and IEEE 802.1.3c is concentrating at a great deal of devotion on MAC protocols using directional antennas. In spite of these merits, the directional MAC protocols suffers from the problem of deafness which reduces the network throughput. If a node is not answering a directional RTS(DRTS) frame addressing to it ,then the deafness problem occurs. Thus ,the inventor of DRTS will be trying more DRTS frames ,which will be increase the contention window, within which other nodes messages will be blocked. On the basis of our classification, the current solutions to the deafness problem can be divided as (1) methods using multiple control frames[12];(2) methods that specify potential senders [7,15];(3) tone based Approaches [3,5].The concept of multiple control frames are trying to solve the problem of deafness by revealing the transmission information to all the nodes who are neighboring. For avoiding deafness in order to delay their communication and the forthcoming communication the nodes which receives the control frame understand. In spite of transmitting multiple control frames ,the concept that specify potential senders would explore a local table which maintains the potential senders who have transmitted with a advance notice The receiver was informed by the advanced notice that the sender will be transmitting data in the next possible time resulting in minimizing the duration of deafness. The approaches which are tone-based tries to distinguish deafness from a collision by the use of one or more tone signals. The existing schemes are being classified by us and we also have identified their limitations (in Section 2),We are also proposing a new directional MAC which is referred as New deafness –aware MAC(NDA-MAC) which to the best of our knowledge is completely resolving the deafness problem by distinctive deafness from collision(in Section 3).

In IEEE 802.11 networks performance a important part is played by medium access protocols. As they are defining a proper way of controlling access and sharing bandwidth to the wireless channel.

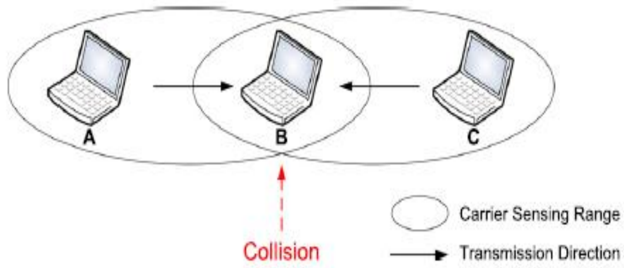


Fig. 1. Exemplary scenario with hidden nodes

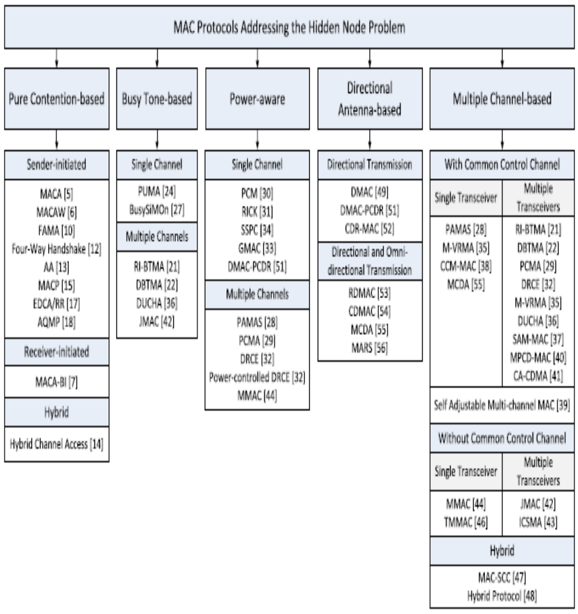


Fig .2. Types of MAC protocols showing the hidden nodes problem in ad hoc networks .protocols related to various categories are listed in each related categories

The famous wireless MAC protocol is dependent on Carrier Sense Multiple Access with Collision Avoidance (CSMA/CA). In this the node should perform physical carrier sensing afore each transmission .In the case if medium is busy , the node changes its transmission. But on idle condition of the medium, the node have its data transmission. Though collisions will takes place on destination on the presence of hidden nodes in the network.

The problem of hidden node is shown in Dig .1 as a related example. Where Node B is in the range of nodes A and C, although nodes A and C cannot listen each other's transmissions.so collisions can be caused at node B. In those cases ,nodes A and C are being referred as hidden nodes.

The problem of hidden node is first described in 1975 by Kleinrock and Tobagi [1].so on this interesting concept various MAC protocols are proposed in the literature which straightly or not mentioning his problem.[14,16] Generally they are classified as: multiple channel based, pure contention- based ,busy tone signal based, power aware and directional antenna –based. Mainly ,protocols fall in more than a single category. Mainly ,both old and new MAC protocols (starting 1987-2011) are mentioned in this paper.

