Routine appraisal of Mac protocols for Ad-Hoc Networks using Directional Antenna

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Abstract

An Ad-hoc network is a dynamic network worked on demand by a group of lumps without any pre-existingnetwork infrastructure. Self configurability and relaxed deployment piece of the Mobile Ad-hoc network (MANET) resulted in abundant claims in modern era. An effective and effective medium access control (MAC) protocol is important in ad-hoc network for proper allotment of channel. The omnidirectionalantenna has been used in outdated MAC protocols. More demanding consideration is giventoward the directional antenna by researchers due to competency of spatial reuse and other beneficialfeatures. Central focuses of this paper is to discus and appraise the performance of MAC protocol expendingomni-directional and directional antenna. We conducted a virtual simulation study of different MAC protocols using Omni-directional and directional antenna. Presentation metrics like throughputand delay are used for the performance analysis. On the basis of result derived from recreation acomparison among these MAC protocols using directional antenna is given.

Keywords - *Ad-hoc network, Directional antenna, Directional MAC protocol, Smart antenna.*

I. INTRODUCTION

There are two opportunities for enabling wireless communications: infrastructure mode and ad-hoc mode. The first one relies on infrastructure that requests to be built in advance. In 802.11infrastructure mode, all the wireless devices in the network can communicate with every otherthrough an Access Point (AP) or communicate with anunderwired network as long as the AP isassociated to a wired network. The other choice is ad hoc mode whose major piece is the nonexistenceof supporting infrastructure. An ad-hoc network is self-organized wireless networkwithout fixed or backbone structure. Ad-hoc network topology is changes dynamically dueto mobile nature of node hence routing protocols are required for data communication amongsource and destination. All nodes have routing capability and use peer-to-peer packettransmission or forward packet for other node using multi-hop communication. Due toplasticity in deployment, ad-hoc networks are very useful in military and other application suchas emergency and saving operation where infrastructure is unavailable or unreliable. Wirelessmesh networks could be measured as a type of wireless ad hoc networks.

Mesh networksencompass the influence of wireless networks and are ideally suited for many environments such ascommercial zones, neighbourhood communities besides university campuses. Wireless sensornetworks are alternative application of ad hoc networks in which sensor devices are connected inopen peer-to-peer ad hoc network architecture to offer various operations such as monitoringtraffic cramming in a city, detecting a biological weapon in the battle field and border intrusion.Outdated work on ad hoc networks assumes that each device is equipped with omnidirectionalantennas. With the enduring reductions in the size and cost of turning antenna in recent years, it has become reasonable to use directional antennas for ad hoc networks.Directional antenna offer potential benefits for wireless ad-hoc networks. With reversingtransmission and reception, spatial reuse ratio and antenna gain can be increased substantially;this leads to significant enhancement in communication system routine. To best exploit thedirectional antenna, a suitable MAC protocol is compulsory. Directional antenna based MACprotocols are proficient of transmitting only in certain narrow azimuth that suggestively reducesthe chance of collision and increase the effective network capacity. Though, use of directionalantenna introduce the some complex issues like hidden terminal, exposed incurable and deafnessproblem at the same time trans-receiver complication increases.

Carrier sense medium access (CSMA) protocol sources hidden terminal and exposed terminalproblems. These hitches are decreased by MACA using RTS/CTS frames. Some optional controls are added forbetter show in Multiple Access with Collision Avoidance for Wireless (MACAW).IEEE 802.11 MAC DCF protocol is CSMA/CA (Carrier sense multiple access with collisionavoidance) with optional RTS/CTS control message. The IEEE 802.11 MAC protocol isplanned to exploit omni-directional antennas and could not work well in steering antennabased ad hoc networks. Therefore, several modified MAC protocols have been proposed toadventure directional antennas, enhance the spatial reuse, and growth network capacity.

II. RELATED WORKS

In this Section we review some directional MAC protocols projected in literature for ad-hocnetworks using directional antenna. The major improvement of directional antenna with 802.11based ad-hoc network is the condensedinterfering and the opportunity of having paralleltransmission to increase the spatial reuse of radio resources. A number of steeringprotocols have been proposed for wireless ad-hoc networks using directional antenna.IEEE 802.11 DCF MAC is initiallyconsidered for omni-direction transmission using omnidirectionalantenna known as CSMA/CA. If a mobile node sense the channel is free/ idle it waitsfor extent DIFS, if channel is still idle it will wait for additional random duration of timecalled back off time. Once back off time expires, data transmission is opened. After eachcollision CW (Contention window) size is doubled up to maximum window size. On the otherhand after each successful transmission minimum size of window is set. If data packet size islarger than specific beginning, it will use four ways hand shake mechanism for datatransmission. If mobile node has packets to transmit, it will transmit the RTS frame, in reply of RTS receiver will transmit CTSframe. After reception the CTS frame source will send the DATA packet, after efficaciousreception of DATA, receiver will send the ACK frame for each data packets. This controlpacket (RTS, CTS) decrease the prospect of data collision, as they allow communicatingnodes to reserve the channel for the entire communication duration before the actual datatransmission begins. All neighbours' nodes of sender or receiver are estimated to keep silent toavoid collision or interference with ongoing transmission, which causes low altitudinal reuse. Thebasic operations of these schemes are illustrated in figures 1(a) and (b).

