Design of Plbu Routing Protocol Using Directional Antennas for Emergency Ad Hoc Networks

K. V. K. Venugopal	M.Tech, Digital Communication, R.V. College of Engineering. Professor and Associate Dean, Telecommunication Engineering, R.V. College of Engineering
Dr. K. Sreelakshmi	M.Tech, Digital Communication, R.V. College of Engineering. Professor and Associate Dean, Telecommunication Engineering, R.V. College of Engineering

ABSTRACT

In Ad Hoc Communication Networks, the shared wireless channel is responsible for decrease in Throughput and increase in Packet Loss and Collisions during Data transmission. Directional Antennas can be used instead of Omni-directional Antennas to reduce the collisions during data transmission, and thereby improve the network throughput. In this paper, we propose a PLBU Routing Protocol for Ad Hoc Communication Networks. Directional MAC Protocol has been used instead of 802.11 MAC, along with Power and Rate Control Mechanisms to help deal with the collision and interference problems among signals and simultaneously improve the Throughput by adapting to the channel behavior. The Preferred Link-Based Unified (PLBU) Routing Protocol has been designed and validated using Cinderella SDL tool. A simulation study of the designed protocol is performed in NS2 to demonstrate its better network performance over AODV in Ad Hoc Networks.

KEYWORDS	Ad Hoc Network; Directional MAC (DMAC); PLBU; AODV; Throughput; Packet Delay; Packet Loss; FSM

INTRODUCTION

Ad Hoc Networks have gained great significance in recent years with implementation in Traditional applications like Military operations, Emergency and Rescue operations, and commercial applications for voice and data communication. Ad Hoc networks can also be used as an alternative to existing cellular networks in remote locations.

Communication protocols which are being used with present Wired and Wireless networks cannot be suitably used with ad hoc networks because of its high dynamics and infrastructure-less systems. Some protocols are the enhanced and modified version of the previously used protocols.

The protocols being developed or modified for the ad hoc networks consist of Omni-directional antennas. These antennas transmit in all directions at the same time. This causes collision and interference with other data transmissions. It also causes the other nodes to wait for the present transmission to get over, thereby increasing the wait time and thus reducing the bandwidth efficiency. Directional antennas can be used instead of the Omni-directional antennas which will reduce interference and collisions and this improve the throughput and bandwidth efficiency.

Directional MAC protocol is a Data-link layer protocol for ad hoc communication networks with nodes (transmitters and receivers) having 'N' directional antennas, so that the coverage region is divided equally into $2\pi/N$ radians. This increases the network throughput and improves bandwidth efficiency. It also reduces the number of packets lost due to collisions and interference.

Auto-Rate MAC (RBAR) protocol can be incorporated with all the existing MAC protocols to dynamically change the data rates based on the channel conditions so as to achieve optimum throughput. The Power Control MAC (PCM) protocol is used to control the power utilized in transmission of data packets. RBAR and PCM protocols are incorporated in D-MAC protocol for Rate and Power control.

Preferred Link-Based Unified (PLBU) Routing Protocol can be used both for unicast and multicast. The protocol forwards RouteRequest (RReq) packets to the nearby nodes based on Link Stability, which is being calculated by the power levels of received periodic beacon signals. The integrated use of PLBU Routing and D-MAC protocol results in improvement of Throughput to the Network and Bandwidth Efficiency.

The detailed structure of this paper is as follows. Section II presents the Literature Survey and section III discusses the detailed design of the PLBU Routing Protocol. Following this, the designed protocol has been simulated by creating Ad Hoc Scenarios in section IV. Section V deals with the results obtained after the simulation of Protocol, and section VI highlights on Conclusion and Future Scope of the carried out Work.

LITERATURE SURVEY

Directional MAC Protocol and Preferred Link-Based Unified Routing Protocol have been studied and analyzed in various fields of Wireless Communication and Ad Hoc Networking. The Directional behavior of this protocol improves the throughput of the system by reducing interference and collision. A combined proactive multi-channel MAC and routing protocol has been studied and analyzed in [1]. Similar work has been carried out in [2]. Reference [3] was the first to implement smart antennas in MAC protocol and showed improvement in performance.

The initial research related to use of Directional Antennas in Ad Hoc Communication Networks, as shown in [9], [10] and [11] deals with the modified RTS/CTS exchange and blockage of certain antennas which results in improvement in throughput and reduction in interference and collision. Survey of directional antennas and its implementation in Ad Hoc networks has been studied in [5]. MACA/CA has been implemented with directional antennas for multi-path networking, as in [6]. A modified version of Directional MAC has been studied and analyzed which deals with neighbor discovery without interference, as in [7]. Research related to improvement of Throughput in Ad Hoc networks, especially in Military applications, has been studied in [8].