2 Pure contention –based protocols

They are mainly based on CSMA/CA and are divided onto three categories: sender-initiated, receiver-initiated and hybrid. They mainly have two main advantages. Firstly ,nodes are using standard hardware with a single transceiver, which is mainly not costly and easily available in the market. Secondly, compatible with IEEE 802.11 is possible if we are using standard frames.

1.1 MACA (1990)

Multiple Access with Collision Avoidance (MACA) [4] is basically a sender-initiated protocol which in the starting Is introducing two fixed –size signaling frames (Request to send – RTS and Clear to send-CTS) for improving the problem of hidden node .The RTS frames are send from source to destination .Each time when sender's neighboring nodes hear the RTS frames they should Change their transmission. The RTS frame mainly have the information for the length of planned transmission for informing other nodes in the network. As the reply ,to the RTS frame ,the destination is sending the CTS frame containing information on the transmission length. The result is the neighbored nodes hear the CTS frames as they defer in length for the transmission which is to be expected. On the condition if two RTS frames have a collision with each other ,each node which is sending must wait for a Back off interval which is randomly chosen before starting its transmission again. This process is continued till one of the senders hears CTS at its destination .The main disadvantage of MACA is the absence of acknowledgments for a successful transmission on the MAC layer. All re transmissions positively to be done by the use of layer referred to as transport layer of the OSI model .So due to this protocol is not suitable for delay sensitive traffic ,e.g., video and voice. Other protocols are MACAW(1994)[19],MACA-BI (1997)[20].

2. RELATED WORK

The author proposed a CRCM scheme in which a receiver and transmitter pair is sequentially transmitting multiple control frames (DCTS and DRTS respectively) using all the antenna beams in [11].On the condition of overhearing the control frame by a nearby node the matching beam is blocked 1.As the control frames are being transmitted in all the directions near the receiver and the sender, the nearby nodes are attentive for the ongoing communication. likely [13] control frames used in multiple fashion. Basically these concepts have multiple RTS/CTS overheads ,as they are unable to resolve the problem of deafness. Dig 1 is the best example of the problem of deafness accruing in [10,13,17]. Presuming that node S has data for D. Node S will the be transmitting DRTS frames to D and to its neighbored nodes. Similarly ,node D and its corresponding neighbors will be answering with DCTS frames. At the time of exchange of the control frames which are causing the interference to S and D are Blocked, same as beam 4 of node B is being blocked in Dig.3.On the condition if node A is having data for the node B the node A will be sending DRTS frames to node B and to its neighboring nodes.

Node B will not be receiving the frames of DRTS as beam 4 is in the blocking condition , causing the problem of deafness.

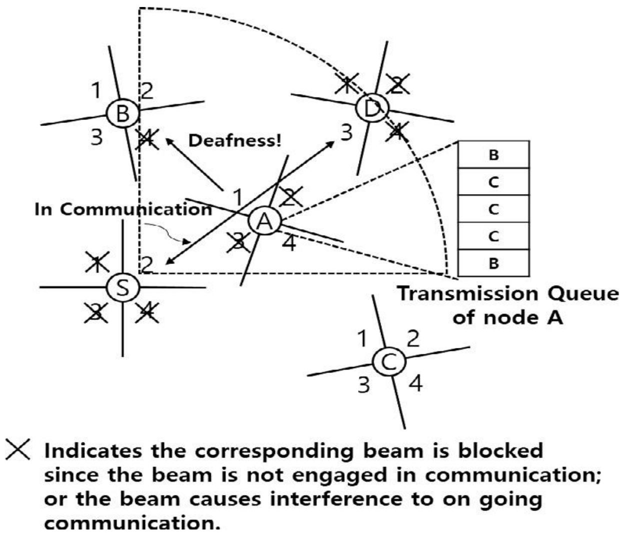


Fig. 3. An example of the deafness problem (4 antenna beams)

