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Study and Analysis of Power Aware Transport Protocol for Ad Hoc Networks

Sapam Rebika Devi, Neha Bagoria

Abstract— Transport layer is the foundation of the internet and it provides end-to-end control. The transmission control protocol (TCP) was de signed to provide reliable end to end delivery of data over unreliable networks. TCP is not suitable in case of ad hoc network. Therefore different transport layer protocols have been developed. These different transport protocols have been classified as TCP over ad hoc networks and exclusively for ad hoc networks. Among these transport protocol ATP found to be more suitable for ad hoc network. But in case of ATP the performance and load of the intermediate node is not considered so there is one problem. To provide power aware and reliable transport protocol as well as to address the intermediate node problem over ATP, PATPAN is designed. In this paper, first study the problem of intermediate node in ATP in association with power consumption. Then modification is done to ATP to overcome this intermediate node problem. Finally comparison is made between ATP and PATPAN in terms of power consumption with the help of NS2 simulator.

Index Terms — Transport layer, TCP, TCP-BuS, ACTP, ATP, PATPAN, NS2.

1 INTRODUCTION

An ad hoc network is one of the wireless networks. In this type of network all nodes are mobile and it does not need any communication support facilities such as base station and router. In ad hoc networks all nodes takes the responsibility to discover its corresponding nodes and also takes the maintenance of route to other node. Ad hoc networks become very useful in emergency situations. Therefore ad hoc networks become very popular. Because of many issues in ad hoc networks TCP cannot be work properly. This is pointed out in [1]. At the transport layer, several researches worked and developed many protocols such as Split-TCP, TCP-F, TCP-ELFN, ATCP, TCP-BuS, ACTP, ATP etc.[2][3][4][5][6][7][8]. Among these ATP found to be more appropriate. As in general condition intermediate nodes operate only in the three layers but in this ATP intermediate nodes are operate in four layers. Therefore there is more power consumption in ATP as it operates in four layers. In ad hoc network energy conservation is one of the important characteristic. As intermediate node in ATP operates in four layers, it takes unnecessary flow which may consume more power. Therefore for providing power aware and reliable transport protocol over ATP, modification is done in ATP to act as power aware transport protocol.

- *Sapam Rebika Devi is currently pursuing masters degree in computer science and engineering in Rajasthan Technical University, India, PH-08794835291. E-mail: rebikas01@gmail.com*
- *Neha Bagoria is an asst. professor in computer science and engineering in Rajasthan Technical University, India, PH-08290985518. E-mail: neha.bagoria@rediffmail.com.*

2 AD HOC TRANSPORT PROTOCOL

Ad hoc transport protocol is a transport layer protocol specially designed toward the characteristics of ad hoc networks. The design element of ATP is totally different form the TCP. TCP uses window based transmission, slow start, low based congestion detection, multiplicative decrease, retransmission timeouts and reliance on reverse path. But ATP uses layer coordination, quick start, rate based transmission, decoupling of congestion control and reliability, assisted congestion control, congestion detection and congestion control, no retransmission timeouts and coarse gained receiver feedback. There is also some similarity between the two. Both TCP and ATP uses information from lower layers to estimate the initial transmission rate, congestion detection, congestion avoidance and congestion control, and detection of path breaks. But in ATP network congestion informations are got from intermediate nodes, while the flow control and reliability information are obtained from the ATP receiver.

The ATP uses a rate based transmission instead of window based to avoid the disadvantage due to burstiness and to eliminate the need for self clocking through the arrival of ACKs. This rate of rate based transmission in ATP is depend on the congestion occurred in networks. When packet travelling starts, then intermediate nodes attach the information of congestion to each ATP packet. This congestion information is defined in terms of average of queuing delay (Q_t) and transmission delay (T_t) that are experienced by the packets at intermediate node. At the intermediate node, Q_t is impacted by the contention at that node between different flows traversing the node whereas T_t is impacted by the contention between the different nodes in the vicinity of that node.

To assist in reliability and flow control, the ATP receiver provides periodic feedback to the sender. The receiver runs an epoch timer to send the feedback periodically. In the next ACK packet, the ATP receiver assembles and designs the information of rate feedback and sends it back to the sender. The sender adjusts its transmission rate based on this information of rate feedback.