Power Control MAC (PCM) and Auto-Rate MAC (RBAR), as shown in [12], [13] and [14], controls the signal power and data-rate of the transmission based on estimated channel behavior.

In this paper, we have proposed a Routing Protocol (PLBU) that makes use of Directional Antennas (D-MAC) and Power and Rate control mechanisms. By using the power and rate control methods, this protocol reduces the interference and collisions during data transmission. It also improves the network throughput and thus increases the bandwidth efficiency. We have simulated the designed protocol in Ad Hoc communication networks and studied and analyzed its performance based on Throughput, Packet Delay and Packet Loss.

DESIGN OF PLBU ROUTING PROTOCOL
Cinderella SDL Tool has been used to design the PLBU Routing Protocol. Firstly the Signals package is defined, then the System is defined which consists of the block, then the processes are defined which consist of the sender, receiver and channel Processes, then lastly the PL_Selection procedure is defined inside the sender process. The Design procedure is as follows.

I. Signal Package
The signal Package has been defined in Fig. 1, which defines the various signals to be used in the design of PLBU Routing protocol.

II. PLBU System
The PLBU System has been defined in Fig. 2, which consists of the PLBU block, incoming and outgoing signals, and the Package Use block which enables the system to use the signals defined in Fig. 1.
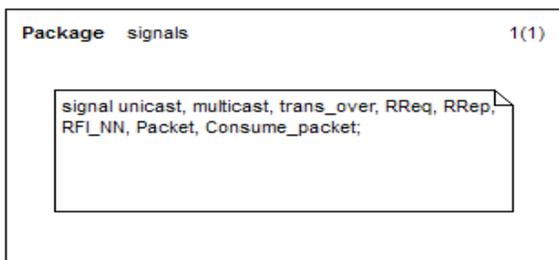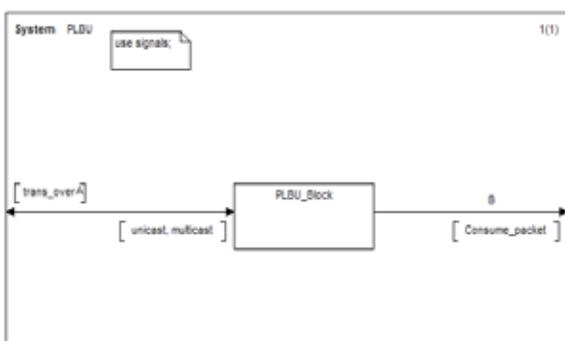

Figure 1. Signal Package

Figure 2. PLBU System

III. PLBU Block
The PLBU block consists of the Sender, Receiver and Channel Processes, and the incoming and outgoing signals to each process. The signals defined in Fig. 1 are being used. The PLBU Block is shown in Fig. 3.

Figu re 3. PLBU Block and Processes

IV. PLBU Sender, Receiver and Channel Processes
V. The Sender Process (SenderP) consists of the FSM (Finite State Machine) of the Sender using the PLBU protocol for routing the control and data packets, as shown in Fig. 4.

Figure 4. Sender Process of the PLBU Protocol

VI. Receiver Process
The Receiver Process (ReceiverP) consists of the FSM of the Receiver, as shown in Fig. 5.
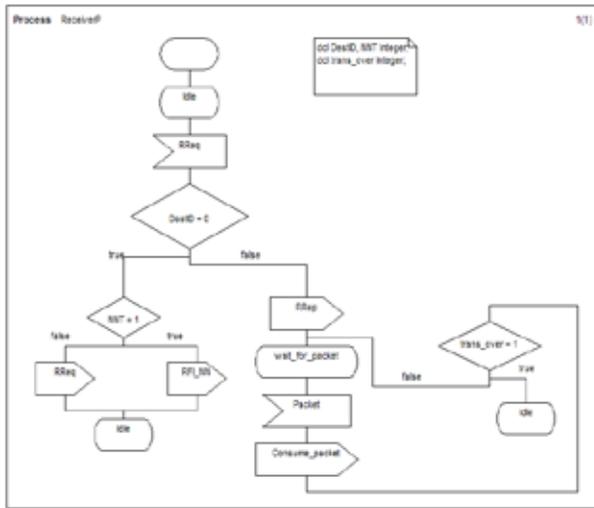
Figure 5. Receiver Process of the PLBU Protocol