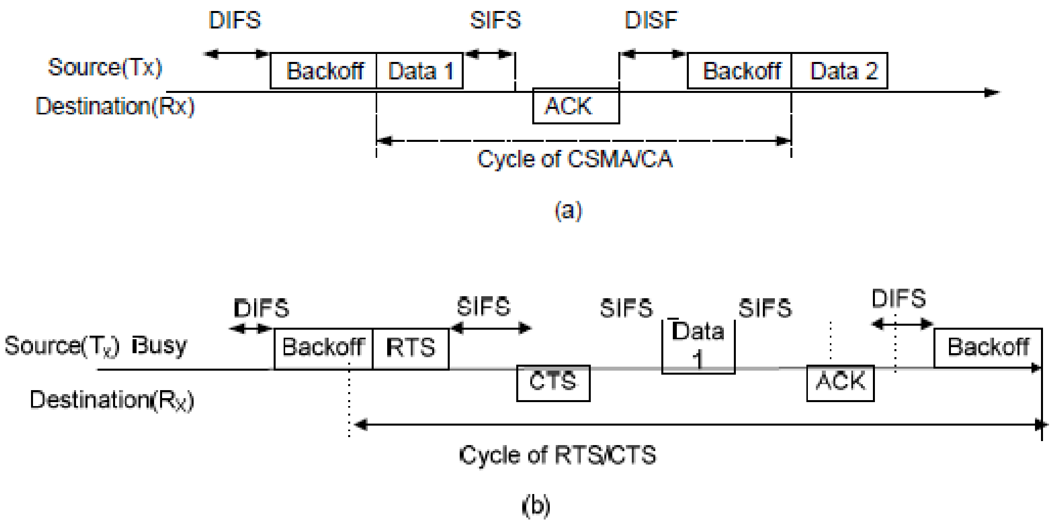

Fig 1. Timing diagram of (a) CSMA/CA and (b) RTS/CTS

In authors proposed a MAC protocol using manoeuvring antenna. It has been presumed thateach node knows it own position and neighbour's node, and directional and onmi-directionaltransmission range are same.

Two schemes:

- Directional RTS (DRTS) MAC
- OmnidirectionalRTS (ORTS) MAC

Node will send the ORTS frame omnidirectionalif none of the directional antenna elements are blocked, then node will send aDRTS frame, provided that anticipated directional antenna element is not blocked. In both scheme the DATA/ACK are transmitted directionally, whereas the CTS is transmitted Omni-directionally,if it does not restrict with other ongoing transmission.

Nodes have dissimilar transmission rangefor directional and Omni-directional transmission in MAC protocol proposed. All framesare communicated directionally. RTS frame send using multi-hop while CTS, DATA and ACK arediffused using single hop. In authors proposed an algorithm in which RTS, CTS, DATAand ACK frames are conducted using the directional antenna in the directions which are freeaccording to the directional network allocation vector (D-NAV) table. In this scheme mobile node do not have any position information.In authors have proposed dual busy tone numerous accesses (DBTMA) and its directionalversion (DBTMA/DA). It divisions the channel in two sub channel. Busy tone isconducted omni-directionally while directionally. Authors have split the channelin two deputize channels, one is used for RTS/CTS/DATA/ACK and the other is used for busytone transmission. A Selective Turning MAC (SDMAC) protocol is proposed by authors. This paper deal with the problems, like deafness problem, hidden terminal problem, andHeal on line (HOL) blocking problem. An arrangement algorithm has been proposed to deal with HOL blocking problem. A range adaptive directional MAC is proposed. In the place of single fold directional transmission range they proposed multi fold transmission range. A range based DNAV and distance among source and destination is used to excellent the transmission range. In authors give the comparative study of dissimilar omni-directional and directional MAC protocols like 802.11 MAC, MACA, MACAW, FAMA, DBTMA and DBTMA/DA.