In spite of transmitting multiple DRTS/DCTS frames , the schemes in [7,15] will be exploring a concept that specify potential senders. The author is proposing an advance notice directional MAC (AN-DMAC) in which it is using a additional (ARTS) frame to specify al the potential senders To wait till another node completes its transmission for avoiding the deafness in [7]. The ready –to- receive (RTR) frame is used in [15] that once the node completes its transmission to other respective nodes such that the receiving node receives data from its respective potential senders ,and reduces its deafness duration. Apart from it the above schemes are trying to reduce duration of deafness and avoiding it by specifying the potential senders, which are not always successful. So we see again in dig 3 ,though node A will be transmitting the advance notice evidence to B, node B will not be receiving the DRTS frames as nodes D and S are already engaged in communication and thus B's beam 4 is in the blocking position, which is causing the deafness problem. From the above experiences , we conclude that the main solution to the problem of deafness is to trace out whether or not a node faces deafness. On tracing out deafness is not a simple task as the sender is not knowing why the DCTS frames are not received, either due to collision or deafness.one technique of tracing out deafness from collision is given in [3,8]. The author is proposing the concept of dual sensing directional MAC(DSDMAC) for transmitting tone signal & data frames separately by the use of two transceivers .

When a sender is transmitting data frame to a concerned receiver , the receiver and the sender also parallelly transmits a tone signal in the Omni-directional fashion so that the other nodes who are neighboring should be attentive of an ongoing transmission in their scheme. The basic use of tone is that: on the condition if a sender wants to have a communication with its corresponding receiver , on that moment it starts sending a DRTS frame. On the condition if the DCTS is not delivered to the sender within the specified time, the sender starts the tone direction concept. On detection of no tone by the sender, it settles the DRTS collision ,otherwise it settles receiver is engaged in ongoing communication.

For example, node A is transmitting DRTS to the node B using beam 1 .Then if A is unable to receive the DCTS from B ,it will be trying to notice a tone at the beam 1.Though , node A is unable to detect any tone at beam 1 as Node B is not involved in communication and B's beam 4 Is obstructed. Due to this , node A accomplishes that a collision is there at the transmitted DRTS which it is trying to transfer DRTS frames to B continuously. The concept mentioned in [8] is trying to differentiate deafness from collision by using a tone signal. The sender and the receiver are transmitting the tone Omni directionally after completing their communication in that scheme. The deafness problem received by a tone is experienced by once a node, the node is having the awareness that the destination node is unable to deliver the DCTS to source as the neighboring nodes are involved in communication by the use of same medium. For example in fig 1 ,once the node A is receiving the tone from node D or S, ,node A will be realizing that it is unable to receive the DCTS from node B's beam 4 is in the blocking position due to communication between the node D and the node S. The scheme problem is node A will be awake of deafness after D and the node S will be completing their communication.

The deafness problem becomes more critical ,if the time of communication increases between D and S.As mentioned previously ,the current techniques are unable to solve the problem of deafness. If it is possible by providing a method in which we are realizing the node A in advanced that node D and the node S are already involved in communication ,then it is possible for us to solve the deafness problem. On the condition if the node A is knowing that beam 4 of the node B is in the blocking condition in advance ,it can have its communication with the other respective nodes in spite of the node B. For example, node A is able to check the transmission queue and able to start the frame which is next for increasing the throughput in dig 3.

3. THE NDA-MAC PROTOCOL

3.1 Basic Assumption and System Mode

A single channel scenario is assumed in this paper. It is sub divided in two logical channels :a control channel xC and a data channel xD. Assuming that the two channels are not interfering with each other same number of frames are being transmitted simultaneously by the two channels. For increasing the data throughput ,we should assign extra sub carriers to the data channel as compared to the control channel. It is not possible to give the details of physical layer. On the basis of our assumptions, every node is having a switched beam antenna system where patterns of M beam are preferably non-overlapping for covering in all the directions. It is possible that all the beams might be used simultaneously for providing a omnidirectional function receiving or might be individually switched for receiving in a particular direction. This system is being operated from a controller which is keeping way of the directions having the highest SNR .Then the controller will be informing the top layers for the sector of the signal which is being received.Antenna controller switching can be attained by the use of very fast analog CMOS multiplexers/de multiplexers ,having the transition time of less than 217 ns[18],which is less than the delay of signal propagation. So, the (SIFS) short inter frame space mentioned in 802.11 standard is large enough for the respective antenna to be substituted in between receiving and transmitting modes.

