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Effect of Client Mobility and Request to Send/Clear Protocol on TCP Performance In Wireless Network

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Abstract

Due to node mobility in wireless Local Area Networks (LAN), there are often irregular disconnections as a result of a node inability to relay information to the next node, hence the transmission control protocol (TCP) interprets this as network congestion because it does not have the capability to discern between channel congestion and node disconnection, and by default, it decreases the congestion window size; after successful reconnection, the TCP take unnecessary longer time to return back to the normal congestion window size which results in network inefficiency. Thus node mobility is a major problem to TCP operation and some of its effects are closely examined in this paper. The wireless deployment wizard in Opnet Modeler software was used to simulate the effect of mobility on the Transmission Control Protocol (TCP), the Request to Send/Clear to send (RTS/CTS) was used to control the negative effects of hidden nodes. Some test nodes were configured with mobility while the other will be left to function as stationary nodes. Again these nodes performances were thus evaluated against their ability to reduce the hidden node problem by turning on the RTS/CTS function at one time and off at the other time. Results show that there is significant network degradation during node mobility and that the use of RTS/CTS can effectively reduce hidden node problems.

Keywords: Node mobility, Transmission Control Protocol, RTS/CTS, wireless network, send/clear protocol

1.0 Introduction

The major challenges that faces wireless network is the problem of mobility of node within the network and these often cause rapid changes in configured topology alongside latency problem in throughput and the challenges to discover new path to mobile nodes such that communication can be uninterrupted and progressive. Kwon and Kwon[1] stated that efficiency of wireless network is controlled by the medium access control (MAC) and Physical Layer, whose main function is to ensure communication medium sharing due to bandwidth limitation. They enhance channel availability using the carrier sense multiple access /collision avoidance (CSMA/CA) mechanism to avoid collision. Analysis of the effect of mobility in wireless network entails a comprehensive study of the 802.11 standards, the MAC and Physical layer mechanism [2]. The MAC and the Physical layer protocol ensures that the channel is free and dedicated to a particular node during data transmission; this is made possible by the use of the distributed coordinated function (DCF) that is available in every node by default and an optional point coordinated function (PCF). As mentioned above, these mechanisms have the request to send (RTS) and the clear to send (CTS) option to minimize collision in wireless transmission. Again throughput in wireless network can be achieved with the use of fragmentation mechanism; this can increase the reliability of frame transmission. With threshold properly set, fragmentation can be used to reduce retransmission of data owing to the fact that longer data frame could easily be corrupted when the channel experiences slight disturbances [3]. Therefore in this paper, the effect of mobility on Transmission Control Protocol (TCP) and the use of RTC/CTS protocol to address the issue of hidden node which is also a characteristic of client mobility are examined. Mobility causes frequent route discovery algorithm to be invoked by the client to discover new route to where packets are sent to, however this frequent route discovery could lead to network inefficiency [4].

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1.2 Hidden Node Problem

Hidden node problem in wireless network is the phenomenon by which a node is visible from a wireless hub, but cannot be detected by other nodes communicating with the same hub. These are known to be nodes that are out of range from other nodes or set of nodes. The 802.11b/g/a standards make use of the media access control (MAC) protocols to control interference in wireless network, however since client nodes that have a distance of 300 feet apart are not likely to hear when either of them is transmitting, then the use of MAC protocol to avoid interference is unlikely to yield useful result. So two or more nodes transmitting on a common channel at the same time is likely to result in data collision which result in interference and this lower throughput , reliability and response time. Figure 1 is an example of client A and B both of which can communicate with the hub but are hidden from each other [5].

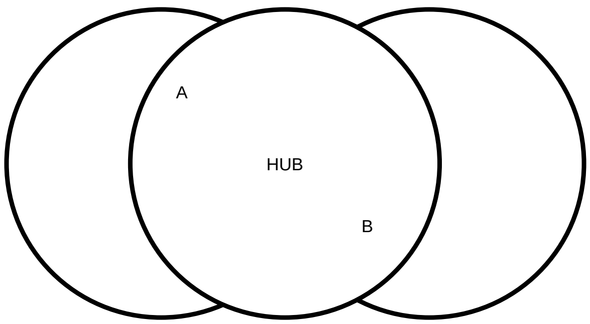

Fig 1: Hidden node problem Illustration. [5]

