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Adhoc Protocol to Enhance Wireless Network Performance

Bilal Muhammad Khan[1*] and Rabia Bilal[2]

[1]Pakistan Navy Engineering College, Faculty of Electronics and Power Engineering, National University of Sciences and Technology (NUST), Islamabad, Pakistan.
[2]Department of Electrical Engineering, Usman Institute of Technology, Karachi, Pakistan.

[1]ORCID: 0000-0002-0382-4502, [2]ORCID: 0000-0002-1576-9520

Abstract

Adhoc protocols present challenges like reliability, routing overheads, channel capacity utilization and latency in the network. Interferences and dynamic changes in network causes frequent paths disconnectivity due to which the network throughput decreases. In this paper, an improved protocol with adaptive cross layer (Adap-CP) is proposed which reduces the routing process and utilize the channel capacity in a better way. This new approach enhances the network performance significantly as compare to conventional 802.15.4 and AODV in terms of throughput, route discovery rate, PDR and energy efficiency. In rest of the paper, we will refer enhanced adaptive cross layer protocol as Adap-CP and conventional cross layer of 802.15.4 and AODV as Conv-P.

Keywords: adaptive MAC, aggregation, dynamic data rate, reduced routing.

INTRODUCTION

It is challenging to provide high reliability and high quality of services to the adhoc networks with less complexity. Due to dynamic changes interferences on radio channel and path loss increases, which bounds the gains of the network. The throughput of these network can be enhanced by using several cooperative and adaptive techniques at cross layers. It was found that data loss due to collision can improve by aggregation [1, 2]. In our scheme we are implementing the data aggregation which improves, the throughput by avoiding collision and network congestion. On the other hand, aggregation can increase network complexity this can be reduce by using simple aggregation technique.

Node's mobility and channel fading also degrades the network performance. To maintain and discover routes in such network is difficult and requires frequent local neighbouring updates. This increases the routing process over the network, which in result affects the network efficiency. To reduce the overheads of route discovery, several techniques are introduce in AODV routing. By controlling the flooding of RREQ messages in AODV, the routing can improve as presented in [3]. In proposed protocol, data aggregation can also reduce the number of route to discover for transmission and improves the latency by reducing routing delays in the network. However, for high data rates congestion at MAC can increase the latency and reduces the network throughput.

For various data rates, MAC should be adaptable to provide high gains. This adaptability can be introduces at cross layer according to network behaviour to increase the network QoS [4].

We have made the MAC adaptive so it can configure its parameter according to network requirements to produce better network services. As the number of nodes increase in the network, the probability of data loss due to collision also increases. Therefore, maintaining network performance for large scale is challenging.

The rest of the paper is organized a follows, related work in section 2, adaptive cross layer protocol (Adap-CP) in section 3, section 4 describes simulation and result analysis, conclusion is presented in section 5.

RELATED WORK

Adhoc network poses several challenges due to their dynamic nature. Various routing protocols are introduced to maintain link connectivity in the network. Comparison of some reactive and proactive routing protocol for adhoc network is presented in [5]. They considered throughput, end-to-end delay and packet delivery ratio as network performance metrics and conclude that reactive protocol can perform better in dynamic environment. Another comparison of different routing protocol for mobile network is presented in [6] using different network topologies. It was found that protocols using clustering can achieve much better results in mobile scenario.

Performance of the network can also suffer with increased number of sources due to collision. This will introduce delay and enforces the network throughput to reduce. Delay due to routing can be reduces by controlling the transmission of RREQ packets as presented in [6]. It makes use of node's position and customizes the AODV routing by limiting RREQ to specific zone [7]. Another approach uses the residual energy of node [8], while route discovering is discussed in [9]. They increases the life time of the network and reduces the excessive burden on node. Probabilistic approach to find the route is proposed in [10]. They use the probability of success to destination from source and chose the neighbouring node with high success rate for link management.

To avoid data collision, these data packets can combine before transmitting towards the destination. Various data aggregation techniques are available one can avail to improve throughput, reliability and energy consumption. A collaborative processing procedure proposed, where data from several nodes is collected by a mobile agent [11]. The introduced mobile agent works according to specific instruction of collecting data from several nodes and chose optimal shortest path for communication. Using this technique, utilization of link capacity is increased with little complexity. Protocol using fusion scheme was introduced which combine two design of data aggregation together [2]. This method make use of tree-based aggregation along with multipath aggregation and increase reliability by sending redundant data. Power saved by aggregating data is used to enhance reliability of network by increasing retransmission limit in [1].