During the connection establishment, the ATP sender determines the initial transmission rate by sending a probe packet to the receiver. Each intermediate node attaches the information of congestion to the probe packet and the ATP receiver replies an ACK packet including the relevant congestion information to the sender. ATP uses connection request and ACK packet as probe packets.

If the new transmission rate (R) received from the network is greater than a current rate (S) and beyond the threshold (x) then ATP increases the transmission rate, i.e., if R>S (1+x) then the transmission rate will increased. This transmission rate is increased only by a fraction (K) of the difference between two rates, i.e., S=S + (RS)/K. If ACK packets for two consecutive feedback periods have not received by the ATP sender, then the transmission rate will decrease. After a third period, connection will assume to be a lost and then the ATP sender moves to the connection initiation phase. Then the network layer sends an explicit link failure notification packet to the ATP sender when the path break occurs, and then the sender moves to the connection initiation phase.

3 Motivation

According to TCP/IP internet model, Transport layer protocol and application program work only in source and destination node not in the intermediate node. But in ATP, each and every intermediate node from source to destination path receives the TCP segment, processes it and appends Rate estimate (D). In ATP, TCP protocol is operated in the intermediate node. In order to increase the performance of source TCP, the intermediate nodes are made to operate in four layers (physical layer, data link layer, network layer and transport layer). But in normal case the intermediate node operates only in three layers (physical layer, data link layer, network layer). This makes the Ad hoc transport protocol to behave as node to node rather than end to end. In ad hoc network, the nodes must act as both end system and router. Due to this, the workload of intermediate node will be high. Again in ATP the intermediate node operates at four layers instead of three. Therefore, it can be proved that the workload on the intermediate node in ATP will be increased further which increases the power consumption. The intermediate node in ATP operates in four layers.

Here the design of ATP is analyzed in association with the performance of intermediate node in ad hoc networks. It is categorized in to the following components:

1. End to end versus node to node transport protocols
2. Intermediate node problem

3.1 End to end versus node to node transport protocols

By considering the procedure followed by the TCP/IP internet model, TCP is end to end transport layer protocol. It means that TCP allow passing of packets through the transport layer from the source nod to the nodes only. But both in network and data link layer allow packet passing from node to node. It means packet operates in source, all the intermediate nodes, and destination. Therefore, in end to end protocols, there are problems in the interior nodes which cannot be handled until they propagate to the source and destination nodes. Node to node transport protocols have been designed to overcome this limitation of end to end transport protocol. In node to node protocols, TCP packet is passes to the transport layer at every intermediate node in source to destination path. Therefore, rate adjustments can be made anywhere by allowing interme

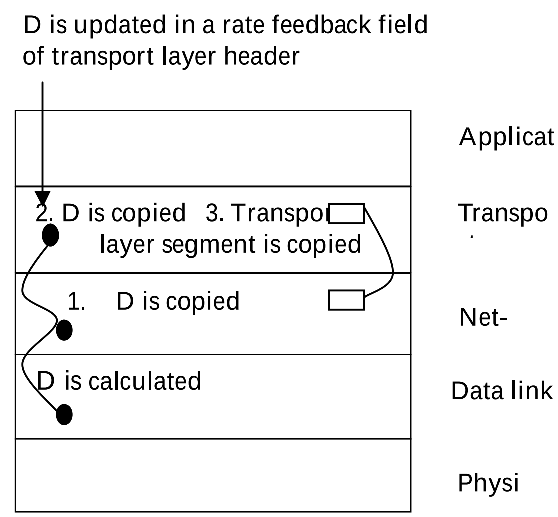


Figure 1: Intermediate node in ATP

diate nodes to respond to adverse network conditions where they occurred. But in case of the reliable transport protocol for ad hoc networks, ATP transport protocol is semi node to node transport protocol. It is because the transport layer of intermediate node in ATP processes only to append the delay (D) and not to control the transmission rate. On the other hand, the rate estimation and rate adaptation is done only by the end system i.e., the transport layer of source and destination. Therefore, it is required to design a derivative of ATP which does not operate in the transport layer of intermediate node.