The problem that can occur in Figure 1 is that, it is most likely that the node at the extreme of the access point range known as A can see the access point but it become more difficult for the same node at the other extreme of the access point range to see the opposite end of the access point range B. These nodes are called hidden node, the major problem is when both A and B start to transmit packet simultaneously to access point, owing to the fact that they cannot see each other, then collision of packet occur and in this case the Carrier Sense Multiple Access with collision avoidance (CSMA/CA) will not work. However overcoming this problem require the proper use of the handshaking procedure, otherwise it will not be effective. This problem is both common in infrastructure and ad-hoc network. In [6], a major problem associated with most wireless network is the link failure experienced when nodes are communicating with each other; this is mainly due to the mobility of these nodes within the network. The higher the speed of nodes mobility, the faster the topology changes that are experienced, and the more unstable the network becomes, link failure could also occur due to congestion in the network, therefore this lead to low throughput and quality of service. When link failure occurs, there could be packet lost or packet could be held back, this will make the TCP assume that congestion has occurred within the network and hitherto result in invoking congestion control algorithm and this leads to unnecessary degrading of network performance since TCP cannot differentiate the difference between congestion from route failure. In [6], it was noted that link failure is a major degrading factor in ad-hoc network, and to improve Quality of Service in network, there has to be method of route maintenance to ensure uninterrupted network service. To decrease link failure, route maintenance protocol has to be employed to deal with this link failure problem.

Again Xiao and Rosdahl [7] described how the Raleigh channel can be affected due to mobility of nodes when two nodes are in communication mode. The signal between two node experiences deep fades and this results in poor performance in throughput, packet is dropped due to low signal to noise ratio in the network. Due to fading in the signal associated with the network, the probability that packet will collide is often higher, and this will eventually lead to packet retransmission and channel contention which leads to network degradation, consequently this channel throughput is lowered and the average packet delay is increased [7, 8]. Due to user mobility in wireless network, hidden node problem are prominent and a clear way to control this is by using the RTS/CTS protocols to inform other stations that the communication medium has been reserved for use by station who want to communicate data between each other.

2.1 Mobility Simulation in Wireless LAN

In other to simulate the effect of mobility on the Transmission control protocol (TCP) and the use of the RTS/CTS to eliminate the problem of hidden nodes, some nodes are going to be configured with mobility with the help of a trajectory movement design, this will enable us to experiment the behaviour of TCP connected with the FTP server. With the help of wireless deployment wizard in Opnet Modeler software, a wireless network was created, each of the nodes were characterized with different features ranging from mobility, stationary and the RTS/CTS characteristics, with these features enabled, the network is well represented such that they fit the real life scenario being simulated.

2.2 Protocol Description

A station wishing to transmit data initiate the process by first sending out a Request To Send frame (RTS), the receiver of the RTS frame replies with a Clear To Send (CTS), when this handshake proceedings has taken place other node that is apparently aware of this handshake procedure in the network refrain from sending data within a certain time limit often stipulated in the header of the initial RTS/CTS frames .With this technique the hidden node problem often experienced in wireless network environment is practically solved and again this will significantly improve the Quality of Service because it saves the network plenty of trouble trying to retransmit data when collision occur .The RTS/CTS is also employed as an additional method used in implementing virtual carrier sensing in CSMA/CA. The threshold attribute is responsible for the control of the RTS/CTS mechanism. The typical RTS/CTS packet size threshold is 0-2347 octet. When packet that is about to be transmitted is greater than the default threshold which is 2347, then the RTS/CTS handshakes gets triggered off and when the packet size is less or equal to the threshold the data frame is sent immediately [2]. The RTS threshold attribute allow different node or station to send a packet in such a way that they may either always, never, or only allow frames that satisfy a specified length using the RTS/CTS. To ensure proper operation of the RTS/CTS all stations must be able to sense the RTS/CTS frames .The proper use of the RTS/CTS help wireless network designer to fine tune the operation of wireless network depending on the environment where it's being operated. When RTS/CTS is enable on stations it refrains from sending data frame until a RTS/CTS handshakes have been completed between two stations [2].

2.3 RTS/CTS Implementation Tips

Before activating RTS/CTS, it is better to first consider if the wireless LAN is susceptible or experiencing collision and when collision is large in the network, then it is better to activate the RTS/CTS [2]. Another reason why the RTS/CTS can be activated is because of the far distance between two stations that may be involved in the transmission of the data frames. RTS/CTS introduces overhead, this is a major disadvantages of using the technique in enhancing performance in wireless LAN. Having considered it limitation, it will be better to know exactly when to activate the RTS/CTS, so it better to do a test whether the number of Collision is less then there will be no need to implement the RTS/CTS mechanism, otherwise the performance will be degraded when RTS/CTS is used when it is not necessary for the network use, so it better to deactivate the RTS/CTS when there is less collision. In most cases it better to focus on using RTS/CTS in the network interface card to improve performance since RTS/CTS implementation on the access point is useless because hidden problem rarely exist from the access point end ,this is because all nodes having a tie with the access point are just within range and therefore are not hidden from the access point, this forces the access point to activate RTS/CTS handshakes and this may lead to excessive overhead ,causing bandwidth mismanagement and again compromising the network throughput. Due to user mobility in wireless network, hidden node problem are prominent and a clear way to control this is by using the RTS/CTS protocols to inform other stations that the communication medium has been reserved for use by station who want to communicate data between each other.