Assuming a node for transmitting to a particular beam

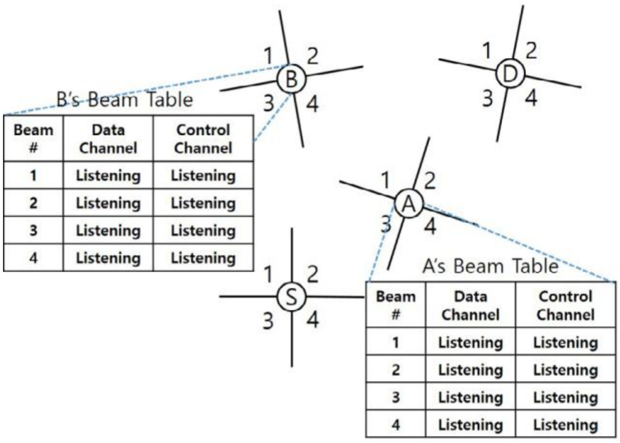
Whose range haves the destination node for directional communication. Assuming also that ,if a node is transmitting by the use of a single beam, the other beams are unable to receive as single channel 3 is in use. We are also assuming that every node adventures beam table catching (BTC) as in the current existing methods[2,6].By the use of BTC, every node is knowing its respective beam index where its one-hope neighbors are present. For static and fixed networks only a single-time pairwise altercation for the beam table is enough , apart from it regular changes are required for dynamic networks.

In NDA-MAC protocol , only the DCTS and DRTS frames are swapped on the control channel , apart from it all the DCTS /DRTS/DATA/ACK frames are swapped on the data channel.

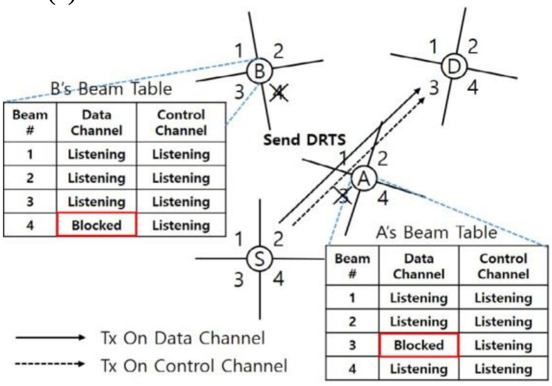
For transmitting data , if a sender has , it will be transmitting a DRTS frame to the receiver end for both the channels over the beam on the receiver location. DRTS receiver will be responding a DCTS for both the channels and sense continuously the control channel during the use of data channel for receiving the data. Also note , as the data frame is being transmitted over the data channel , the sender(receiver) might be able to notice the signal from the control channel during the transmission(reception).The receiver will be transmitting an ACK to the concerned sender on to the data channel , after a successful transmission.

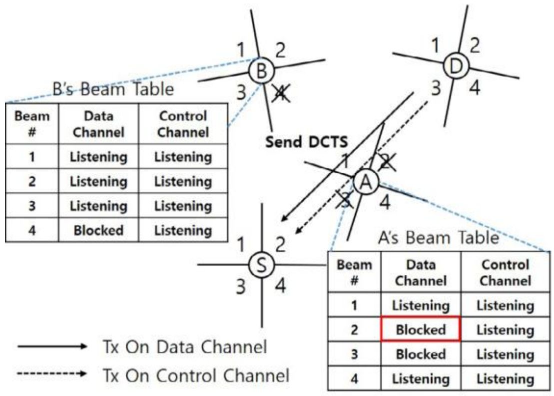
3.2 Distinguishing deafness from collision

For transmitting DRTS is to differentiate collision for the deafness , is the main cause for the use of data and control channels. Let us apply the NDA-MAC protocol to the example in dig 4.The nodes A and B are attending Omni-directionally for the both channels as shown in the beam tables. Presuming that node S has the respective data for the node D.S will be concurrently transmitting a DRTS frame for both the control(dashed) and the data channels(solid line). Dig 4(b).Then the node B and the node A will be receiving the frames of DRTS by the use of beam 4 and the beam 3, correspondingly , as the beams are present having the highest SNR are measured .As the DRTS frames receiving destination is D ,B's beam 4 and A's beam 3 are in the blocking position as shown in the Dig 3, over the data channel , as they are in the state of listening for the control channel. In NDA-MAC , data channel beams are in the blocking position only for differentiating collision from deafness .Due to DRTS response ,node D will be sending a DCTS frame to the node S for both the respective channels (Dig 4 (c)) , and the respective node D and the node S are involved in the communication.(Dig 4 (d)). (a) t = t1