III. SMART ANTENNA

The enhancement of the spectral competence in Ad-hoc network may be realized through the application of directional antennas. The employ of directional antennas has demonstrated improvement in the performance of Ad-hoc network. This augmentation is because directionalantennas concentrate the power into limited regions, and accordingly, they considerablydiminish the interference caused to users that are not within these regions. Nonetheless, directionalantennas lack of the required flexibility that ad-hoc networks demand. Automatically reconfigurationof the network is violated by the engagement of directional antennas. A more appropriate kind of antennas that have the recompenses of reversing antennas and offer a major elasticity is the so-called smart antennas. Smart antennas generally combine various antenna elements with a signal processing proficiency to optimize its radiation and/or response pattern robotically in response to the signal environment. Basically, there are two foremost categories of smart antennas.

A. Type of Smart Antenna

1) Switched Beam Antenna

Switched beam antenna is embraced of multiple fixed beams that are designed by shifting thephase of each antenna division of an antenna array by a predetermined amount, or simply bysubstituting between several fixed directional antennas. The transceiver can select one or morebeams to communicate or receive.

2) Adaptive Arrays Antenna

Adaptive arrays antenna is tentatively able to form an infinite number of radiation patterns.The outlines are created taking into account the desired signal and the interferers. In otherwords, they have the competence of direct the main beam toward the desired signal whileoverturning the antenna pattern in the direction of the interferers. Adaptive arrays tend tocomplete better than switched beam antennas, since they place the desired signal at the maximumof the main lobe and reject the interferers. Nevertheless, adaptive arrays are not appropriate forad-hoc networks due to their high complexity and cost. Switched beam antennas, while notperforming at the same level of adaptive arrays, offer the recompenses of directional antennasjoint to a major elasticity, and a lower cost and complexity compared to adaptive arrays.

B. Need of Smart Antenna

There are many enthusiasms to utilize the smart antenna performance in a wireless system. As an example of a cellular communication system where the volume has become a critical issue, the use of conventional omni-directional antennas not only causes huge waste of signal energy since only a small part is communicated to desired receiver but also generates serious interference to neighbouring base stations and terminals. Consequently, separating one cell into numerous sectors and uses a directional antenna for transmission was established with the goal of reducing the interference level. Unscrambling in sectors has shown ability to increase frequency spectrum utilization. Though, sectorized systems lack the ability to change the antenna's beam width or orientation in response to a changing propagation environment and traffic condition. This deficiency results in large capacity waste in sparse traffic sectors and traffic blocks indense traffic sectors.

The adaptive array smart antenna system which can judiciously control its radiation pattern based on signal processing provides an admirable solution to these problems. Its feature of engendering null towards interferers results in higher frequency spectrum utilization and thus increases the system capacity. The smart antenna technique is applicable for almost all major wireless protocols and industrial principles to achieve larger network coverage and higher system capacity. Examples of these standards could be FDMA (frequency division multiple access) employed in AMPS(advanced mobile phone system) and NMT (Nordic mobile Telephone); TDMA (time division multiple access) employed in GSM (global system for mobile communication) and IS-136; CDMA (code division multiple access) employed in IS-95, WCDMA (wideband CDMA) and TDSCDMA (time division synchronous CDMA); FDD (frequency division duplexing) and TDD(time division duplexing). As its costs endure to decline, the smart antenna offers a practical, reasonable solution to address wireless network capacity and performance challenges ford is similar communication systems, including RFID, WiMax, Ultra wideband (UWB), and evenWiFi.

C. Antenna Model used for Simulation

In this paper we used the converted beam antenna. Every node has N highly directional, fixed predefined antenna beam elements which are deployed into non overlapping fixed sectors, each spanning an angle of 360/N degree. Each node can transmit in two modes: omni-directional and directional mode. That has been accessible in figure.2 by unicast and broadcast transmission.