3.2 Intermediate node problem

By design of ATP, the two parameters average queuing delay and transmission delay are calculated for all the packets passing through the node. Queuing delay is an exponential average of the queuing delay experienced by packets traversing the node while transmission delay is also an exponential average of the transmission delay experienced by the head-of -line packet at the node. In ATP intermediate node maintains the sum of average queuing delay and transmission delay. Therefore queuing delay and transmission delay are maintained on a per-node basis not on a per-flow basis. These two values are updated by the intermediate node for every outgoing packet. Every packet consists of rate feedback field. The rate feedback contains the maximum value of queuing delay and transmission delay. When the packet begins for transmission, the transport layer of intermediate node will check the value of rate feedback. If the rate feedback value is lesser than the new upcoming (Q_t+ $T_{t)}$ value at that node, then the intermediate node updates the rate feedback on the packet to its new (Q_t +$T_{t)}$ value. After receives the packet by the receiver, the rate feedback field in the packet determines the maximum delay at any of the intermediate node that traversing he path. Here, rate feedback D is calculated at the data link layer and updated at the header of the transport layer. Therefore the delay D has to be copied from the data link layer to the network layer and again from the network layer to the transport layer which is shown in the figure 1. It means that it takes two copies as shown in figure 1 as 1and 2. From the above we know that in ATP intermediate node run transport layer only to add or update the value of D. Due to this reason, the whole transport layer segment along with the header and data must be copied from network layer to transport layer as shown in figure 1 as 3. This unnecessary copying of data in the intermediate node in ATP is called intermediate node problem.

4 THE DESCRIPTION OF PATPAN

ATP is a transport layer protocol that is designed towards the characteristics of ad hoc networks. In ATP each and every intermediate receives the TCP segment, examine it and added the rate estimate (D). In ATP transport layer is also run in the intermediate node. So in order to increase the performance of source TCP the intermediate node are operated in four layers. Here in ATP transport layer of intermediate node takes place the packet only to add the delay. Transport layer of intermediate node does not take part for controlling the transmission rate. Due to the increase of workload on the intermediate node there will be increase in the power consumption.

In order to reduce the power consumption in the transport layer protocol of ad hoc network protocols, another protocol called PATPAN is designed. PATPAN is the derivative of ATP. The design element of ATP and PATPAN are same. It means PATPAN consists of layer coordination, rate based transmission, decoupling of congestion control and reliability, assisted congestion control and TCP friendliness and fairness. The difference between the two protocol is that intermediate node of ATP is run in four layers whereas the intermediate node of PATPAN run in three layers.

In PATPAN, the intermediate node added the delay in the IP datagram header instead of TCP segment in ATP which is shown in figure 2. It means that instead of sending the delay in TCP segment, it transmits the delay in IP datagram itself. Therefore for every intermediate node some fields like time to live, fragment offset will be updated. From source to destination all other field do not change. Therefore, Rate estimate delay is added in IP datagram header. Including with the TCP segment the Rate estimate delay will be put to the transport layer by the network layer at the receiver side. By using the delay the receiver will calculate the rate feedback and sends it back to the sender. The modified IP datagram for PATPAN consist the rate estimate field in between destination IP adress and option field. Here minor changes must be done in the IP protocol format so that rate estimate D can be added in the IP datagram header format. So the IP datagram format for PATPAN is different from the traditional IP datagram format. This means that the IP datagram for PATPAN will not be compatible with traditional IP. This is one of the incompatibili ty problems that have occurred in same as the ATP. In transport