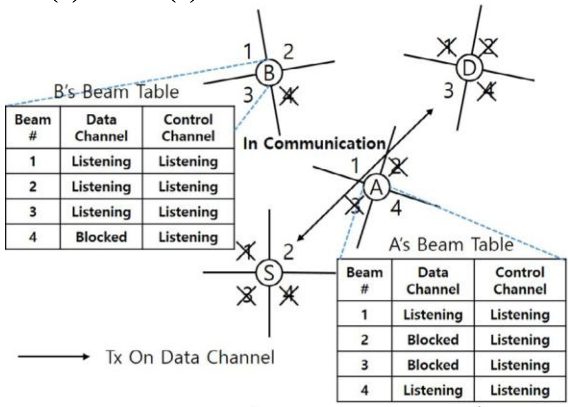


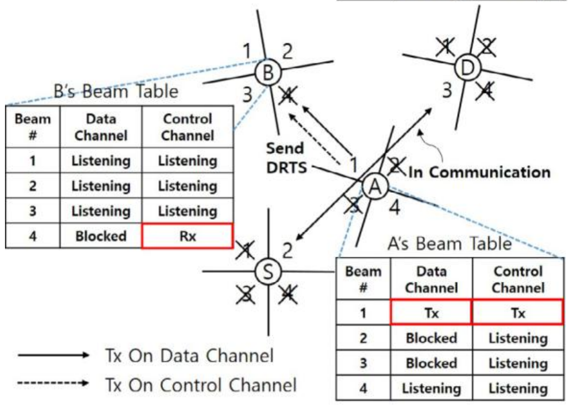
(a) *t* = *t*2



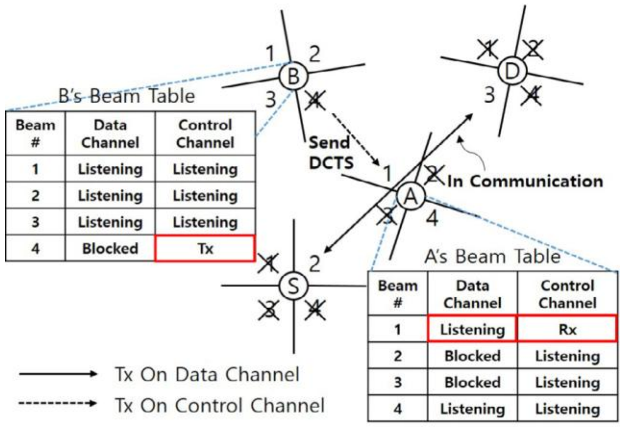


(b) *t* = *t*3 , (d) *t* = *t*4





(e) *t* = *t*5



(f) *t* = *t*6

Fig. 4. Resolution of the deafness problem in the NDA-MAC protocol (t1 < t2 < t3 < t4 < t5 < t6)

Node A has the data for B ,on the condition , it will be transferring a DRTS frame for both the channels

(Dig 4 (e)).Detecting that the state of channel for the A's beam will be showing the transmission (Tx).Even on the condition that node B is unable to receive the frames of DRTS on to the data channel ,it can still get the DRTS frame on to the control channel as control channel B's beam 4 is in the state of listening.so, the B's beam 4 state for the control channel will be showing the state of receiving (Rx).Node B will the be replying to the node A with a frame of DCTS on to the control channel (Dig 4 (f)).

As the node A will be receiving the frames of DCTS only to the control channel but not to the data channel as it can control that the nod B is in the state of deaf. But in the normal condition , the DRTS will be received for both the channels. On the condition of DRTS frame collision at the respective node B (Dig 4 (e)),then the node B is unable to receive the frame of DRTS on either channel as the data channel frames of DRTS is facing collision.so node A is not receiving no DCTS frame .So the node A can define a collision.

3.3 Protocol description

In the previous section it is shown the model behavior of the NDA-MAC in clearing the problem of deafness .In details , the NDA-MAC will be providing the listed features:

_ Deafness-awareness: Detecting the real network failure by the sender by differentiating collision from deafness.

_ Queue scheduling: Receiver deaf state condition is being aware by the sender ,it can start the process of communication with the other nodes who are in the idle position for refining the aggregate throughput 4.