3.0 Mobility Implementation in Wireless LAN

This implementation is the study and the simulation of the effect of the Request to Send (RTS) and the Clear To Send (CTS) protocol in the wireless network, this protocols is being deployed so as to observe it performance in solving the problem of hidden node that is often characterized in wireless LAN due to random movement in wireless network configuration. The effect of mobility on the transport control protocol (TCP) in the FTP session will also be looked into.

3.1 Design Configuration

In the design, two client nodes were configured, client A with the characteristics of mobility, an FTP server, an application and a profile node while client B was left untouched.

Client A and Client B

These two nodes will represent the wireless nodes in the network, while client A will be modeled with the attribute of movement such that the effect of node mobility on the TCP will be examined, and again how the RTS/CTS protocols can be used to reduce the problem of the hidden node caused by the mobility of nodes. Both clients are positioned in the work place with the aid of the node attributes present in the software.

3.1.1 Mobility Design in Client A

The design of the mobility was done with the aid of trajectory design that could be found in the software that help in the simulation of node movement and this was used in designing client A movement from one position to another within the network. Table 1 below shows the simulation parameters that were used in mobility design.

Table 1: Simulation Parameters for Mobility Design of Client A

X Position(KM)	Y Position (KM)	Altitude (M)	Traverse Time	Wait Time
0	0	0	0h:0m:0.00s	0h:02m:0.00s
-0.70	0	0	0h:0m:20.97s	0h:1m:0.00s
-0.85	0.002	0	0h:0m:20.24s	0h:0m:0.00s
-1	0.002	0	0h:0m:6.50s	0h:0m:0.00s
-1	0.002	0	0h:0m:2.24s	0h:0m:30.00s
0	0.004	0	0h:0m:27.96s	0h:0m:0.00s

This design trajectory makes client A start moving after two (2) minutes from the beginning of the simulation as shown in Table 1.

4.1 Simulation and Results

RTS/CTS protocols simulation have been implemented in wireless LAN infrastructure and the effect of mobility on Transmission Control Protocol were observed in mobile nodes. These are outlined below:

(a)Effect of mobility on wireless network

Fig.2 shows the graph of the congestion window size that was induced in the transmission control protocol (TCP) as a result of the client A mobility, the TCP cannot differentiate between mobility and traffic in wireless network, hence whenever there is mobility the TCP interprets this phenomenon as traffic congestion , therefore this forces the TCP to decrease the congestion window size in a bid to ensure that traffic is properly managed , but how wrong the TCP could be , unknown to it that this fluctuation that the TCP is experiencing is as a result of node mobility as this is responsible for the overall degrading of the wireless network. It takes time for the TCP to reorder the congestion window size when things gets back to normal, thus overall performance in network is compromised. It could be seen that congestion window of client A is made small and the constriction is very visible from the graph of Fig.2, but considering the congestion window of Client B, it will be discovered that the congestion window is much bigger than that of client A, this is because there is no mobility of any kind in Client B. Fig.3 depicts the congestion window characteristics of client B.

(b)Effect of mobility in Client A

From Fig. 2, it shows that the congestion window size for CLIENT A is smaller than of CLIENT B as shown in Fig .3, the simple reason is that client A was configured with mobility and this results in disconnection, as explained earlier this causes the transmission control protocol (TCP) to decrease the congestion window size, and again return to it default setting when normal connection is established. But looking at client B, it window size is larger than Client A window size mainly because mobility was not implemented in it.

(c) Effect of RTS/CTS

Considering the RTS/CTS protocols, it could be seen from both Fig. 2 and Fig. 3 that with the use of the Request To Send and Clear To Send protocol, the Transmission Control Protocol (TCP) was more effective in dealing with the effect of link failure and mobility related problems in communication networks, whereas the absent of the same protocols resulted in ineffective control of the congestion window size. With this, more and more packet will flood the network and this will definitely lead to network break down. Therefore for effective functioning of TCP in packet delivery, it better to ensure that the RTS/CTS protocols are configured in the transport layer. Our result has evidently shown the negative effect of mobility of nodes in networks, because like we have earlier said in this paper that Transmission Control Protocol cannot discern between network congestions and node mobility, hence the RTS/CTS is always triggered to ensure that congestion window is decreased in a bid to ensure that the network is prevented from packets over flooding.However this is disadvantageous in this content of node mobility, but will be very effective in solving hidden nodes problems as discussed in section 2. The hidden node problem that could hitherto result in frame collision, therefore making the TCP to decrease the network size can be solved by the RTS/CTS protocol.