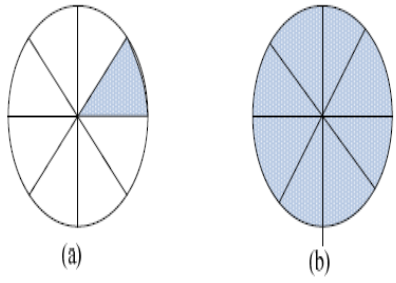

Fig 2. (a) unicast and (b) multicast

IV. MAC PROTOCOL

Despite recent advances in MANET, there is still a wide range of dissimilar open research issues. One of the most imperative building blocks of wireless ad-hoc networks consists in deceitfularesourceful medium access control (MAC) scheme. A well-considered MAC protocol is essential tomaximize the performance and the efficiency of the network. One method for multipleaccesses is to employ disputation based schemes where nodes compete for accessing the channel. Still, contention-based medium access method isintrinsically inappropriate forifQoS guarantees, which is becoming a basic premise for lots of announcement.Collision-free access procedures are another kind of MAC scheme more apposite for QoSwireless ad-hoc networks, since it is thinkable to guarantee QoS. All above discussed MACprotocols are grounded on using omni-directional antenna.Directional antenna has been broadly used in numerous communication systems. However, tosimply use directional antenna with the conventional IEEE 802.11 standard for ad hoc networkcould not bring substantial network expansions. This encourages countless researchers todevelop new MAC protocols which could fully exploit the advantages of directional antennas.

A. MAC Layer Problems using Directional Transmission

The protocols declared in introduction sections allow the spatial reuse and routineenhancement. However, these procedures fails to address the issues arise using the directionaltransmission, like deafness problem, hidden terminal problem and HOL blocking problem.

B. Architecture

This subdivision details the architecture and operation of MAC protocol. In this construction every node keeps a MAC table that gives the impassable and unblocked beams and best beam for transmission among source and destination. All nodes send and receive the packet directionally. We assume every node know the relative bearing of its neighbouring nodes. This information can achieved through GPS system fixed at each node. Switching among beams and blocking of the beams are done via radio occurrence switches. At the receiving node selective diversity is functional to determine the best beam over which the highest SNR is measured.

C. MAC Operation

When node A has data for broadcast to node B, if it senses channel is free, then it will transmit RTS frame using all beams. RTS [B, A, n] packet are sent over all beam and they are received over the beams of neighbouring nodes. Where n is used to epitomize the 8 beam starting from 1 to 8 and 8 bits are being used and bit situation value in bit pattern represent the each beam. Bit pattern 00000100 epitomize that this packet is being transmitted using beam number 3 (3rd bit is 1). RST [B, A, 8] signpost that RST packet is transmitted to node B using beam 8 of node A and it is being received by the node B over beam 5. Other RTS diffused by the beams of A, may be received by the node B, but on the basis of SNR value beam 5 is particular. Node C and D also receive the RTS packet transmitted because they are in transmission range of A but they will not reply. C and D record the beam number used by A asbest beam for announcement to A that can be used in future. After receiving the RTS intended to B, it will sent CTS packet using all beams. CTS [A,B,4,8,4] designate that B is source and A is destination of CTS packet , B use the beam number 4, beam number 8 and 4 are best beam of node A and B respectively for transmission among A and B.

V. PERFORMANCE EVALUATION

A. Simulation Setup

Simulation is done on Qualnet that is inscribed using PARSEC, a C language basedis connected event simulator. Traffic model used in our simulation is CBR with packet size of 512byte and transmission data rate of 2 Mbps. The reformations are run for different random seed and the results are statistically averaged out for 25 iterations, each running for 600 simulation seconds. For fair comparison of MAC protocols we have used two dissimilar topologies, first is5X5 mesh topology with dissimilar source and destination combination.

B. Simulation Results

In first Scenario we deliberate the single hop communication among any two node e.g. connection between nodes 1 to 2 (1 _ 2) and construction between nodes 6 to 11 (6 _11). The performance of proposed MAC (Angular-MAC with eight beams "A-MACEB") is higher compared to IEEE802.11 MAC but nearly same as D-MAC and A-MACFB. This is due to fact that, with IEEE802.11 two acquaintances cannot communicates the packets at the same time but using the D-MAC, A-MACEB simultaneous transmission is possible due to numerous beam antenna of each node. Performances of A-MACEB increased with node density, because multiple beamprotuberances are under utilized in the case of low density but they are efficiently utilized with high node density at the cast of increased processing time. The subsequent scenario used, two multi-hop statement between any node e.g. connection between nodes 1 to 21 (1 _21) and connection between nodes 1 to 5 (1_5). Performance of D-MAC and A-MACEB are better associated to IEEE802.11, but performance of these MAC is nearly equal.

VI. CONCLUSION

We have achieved proportional analysis of omni-directional and directional MAC for ad-hoc networks. We considered the basic concepts of smart antenna and use of directional antenna in ad-hoc networks. Additional we discuss the MAC protocol in directional antenna and issues likedeafness, buried terminal and HOL problems. We have done reproductions to evaluate the performance for CBR traffic on mesh and random topology. The results demonstrate that directional MAC protocol A-MACEB and DMAC are more operative than omni-directional MAC 802.11MAC, especially when traffic load is high. It is noticed that A-MACEB achieves the better presentation associate to the DMAC.

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