Evaluation of Hidden Terminal Problem in Wireless Local Area Network Using Network Simulator Version 3

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Abstract—**Hidden terminal problem is common problem in wireless connection especially in Wireless Local Area Network (WLAN) connection. Hidden terminal problem can cause the packet loss becomes high and the throughput becomes low. This condition can be solved using the Request to Send/Clear To Send (RTS/CTS) mechanism. The RTS/CTS mechanism doesn't work optimal for all of the condition of the connection. The optimization of RTS/CTS can be caused by many conditions and parameters in the connections and two of the parameters are data rate of producing data and value of packets in Constant Bit Rate stream. In this discussion, in order to provide reliable connection WLAN, we primary focus on the performance of RTS/CTS in hidden terminal problem can be evaluated using simulator and one of the simulator is network simulator version 3 (ns-3)**

Keywords- constant bit rate; hidden terminal problem WLAN; network simulator version 3; RTS/CTS

I. Introduction

In wireless communication especially in Wireless Local Area Network (WLAN), some problems regarding the connections between Access Point (AP) and users usually occur. One of the problems that usually occur when an AP is connecting to more than one user is hidden terminal problem. Hidden terminal problem can affect the whole connections from users to the AP and cause the performance of the connections become very bad.

One of the solutions to solve the hidden terminal problem is using the Request to Send – Clear to Send (RTS/CTS) mechanism. This solution doesn't need to change the primary parameters of the connections such as the transmit power and receiving power. But can this solution solve the hidden terminal problem effectively? Or there are some conditions of the connections where the RTS/CTS will work more effectively?

In evaluating the hidden terminal problem and the effectiveness of RTS/CTS mechanism, telecommunication network simulator can be used. One of the up to date network simulator is network simulator version 3 (ns-3). With using ns-3, we can evaluate the performance of the connections in hidden terminal problem and the RTS/CTS mechanism in order to solve the hidden terminal problem.

II. Basic Theories of Hidden Terminal

A. Hidden Terminal Problem

The hidden terminal problem happens when there are more than one user which connect to one AP at the same time. Each of the users doesn't know that there is other user which connects to the same AP. It is because of the coverage area of each user is not wide enough to cover the other user. In this condition, there is big possibility that the users will send data to AP at the same time and the data will collide. The next effect is the data sent will become broken and need to be resent. The hidden terminal problem will cause lower throughput and high overhead because the data which are broken need to be resent [1].

The hidden terminal problem can be solved by widening the coverage area of each user so that the users can detect each other. The other solutions are decreasing the distance between users, removing the barrier between the users in order to decrease the loss and of course the RTS/CTS mechanism. The main purpose of all the solutions is to make the users can detect each other so that the collision of data can be prevented and the total packet loss can decrease.

B. Theory of RTS/CTS Mechanism

The RTS/CTS mechanism is actually very simple. The main idea of this mechanism is to make a mechanism that can arrange the connections between users to AP in order to prevent the collision of data. This mechanism uses additional header in order to check whether the AP is idle or doing connection with the other users.

So this is the mechanism of RTS/CTS. If there are two users which connect to an AP, assume that computer 1 and computer 2, the steps of RTS/CTS mechanism are:

1. Computer 1 sends RTS message to the AP

2. AP receives the RTS message, if the AP is idle, AP will send CTS message to computer 1 which give permission to computer 1 to send data.

3. If the AP is busy or there is other user which connects, AP will not send the CTS message which means that computer 1 is not permitted to send data.

4. If the computer 1 receives the CTS message, computer 1 will start to send data to AP.

5. After the data is sent, AP will send Acknowledgement message to computer 1 which ensure computer 1 that the data has been sent successfully

From the mechanism above we can conclude that only user which sends RTS and gets CTS message which is allowed to send data to AP. The purpose is in order to prevent all users send data in the same time and prevent the collision of data.

The main concept of RTS/CTS is adding additional header to the data which will be sent in order to prevent collision of data and decrease the possibility of sending back data because of damage data in collision.

In the condition where hidden terminal problem doesn't happen, the RTS/CTS mechanism will only make the performance and throughput becomes lower because need more time to send data with additional header rather than the data only.