High data rate in network introduces collision and contention delays at MAC. This can lower the network throughput however controlling MAC overheads and delays in an efficient manner can improve the network QoS [12]. Cross layer protocol is also design to improve performance of a network. Comparison of reactive routing protocol with different MAC is presented in [4]. Congestion control, path loss and delays are optimized using different schemes on three layers of protocol to make it perform efficient. Performance of different routing algorithm can be improved using different mechanism.

ADAPTIVE CROSS LAYER PROTOCOL (ADAP-CP)

In this paper, to increase the network throughput and its efficiency, an efficient cross layer adaptive protocol is proposed and implemented. The most common reactive routing protocol AODV is used which provides effective results for dynamic network with less overheads as compare to proactive routing protocol. AODV can work well in mobile network by exchanging control packets for links update. With increased number of source nodes, network routing also increases. More control packets will be needed to determine several routes, which will increase the routing computation and its delay. We are reducing the need of discovering more paths by aggregating data packets of several nodes. Single node is now responsible to send data towards destination hence reduces the route discovery process. Transmission over fewer paths reduces the routing burden over nodes and improves the network services.

Moreover, aggregation also overcome the loading capacity by merging the data packets of neighbouring nodes and improves the throughput by avoiding collision and contention at network. This can provide the network to better utilize its frequency bandwidth by transmitting more data packets. Collision at receiver end also reduces by delivering single compact data packet of several nodes instead of transmitting from different nodes

To further enhance the performance, an adaptive MAC is introduce which is an extension to conventional 802.15.4. This MAC can provide reliability and energy efficiency along with low latency. For high data rate, MAC delays should reduce with increased retransmission limit to deliver maximum packet without collision. Whereas, an optimize value of MAC are selected for low data rate to improve reliability and latency. This adaptive MAC configure its parameters according to network changes, hence provides optimize results for various network states.

This protocol can also resolve the problem of scalability in adhoc network and can provide better result as compare to conventional protocols. Since the network parameters in this protocol are adaptive, they can configure them according to network size and data rate and maintain network performance in scalable and mobile network. The Adap-CP can produce improve results of throughput, PDR, routing computations and energy efficiency for different network as compare to conventional adhoc protocols.

RESULTS AND DISCUSSION

Simulation has been done using MALTAB-Simulink R2012a with true-time beta 2.0 library. The network contain 7 wireless mobile nodes with 2 sources and 1 single sink. Results are obtained for both Conv-P and Adap-CP for static network with varying data rate. Mac backoff exponential and retrial limits for Conv-P are taken as 5 and 4 respectively, whereas it's ranging from 3-5 and 3-8 for Adap-CP. To analyse the protocol performance, in worst case, sources are placed in same radio range and similarly sink nodes present within radio range of each other. Network performance metric such as throughput, PDR, route discovery attempts and energy has been analysed for different network rate.

Throughput

Throughput is measured as number of successful received bits at receiver end in a second. It is initially increased by aggregating data, further efficiency is gained by using adaptive MAC parameters. Throughput of the network can express mathematically by Eqn. (1)

$$Throughput = \frac{8 * No.of\ packets\ received}{T_{mac} + T_{rout} + T_{agg}} \quad (1)$$

T_{mac}= No. of retrials * backoff delay (2)

T_{agg}=$(T_{enc} + T_{dec}) * data\ rate$ (3)

where $T_{mac,}$ T_{rout}, T_{agg}, T_{enc}, T_{dec} are the MAC backoff delay, time required for route discovery, time required for data aggregation, time for encoding data bits, time for decoding data bits respectively.

Figure-1 shows the throughput of Covn-P and Adap-CP for static network with different data rates. The throughput for Conv-P is lower than Adap-CP for each data rate. This is because the contention and collision in network caused by presence of two or more source node in same radio range. Adap-CPenhance the throughput of the network by sending an aggregated data packets of such nodes. This avoids the data loss due to collision and transmit more packets by reducing routing delay. With the increase in data rate, the throughput of the network increases more due to transmission of more data packets. Since probability of collision increases in Covn-P which is controlled in Adap-CP through adaptive MAC, therefore high gain is observed for Adap-CP. Adap-CP provides throughput of network of about 10% improved as compared to Conv-P.