_ Reducing control overhead: DRTS and DCTS frames are not being transmitted by the sender and the receiver to their respective neighbors. Removing the control frame overhead to all its neighbors will result in the increase of the aggregate throughput 5

Algorithm 1. The DA-MAC Algorithm

1: loop

2: if Data to send then

3: Set Contention Window in [0, CWmax];

4: Send ACK to wd and wc

5: if (UD==IDLE) and (UC==IDLE) then

6: Transmit a DRTS on both xD and xC only to the receiver,

7: and set timer;

8: if timer is expired ;

9: no data received on both wd and wc

10: else

11:then go to step 4;repeat

12:else if

13: and set timer; == Control overhead can be reduced

14: end if

15: end if

16: if Frame received then

17: if (FD==DRTS and FC==DRTS) then {normal case}

18:Transmit a DCTS on both xD and xC;

19:else if (FD==NONE and FC==DRTS) then {in communication}

20:Transmit a DCTS on xC; == in deaf state

21:else if (FD==DCTS and FC==DCTS) then {normal case}

22: Transmit a DATA frame on xD, and set timer;

23: else if (FD==NONE and FC==DCTS) then

24: Delay transmission by DNAVa; == found the receiver deaf

25: Schedule Tx of next frame to other node; == Queue Scheduling

26: else if (FD==DATA and FC==NONE) then {normal case}

27: Send ACK;

28: end if

28: end if

29: if Timer expired then {Node does not receive frame}

30: Go to step 22 (schedule ex)

31: Set timer

32: if Node transmitted DATA then

33: Retransmit frame and set timer;

34: else if Node transmitted DRTS then

35: CWmax (CWmax _ 2 and go to step 4;

36: end if

37: end if

38: end loop

On the condition of node overhearing a DRTS frame (or DCTS frame) ,it will set (DNAV) directional network allocation vector timers per sector. All sectors are blocked for communication duration.

Algorithm 1 will be showing the pseudo code for the NDA-MAC algorithm. Suppose UC and UD are mentioning the states of xC and xD, correspondingly .So we suppose FC and FD will be receiving frames on xC and xD. In our NDA-MAC ,if node is having a data for transmitting it will be setting the contention window , which will be in the range of [0;CWmax],in which CWmax will be maximum contention window size .Then the node will be performing a (CCA) clear channel assessment as well as back off as involved in CSMA/CA. On tracing out data and the control channels both are in idle position by the node then it will be transmitting a DRTS frames on both the channels and will be setting the retransmission timer (lines 6 and 7).The node will not be transmitting the DRTS frame to its neighbors in all , due to which the overhead of the control frame is reduced. On the condition of receiving one DRTS frame by each of its control and data channels (line 17),considering a normal case by the node. Then the node will be responding to the concerned sender for DCTS and DRTS frames on both the concerned channels. On receiving the two DCTS frames (line 21) it will be starting by transmitting the data frame only to the concerned data channel and the it will be setting the retransmission timer. The node will be sending the ACK on data successful reception(line 26).

Might be the node will not be receiving any data frames or control channel (line 32) as the two DRTS frames will be colliding on the another channel. Due to this the timer of sender's retransmission will be expired (line 34),due to this the sender have to retransmits the DRTS frames on both the channels after the duration of back off having the range [0;CWmax] will be expiring.

On the condition of another node communication by the respective node , the it will receiving one DRTS frame for the control channel (line 19) as data frames are being transmitted only to the concerned data channel. Replying by the node to the concerned sender with a DCTS frame only to the concerned control channel. So on this time , the DCTS timer will not be set as this DCTS will be informing to the concerned sender for DRTS transmission.

On the condition of not delivering of the concerned DCTS to a sender node , the node will be retransmitting the DRTS frames (line 6 and 7).On receiving the DCTS frames on to the concerned control channel once (line 23) it will be determining the state of deaf .Due to this the sender will be delaying the transmission by the use of DNAV 6 on to the respective beam. On more data by the concerned sender for the other destination , it will be starting such type of communication at the time of DNAV duration(line 24 and 25).So by this there will be a improvement in the aggregate throughput.

4. PERFORMANCE EVALUATION

In this we will be calculating the performance of NDAMAC protocol by the use of OPNET simulator.