C. Constant Bit Rate

Constant bitrate (CBR) requires constant packet transfer [2]. In simulation of hidden terminal problem using ns-3, the rate of sending data is using constant bit rate. The constant bit rate means that the data is sent with the rate which is constant and will not change all the times during the simulation. This condition will ensure that the rate of sending data will not change during the simulation and the data which is sent in one second is also constant.

In ns-3 simulation, user can decide the volume of one packet of data per second in constant bit rate stream.

III. EVALUATION OF HIDDEN TERMINAL PROBLEM IN NS-3

A. Introduction to hidden terminal problem simulation in ns-3

In usingns-3, hidden terminal problem of WiFi can be evaluated. The condition of hidden terminal problem is made by giving high loss (-50 dB) between the users and the AP. This high loss is to avoid the placement of users which are too far from the AP to make the condition of hidden terminal.

In this simulation, the constant bit rate (CBR) is used for sending the data. The volume of one packet of CBR stream can be decided. The number of packets means that the data which will be sent will be divided to packets with each packet has volume same as the volume of packet in CBR stream. In this simulation, each packet will be added by 8 bytes header.

In order to produce the data which will be sent, the on/off application is used. On off application will arrange the data with data rate of producing data can be set by the user of ns-3.

The position of nodes in ns-3 is :

Figure 1. Illustration of nodes placement in simulation

From the figure above, node 0 acts as user 1, node 1 acts as access point (AP) and node 2 acts as user 2.

B. The data rate of producing data versus packet loss

The data rate of producing data which is determined by the application data rate can affect the number of packet loss. In reality, this data rate of producing data related closely with the data which will be modulated and sent in the connection. RTS/CTS is known as one of the solution to solve hidden terminal problem but is RTS/CTS has its own condition in order to make it works optimally?

This result of ns-3 will answer the question about how many data which will be modulated can make the RTS/CTS works optimally to decrease the packet loss. This result of ns-3 is produced with using simulation which has IEEE 802.11a standard, duration 5 minutes, 1000 bytes in CBR stream, modulation is 2 Mbps of Direct Sequence Spread Spectrum (DSSS).

TABLE 1. RESULT OF SIMULATION WITH VARIOUS DATA RATE OF APPLICATION DATA

Variable	Data rate of application data	Data flow	Packet loss	Condition of RTS/CTS
1 AP and 1 User	1 Mbps	From node 0 to node 1	0%	Both on or off
		From node 2 to node 1	0 %	Both on or off
1 AP and 2 Users	1 Mbps	From node 0 to node 1	76.4%	Off
		From node 2 to node 1	75.08%	
		From node 0 to node 1	62.3455%	On
		From node 2 to node 1	59.956%	
	0.5 Mbps	From node 0 to node 1	51.126 %	Off
		From node 2 to node 1	52.07 %	
		From node 0 to node 1	0 %	On
		From node 2 to node 1	0%	
1 AP and 3 Users	0.5 Mbps	From node 0 to node 1	83.416%	Off
		From node 2 to node 1	83.32%	
		From node 3 to node 1	82.913%	
		From node 0 to node 1	47.38%	On
		From node 2 to node 1	48.954%	
		From node 3 to node 1	48.408%	

From the result above, the packet loss can be evaluated. The RTS/CTS work properly in order to decrease the packet loss. If the data rate of application (producing) data is compared to the modulation rate which is 2 Mbps of Direct Sequence Spread Spectrum, the RTS/CTS mechanism will work most optimal when this condition applies:

$$Rate_{prod} = (Rate_{mod} / 2) / n \quad (1)$$

Information :

$Rate_{prod}$= Data rate of producing data

$Rate_{mod}$ =Data rate of DSSS modulation

n = number of users

In reality, the data rate of application data can be found by using:

Data sent = $Rate_{prod}$xt + ($Rate_{prod}$ / V) x 8 bytes (2)

Information:

$Rate_{prod}$= Data rate of producing data

t = time needed to send data

V = Volume of CBR packet

So in this term, the data which will be sent has to be:

Data sent = ($Rate_{mod}$ / (n x2)) x t + ($Rate_{mod}$ / (2 x n x V) x 8 bytes (3)

Information:

$Rate_{mod}$ =Data rate of DSSS modulation

t = time needed to send data

V = Volume of CBR packet

n = number of users

Equation 3 shows the maximum data sent which makes the RTS/CTS works most optimal. It means that if the data which will be modulated and sent is less than that equation, the RTS/CTS will work optimally also.