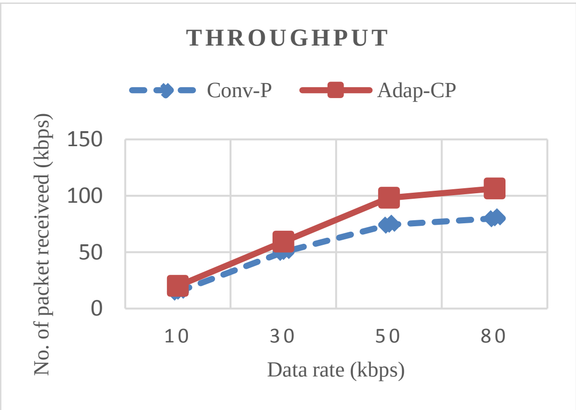

Figure 1. Throughput of Conv-P and Adap-CP for static network.

PDR

Packet Delivery Ratio (PDR) is used to determine efficiency of the network. It is the ratio of number of packet received with respect to the packet transmitted. PDR of the network is improved using proposed AC-Protocol which gives better results maintain high delivery ratio. It can be express using Eqn. (4)

$$PDR = \frac{No. of\ packets\ received}{Total\ no. of\ packet\ transmitted} \quad (4)$$

PDR of Conv-P and Adap-CP are shown in Figure-2. PDR of the network is maintain for Adap-CP and providing better results as compare to Conv-P. PDR of Conv-P has slight improved at data rate of 30kbps due to increased data rate. But as the data rate increases, the collision of data packets also increases hence PDR for Conv-P is dropping with increasing data rate at each step. Also, the contention at MAC causes the packet loss which in result reduces the network PDR. For Adap-CP, PDR of the network is higher than Conv-P along various data rate because Adap-CP utilizes the channel capacity in a better way by aggregating data packets and also reduces the need of route discovery. Results shows Adap-CP provides 20% improved network PDR as compared to Conv-P.

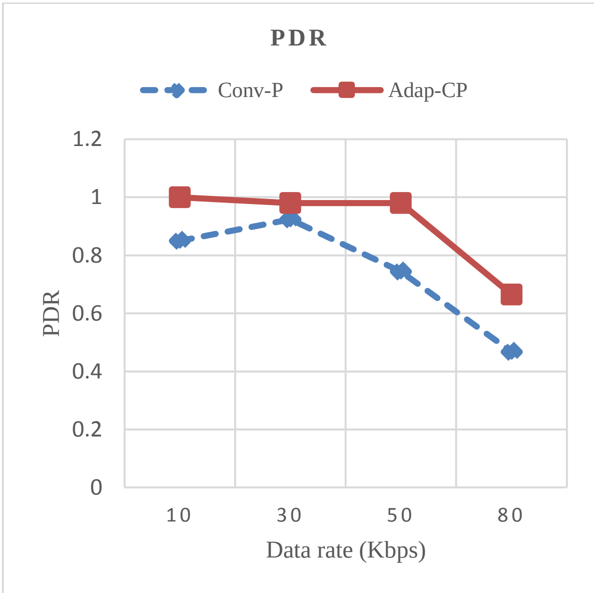

Figure 2. PDR of Conv-P and Adap-CP for static network.

Route discovery attempt

Routing is use to discover route from a node to its destination. More the source nodes are available in the network the more route discovery will be demanded by the network. Mobility and channel fading also causes the path loss. Attempt made by any node for route discovery can be given by Eqn. (5)

$$Route\ discovery\ attempt = N * mob * noise \quad (5)$$

where N and mob are number of nodes and mobility respectively.

Figure-3 shows the attempts made by each of the protocol to discover routes. Demand for route discovery is reduced significantly in Adap-CP since nodes are transmitting an aggregated data packets. This will require to discover fewer paths for packet transmission, since number of sending nodes are reduced. Adap-CP conserve power, improve latency and provides high gain through this technique. Whereas, in conventional protocol attempts of route discovery is much higher because nodes are sending their packets separately. Several nodes perform routing process to discover its path to destination. This increases the contention and delay in the network which in result affect the network latency. Around 60% of reduced demand of route discovery is achieved by Adap-CP in comparison with Conv-P.