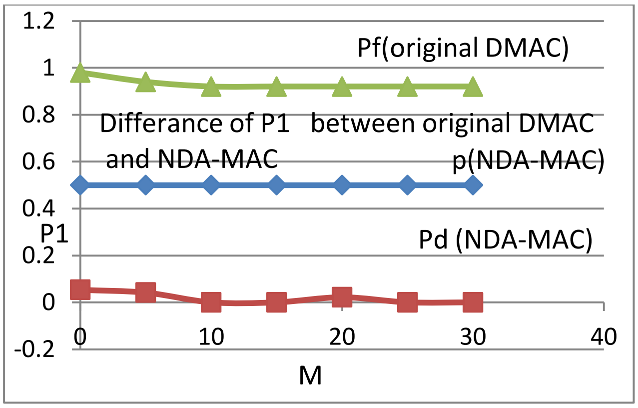


Fig.5. Probability of network failure vs. the number of beams(Nr = 4 and full buffer)

The dig 5 shows the pf when we vary the number of beams.pf is vey high in the original DMAC as compared to our NDA-MAC.As the original DMAC is unable to differentiate collision from deafness ,pf consist of network failure due to both collision and deafness. But , on the other case , as our NDA-MAC protocol is able to differentiate between the two , we trace out how p and pd contributed to pf. As shown in the dig 5 , pd is very less and it does not depend on the number of beams maximum ranges of x-axis in the NDA-MAC. It is obvious that there is a presence of deafness even if the presence of beams. Original DMAC and NDA-MAC is having about a difference of 0.50 in pf over maximum ranges of x-axis. This shows that original DMAC pd is affecting greatly the failure in the network if we assume an equal p , as present in the NDA-MAC . If p=0.50, we assume that pd=0.5 for original MAC.

The parameters which are related to simulation are mentioned in the Table 1 and are same to those in[8].Every node has a variable orientation of the respective beams in our simulation also. To calculate the efficiency of the NDA-MAC protocol , we are calculating the listed performance metrics .

-Deafness duration:-the time in between the transmission which is first of the respective DRTS frame with its corresponding DCTS frame.

-Aggregate throughput: total traffic of the data in bits which are transferred successfully from all its respective nodes with the division by time 1.

Table 1

Simulation parameters.

Parameters	Value
Omni-directional communication range	155 m
Directional communication range	320 m
CW_{max}	1024
Backoff slot size	0.04 ms
Packet size	512 Bytes
Data rate at the data channel (DA-MAC)	40 Mbps
Data rate at the data and control channels (CRCM, AN-DMAC, and Tone-DMAC)	50 Mbps
Data rate at the control channel	0.7 Mbps
Energy consumption	9.9 mW/s (busy) [7] 3.2mW/s (idle) [7]
Traffic load from a node with an omni-directional antenna	8 Mbps

Traffic load from a node with an omni-directional8 Mbps

Antenna

- Per frame energy consumption: The total consumption of energy from all its respective nodes divided by the number of frames which are transmitted.

All the receivers are being located in the range of transmission beam for all the senders.

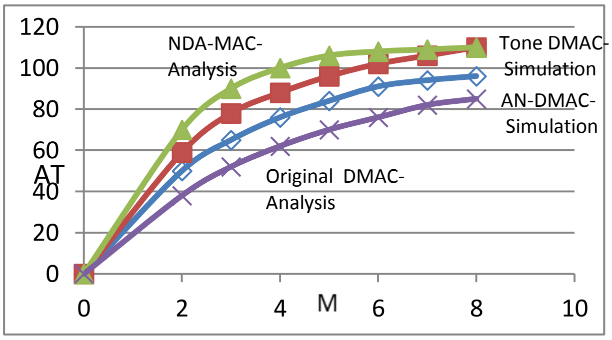


Fig.6. Aggregate throughput vs. the number of beams (Nr=4,N=2Nr and full buffer)

Dig. 6. Shows that the scheme which is proposed by us is performing good in extreme situations. The through in aggregate is achieving good performance on the condition when on the condition of 4 nodes. This is due to the increase in the node number ,which is increasing the interference of each communication which is ongoing. So our scheme which we have proposed outperforms the other schemes having lower rates of data for the respective data channel by reducing the duration of deafness.

For calculating the NDA-MAC effectiveness, we have compared the NDA-MAC performance with AN-DMAC[7],CRCM [11] and Tone –DMAC[8] by the use of OPNET simulator.