VII. Channel Process

The Channel Process (ChannelP) consists of the FSM of the Channel, as shown in Fig. 6.
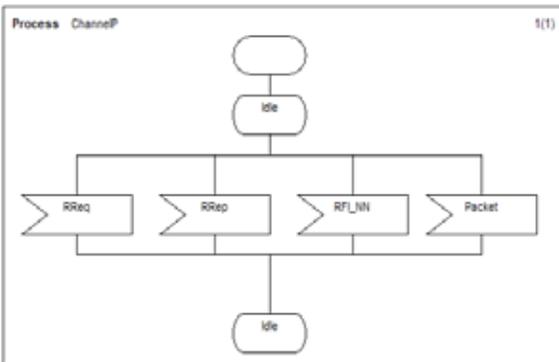

Figure 6. Channel Process of the PLBU Protocol

VIII. PL_Selection Procedure at the Sender

Fig. 7 shows the Preferred Link (PL) Selection Procedure which is used in the Sender Process to select most stable links to forward the control and data packets.
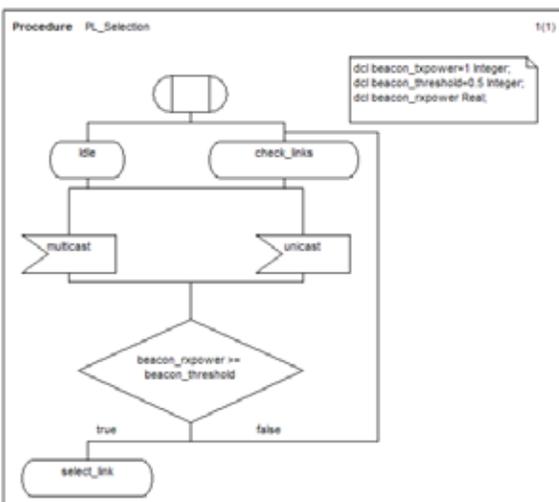

Figure 7. PL_Selection Procedure for PLBU Protocol at Sender

SIMULATION AND RESULTS

Network Simulator 2 (NS2) has been used to simulate the designed protocol by creating ad hoc network scenario. The description of nodes and other specifications are as shown in Table 1.

The nodes are deployed in the network and move in specified directions and at specified speed. This node movement can be random as well. Firstly, we use the 802.11 MAC protocol and AODV routing protocol and simulate the network. The Throughput, Packet Delay and Packet Loss are traced and plotted in graphs

Secondly, we use the DMAC Protocol and PLBU Routing Protocol to simulate the network and record the same statistics as above. These Performance Parameters are then compared and plotted on the same graph as shown in Figures 8-10.

TABLE - 1
NODE DESCRIPTION AND OTHER SPECIFICATIONS

TYPE	SPECIFICATION
Type of Channel	WIRELESS
Data-Link Layer Protocol	802.11MAC and DMAC
Antenna Type	OMNI-DIRECTIONAL AND DIRECTIONAL
Area (m, m)	1000 x 1000
No. of Mobile Nodes	25
Source Type	UDP
Simulation Time	10 seconds
Routing Protocol	PLBU and AODV
Speed of Nodes	30, 40, 60 m/s

The performance of the PLBU Routing protocol using D-MAC protocol is compared with AODV Routing protocol using 802.11 MAC protocol based on Network Throughput, Packet Delay and Packet Loss for the same scenario. Figure 8 shows the Network Throughput comparison. We can clearly see that the Throughput is better when using PLBU Routing.

Figure 9 shows the Packet Delay comparison. Apart from some initial delay and a spike in between, the PLBU Routing still holds good and is far better than the AODV Routing in case of packet delay.

Figure 10 shows the Packet Loss comparison. We can clearly see that PLBU Routing performs far better than the AODV Routing which incur more Packet Loss. Due to reduction in packet loss to a large extent, the Throughput and thus the Bandwidth Efficiency of the Network is improved.
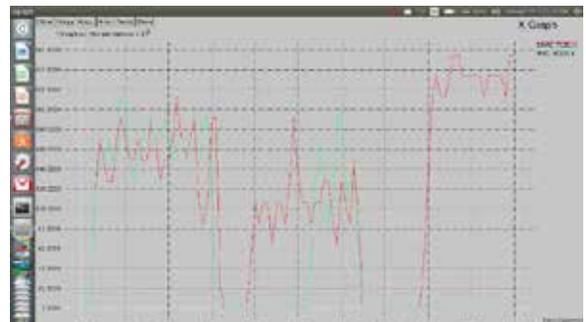