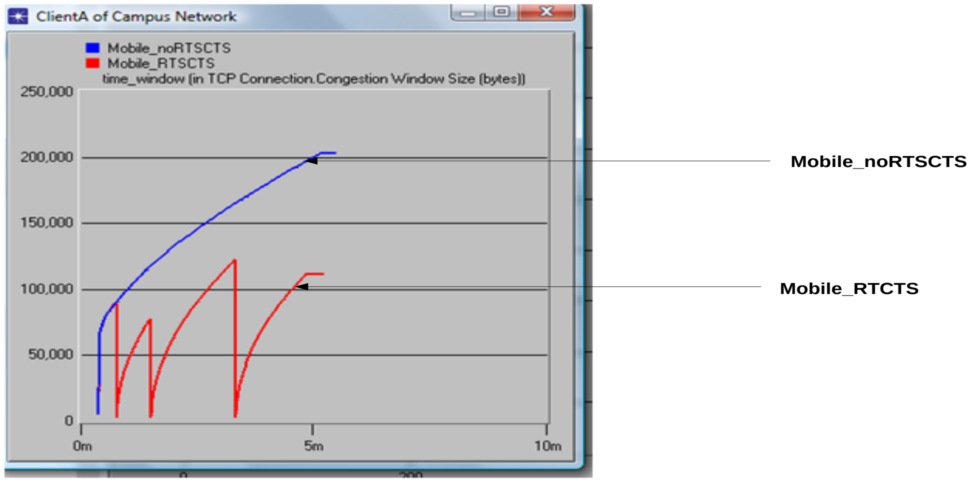

Fig. 2: Effect of TCP on Window Size Due to Mobility

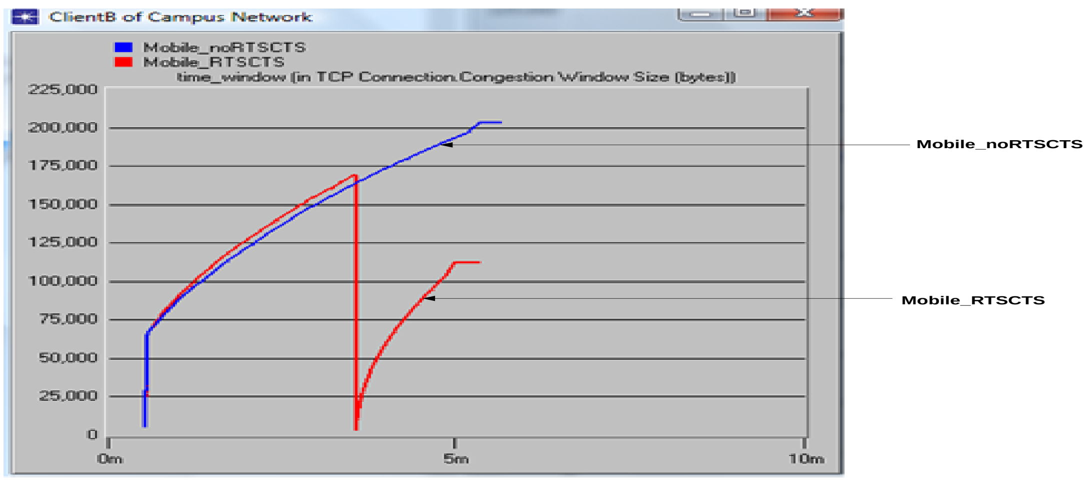

Fig. 3: Effect of TCP on Window Size on Client B without Mobility

4.2 Conclusion

The simulation of the effect of mobility on TCP has shown that with node mobility, unwarranted congestion mechanism is invoked at the transport layer by the Transmission Control Protocol owing to the earlier reason mentioned that the Transmission Control Protocol cannot discern between network congestion and node mobility and this will often time lead to unnecessary decrease in the congestion window size leading to poor network performance. Secondly the use of Request to Send and Clear to Send has also been shown to be another major contributory factor in effective functioning of the Transmission Control Protocol (TCP). In [6] more research is underway at having a reliable, connection-oriented and bytes stream services with Transmission Control Protocol.

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