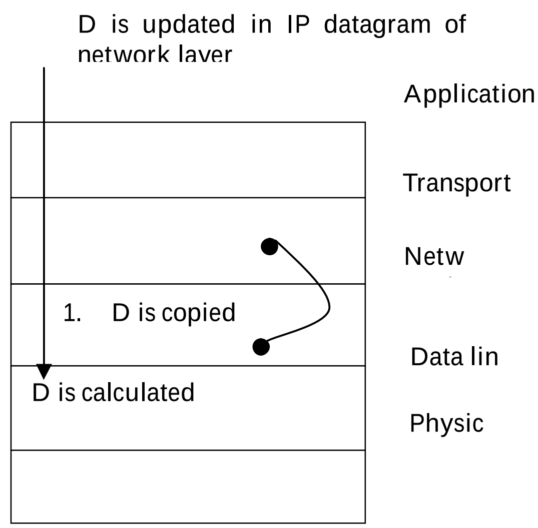


Figure 2: Intermediate node of PATPAN

layer there is already an incompatibility problem therefore incompatibility in network layer does not cause an additional harm in the network.

4.1 IP Datagram Format of PATPAN

There are intermediate node problem in ATP. Due to intermediate node problem in ATP the performance of the system is reduced and load of intermediate node is increased. Therefore to address the intermediate problem occurred in ATP, the delay (D) is appended in the IP datagram. So the IP datagram format is needed to be modified from the IP format of TCP/IP model so that the delay (D) can be included in the IP datagram header. The modified IP datagram format for PATPAN contains the rate estimate field in between the IP address of ultimate destination and IP option field.

4.2 Header Format of PATPAN

In ATP there are different packet header for data packet and feedback packet but in case of PATPAN, changes are required not only in the IP datagram but also required in the transport layer for ATP data and feedback packets. Therefore in PATPAN, instead of having different packet header for data packet and feedback packet a single packet header is used for both in PATPAN unlike in ATP.

4.3 Advantages of PATPAN

Some advantages of PATPAN are given below:

1. Intermediate node consumes less power.

2. Since PATPAN operates only in three layers i.e. physical, data-link, network layer while ATP operates in four layers i.e. physical, data-link, network, and transport layer. The number of data copying will be less. Then the performance of PATPAN will be increased.

3. In ATP data packet header rate estimate is calculated in MAC layer and appended by the transport layer. Therefore D is copied from data link to network layer and then from network to transport layer. Hence, copying of data decreases the performance of the system. While in PATAPN, the delay D is appended in IP datagram so it is enough when D is copied from data-link to network layer. Then the performance of the system will be increased.

4. Data packet header and feedback packet are the two types of packet in ATP. Whereas in PATPAN, the data packet field and feedback packet field are combined and given in a single packet which reduces the overhead involved in the implementation of protocol.

5 Performance Analysis

The comparison of the performances of two transport protocols namely ATP (Ad hoc transport protocol) and PATPAN (Power aware transport protocol) in the context of power consumption are shown below.

The simulations are conducted in two different situations:

1. In the first situation, the two transport protocols are compared by keeping varied simulation time and
2. In the second situation, the two transport protocols are compared by keeping varied number of nodes.

5.1 Performance analysis by keeping varied simulation time

In this performance analysis, the two protocols ATP and PATPAN are compared by varying the simulation time as 10, 20 and 30 sec. The table 1 shows the comparison of ATP and PATPAN in terms power consumption by varying the simulation time and its relevant XGraphs is shown in figure 3. From the above table, the number of power consumed in ATP is greater than the number of power consumed in PATPAN. Therefore, power consumption is of ATP is greater than from PATPAN.

5.2 Performance analysis by keeping varied number of nodes

In this performance analysis, the two protocols ATP and PATPAN are compared by varying the number of nodes as 40, 60 and 80. The table 2 shows the comparison of ATP and PATPAN in power consumption by varying the number of nodes and its relevant XGraph is shown in figure 4. From the table, the number of power consumed in ATP is greater than the number of power consumed in PATPAN. Therefore, power consumption is greater than from PATPAN as in above.