Figure 8. Network Throughput Comparison of PLBU and AODV Routing

Figure 9. Packet Delay Comparison of PLBU and AODV Routing

Figure 10. Packet Loss Comparison of PLBU and AODV Routing

CONCLUSION AND FUTURE SCOPE

In this paper, we have designed and implemented PLBU Routing protocol using Directional-MAC protocol for Ad Hoc Communication Networks and Emergency Scenarios. We simulated the Designed Protocol in NS2 and compared its Performance with AODV Routing using 802.11 MAC on basis of Performance parameters like Throughput, Packet Delay and Packet Loss. The Simulation Results show that the designed PLBU Routing protocol outperforms the AODV protocol in Ad Hoc Communication Scenarios with Mobile Nodes.

This work can be further extended by increasing the number of mobile nodes, by considering the random motion of the nodes, by inducing more data traffic, and also by using different routing protocols. Also TCP layer protocols can be implemented and modified for higher security, which is the keen requirement of Military and Intelligence Operations.

REFERENCES

[1] Gong M.X. , Midkiff S.F. and Shiwen Mao, "A Combined Proactive routing and multi- channel MAC International Conference on Broadband Networks, page 444-453, Vol. 1, 2005. | [2] Hyungkeun Lee, Jang-Yeon Lee and Jin-Woong Cho, "An Adaptive MAC Protocol based on Path-Diversity routing in Ad hoc networks", IEEE 9th International Conference on Advanced Communication Technology, page 640-644, 2007. | [3] Guama J.A. and Saad N.M. , "Improving the Performance of medium Access control protocols with Smart Antennas for Mobile Ad hoc Network", IEEE IFIP International Conference on Wireless and Optical Communication Networks, page 1-5, 2007. | [4] Jinhua Zhu, Xin Wang and Dahai Xu, "A Unified MAC and Routing Framework for Multichannel Multi-interface Ad Hoc Networks", IEEE Transactions on Vehicular Technology, Vol. 59, Issue 9, page 4589-4601, 2010. | [5] Wu Zemin and QiuZhenglun, "A Survey on Directional Antenna Networking", IEEE 7th International Conference on Wireless communications, networking and mobile computing, WiCOM, page 1-4, 2011. | [6] Sugiyama Y. , Tamaki K. , Saruwatari S. and Watanabe T. , "A wireless full-duplex and multi-hop network with collision avoidance using directional antennas" IEEE 7th International Conference on Mobile Computing and Ubiquitous Networking (ICMU), page 38-43, 2014. | | [7] Bilgin Y.A. and Yilmaz A.O. , "Neighbor discovery in network with directionalantennas", IEEE 21st Signal Processing and Communications Applications Conference (SIU), page 1-4, 2013. | | [8] Marius S. Vassiliou, Jonathan R. Agre and Syed Shah, "Crucial Differences between Commercial and Military Communications Technology Needs", 2013 IEEE Military Communications Conference, 2013. | | [9] Nasipuri, S. Ye, J. You and R. E. Hiromoto, "A MAC Protocol for Mobile Ad Hoc Networks Using Directional Antennas", Proceedings of IEEE WCNC 2000, volume 1, page(s): 1214-1219, September 2000. | [10] Z. Huang, C. C. Shen, C. Srisathapornphat and C. Jaikaeo, "A Busy Tone-Based Directional MAC Protocol for Ad Hoc Networks", Proceedings of IEEE MILCOM, October 2002. | [11] Y. B. Ko, V. Shankarkumar and N. H. Vaidya, "Medium Access Control Protocols using Directional Antennas in Ad Hoc Networks", Proceedings of IEEE INFOCOM 2000, volume 1, page(s): 13-21, March 2000. | [12] E. S. Jung and N. H. Vaidya, "A Power Control MAC Protocol for Ad Hoc Networks", Proceedings of ACM MOBICOM 2002, page(s): 36-47, September 2002. | [13] J. Gomez, A. T. Campbell, M. Naghshineh and C. Bisdikian, "Conserving Transmission Power in Wireless Ad Hoc Networks", Proceedings of ICNP 2001, page (s): 11-14, November 2001. | [14] G. Holland, N. Vaidya and P. Bahl, "A Rate-Adaptive MAC Protocol for Multi-Hop Wireless Networks", Proceedings of ACM MOBICOM 2001, page(s): 236-251, July 2001.