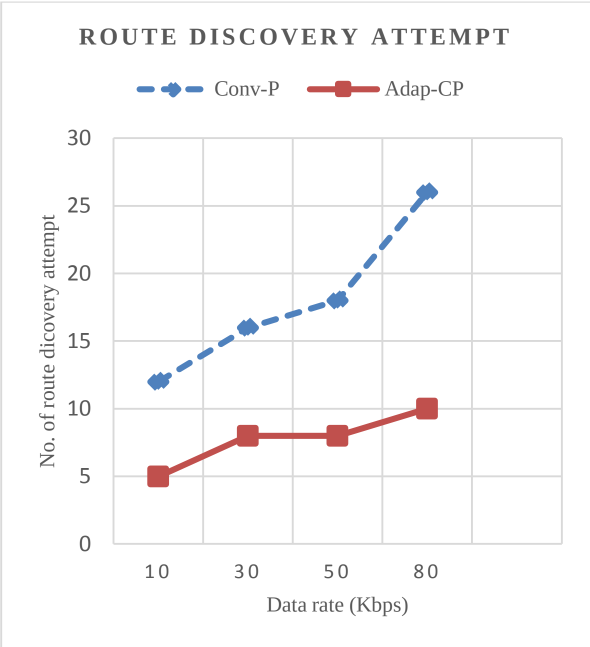

Figure 3. Route discover attempt of Conv-P and Adap-CP for static network.

Energy

Excess number of retransmission, route discovery process and high rate are characteristic factor for increasing energy consumption. This depletion of energy is reduced by controlling network parameters at cross layers. Equation for energy consumption in the network can be stated mathematically as Eqn. (6)

$$Energy = E_{Tx} + E_{mac} + E_{agg} + E_r out \qquad (6)$$

where $E_{Tx}, E_{mac,} E_{agg}, E_{rout}$ are signal transmission power, energy consumption at MAC layer, power consumption for data aggregation, energy depletion due to mobility, energy consume during routing process respectively.

In Figure-4, power consumption for both Conv-P and Adap-CP is shown and Adap-CP has also proved to be energy efficient. The low power consumption of Adap-CP is due to adaptive MAC and reduced routing process by sending aggregated data. Most of the node's energy in Conv-P is lost in packet collision and route determining. Moreover, excessive delay for high data rate for conventional protocol also consume more energy which is optimize in Adap-CP. Adap-CP is designed in such a way that it gives maximum throughput with reduce power depletion. Power consumption in Adap-CP is reduced by around 35% as compare to Conv-P for network with variable data rate.

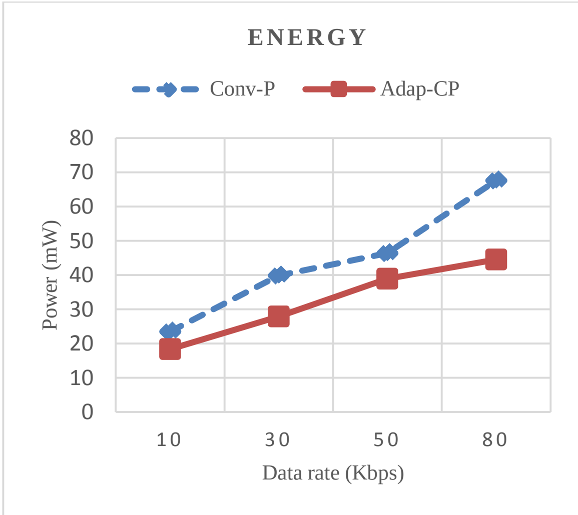

Figure 4. Energy consumption of Conv-P and Adap-CP for static network.

Results of Adap-CP and Conv-P show that QoS of network can be enhanced greatly by introducing aggregation and adaptive MAC to the protocol. It can perform efficiently for various data rate and provide improved result over several performance metrics of the network.

CONCLUSION

Most of the routing protocol does not work well with dynamic network changes. Conventional protocols introduce high complexity and computations to maintain reliability and increase throughput of the network. This paper proposed an enhanced cross layer adhoc protocol to improve network performance. Combination of aggregation and adaptive nature is used at cross layer to enhance network services. The Adap-CP provides throughput gain of up to 55%, PDR improvement up to 63% with reducing route discovery attempts up to 60% and power reduction of about 35% in comparison with Conv-P. The enhanced performance of protocol has been analysed for static network under differ network load capacity. This protocol can be implemented to mobile and scalable network due to its adaptive nature. It will provide better results under different network states. From result, we conclude that the proposed Adap-CP can provide high network throughput for variable data rate and also improves the other metrics like delay, route discovery, PDR and energy consumption. It is a comprehensive protocol that can provide multi folds network gain in several directions with less complexity and reduce computations.

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