TABLE 1
COMPARISION OF ATP AND PATPAN IN TERMS OF POWER CONSUMPTION

Simulation Time	Power Consumed (ATP)	Power Consumed (PATPAN)
10	9.84	7.62
20	18.41	14.74
30	20.50	18.41

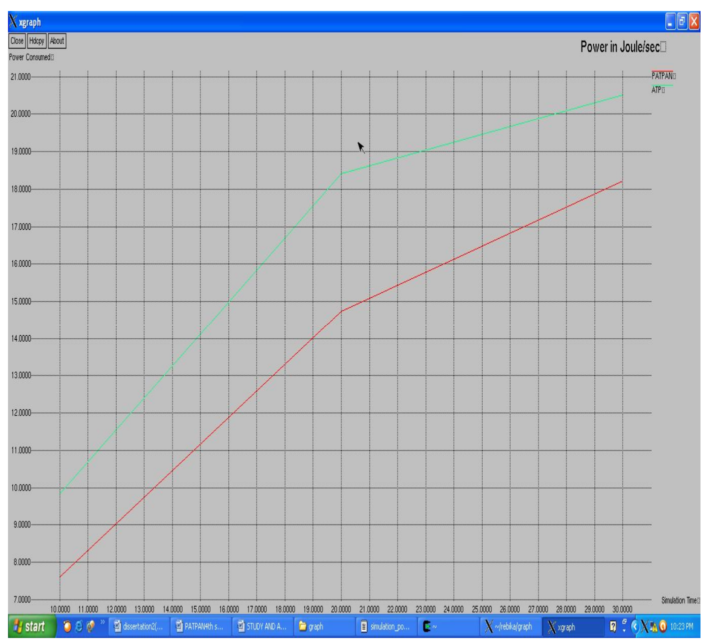


Figure 3: Power consumption Vs Simulation time

Figure 4: Power consumption Vs Number of nodes

TABLE 2
COMPARISION OF ATP AND PATPAN IN TERMS OF POWER CONSUMPTION

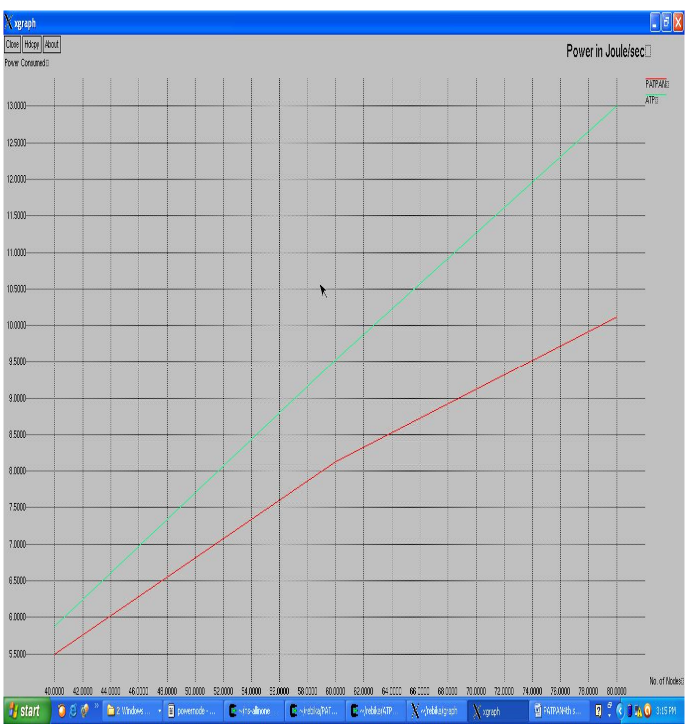
No. of nodes	Power Consumed (ATP)	Power Consumed (PATPAN)
40	5.87	5.50
60	9.53	8.13
80	13.00	10.12

From the above two performances, the power consumption is more in ATP than PATPAN. As nodes are mobile in ad hoc networks, power maintenance is one of the importance conditions. In ATP, the intermediate node suffers a lot in regards to the power consumptions. PATPAN address the problem of ATP and shows considerable reduction in the power consumption of intermediate node over ATP.

6 CONCLUSION

By using network simulator ns-allinone-2.32, the performance of ATP and PATPAN are compared in terms of power consumption with the help of Window XP.
The two protocols are compared in two different situations:

1. By varying the number of nodes and
2. By varying the simulation time.



From the above comparisons, PATPAN found to be consumed less power over ATP. In ATP, the intermediate node suffers a lot in association with power consumption. This problem is addressed by the PATPAN and shows the considerable reduction in the power consumption of intermediate node over ATP.

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