Deafness duration of a total of 20 nodes are being shown in Table 2 As shown in table ,the NDA-MAC protocol is significantly reducing the duration of deafness is compared with the other respective schemes. Mainly the NDA-MAC will be reducing the time of response to 60% Of that to Tone-DMAC [8] and 95% of that to AN-DMAC[7]. This is due to the reason as sender is identifying a node which is in a deaf state will immediately trying for other idle node.

Table 2

The deafness duration (9 Mbps, N= 20, and M = 4).

NDA-MAC	Tone-DMAC	CRCM	AN-DMAC
0.6 ms	4 ms	14 ms	17.3 ms

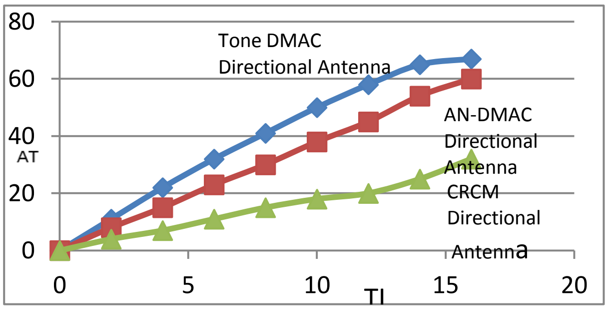


Fig.7. Aggregate throughput vs. traffic load (N= 20 and M=4))

Dig .7. is showing the aggregate throughput vs. traffic load. As shown in the dig. that there is a increase in aggregate throughput as there is a increase in traffic load.

NDA-MAC aggregate throughput is achieving the performance to its best of all the compared schemes.

This due to the fact that NDA-MAC is able to trace out the deaf node. Which is shown deafness duration previous performance, NDA-MAC will not be wasting opportunities related to transmission to other nodes.

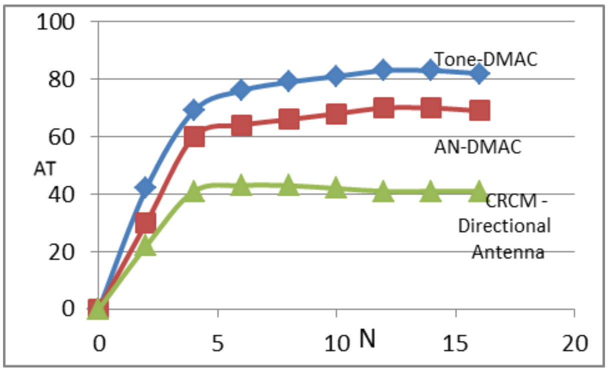


Fig.8. Aggregate throughput vs. the number of nodes (M=4, Traffic Load = 8 Mbps)

Dig. 8. Is showing the aggregate throughput vs. the number of nodes. There is a increase in the aggregate throughput as there is increase in the number of nodes on the receiver side in the sender range .Therefore the throughput in aggregate of the NDA-MAC is attaining the best in performance within all the compared schemes. Worst performance is of CRCM due to noteworthy control frame overhead. Aggregate throughput slope in NDA-MAC is very high as compared to other schemes as the problem of deafness is occurring frequently in other schemes.

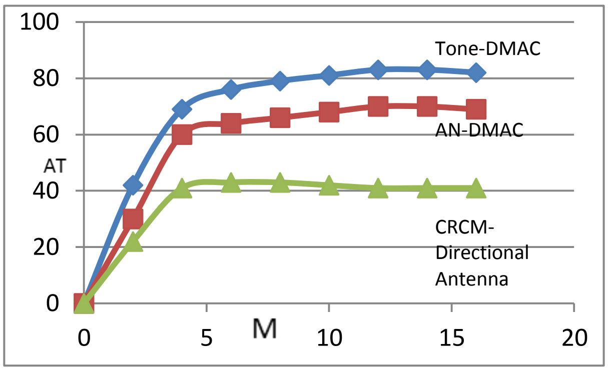


Fig.9. Aggregate throughput vs. the number of Antennas (N=20 and traffic load = 8 Mbps)

Fig.9. is showing the aggregate throughput vs. the number of antennas. There is a increase in the aggregate throughput as there is a increase in the number of beams as a beam which is narrow will be stimulating a spatial reuse in the DMAC protocol. Due to this the nodes will be having more opportunity for transmitting it simultaneously. Aggregate throughput of NDA-MAC will be achieving the performance to its best of the related schemes which are compared. We traced out a interesting finding that the CRCM scheme aggregate throughput is in a saturation position around 42 Mbps by the use of various control frames.

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