From the data in TABLE 1, when the simulation is under condition which fulfill (1) and (3), the packet loss decreases significantly around more than 50 % if we compare with when the RTS/CTS is not activated. If the data which will be sent is same or less than (3), the packet loss when RTS/CTS is activated will be 0% which means that there is no packet loss.

C. The Constant Bit Rate Stream versus throughput

The constant bit rate (CBR) stream can also affect the throughput of the connection. The CBR stream gives the information about how many packets which are needed to send the whole data produced and will also determine how many headers which are needed regarding the number of packets.

This result of ns-3 will give information about how the CBR stream can affect the throughput of the simulation and how the RTS/CTS can increase the throughput of the connection with different volume of packets in CBR stream. In this simulation, the IEEE 802.11a is used with modulation rate DSSS 2 Mbps andsimulation duration 30 seconds:

TABLE 2. RESULT OF SIMULATION WITH VARIOUS PACKETS VOLUME OF CBR STREAM

Data Flow	Packets Volume of CBR Stream	Throughput	Condition of RTS/CTS
Node 0 to node 1	100 Bytes	0.181641 Mbps	Off
		0.127441 Mbps	On
	200 Bytes	0.241443 Mbps	Off
		0.237442 Mbps	On
	400 Bytes	0.360498 Mbps	Off
		0.297476 Mbps	On
	600 Bytes	0.382822 Mbps	Off
		0.477689 Mbps	On
	1000 Bytes	0.308231 Mbps	Off
		0.448621 Mbps	On
Node 2 to node 1	100 Bytes	0.156543 Mbps	Off
		0.154004 Mbps	On
	200 Bytes	0.256924 Mbps	Off
		0.203174 Mbps	On
	400 Bytes	0.308905 Mbps	Off
		0.37356 Mbps	On
	600 Bytes	0.319098 Mbps	Off
		0.349762 Mbps	On

From table above, the RTS/CTS will work more optimally when the volume of packets in CBR stream becomes higher.

The RTS/CTS is very effective to prevent the data collisions and solve the hidden terminal problem. But RTS/CTS also has weakness, in the condition where the RTS/CTS control packets which are need to send before the data are too many, the collision between the RTS/CTS control packets can happen [3]. If this collision happens, the performance of the RTS/CTS mechanism becomes down and the hidden terminal problem cannot be solved.

The condition where too many RTS/CTS control packets need to be sent is happening for small volume of CBR stream packets (for example when 100 Bytes and 200 Bytes). This condition affects the RTS/CTS mechanism will only make the throughput becomes low. From the result, under condition when RTS/CTS is on for 100 Bytes and 200 Bytes of CBR stream, the throughput becomes lower than when the RTS/CTS is off. This condition shows that there is collision between RTS/CTS packets which is because of there are so many packets of data which need to be sent and need to be guided by RTS/CTS packets. Keep in mind that the lower volume of CBR stream packets, the more packets which are needed to be sent and guided by RTS/CTS control packets.

In order to prevent the collision, the RTS/CTS mechanism is needed. But if the RTS/CTS control packets are too many, it will not work properly anymore and only cause the throughput becomes low. In this case, RTS/CTS will work more optimal when the volume of CBR stream is higher.

IV. CONCLUSION

From the evaluation of hidden terminal problem using ns-3, the RTS/CTS mechanism is known to be more effective in preventing the collision of data and increasing the performance of connection when some conditions apply.

The data rate of producing data which is determined by the data rate of application data in ns-3 can affect the performance of RTS/CTS in decreasing the number of packet loss. From the simulation, it is known that the data rate of producing data can make the RTS/CTS work more optimally affected by the number of users and the DSSS modulation rate. In some conditions, the RTS/CTS can decrease the packet loss until 0%.

From the simulation, the volume of packets in CBR stream also affects the throughput of the connection. The higher volumes of data packets, more frequent the collision will happen but the RTS/CTS control packets which are needed to be sent become less. In order to prevent the collision, the RTS/CTS mechanism is needed. It is also evaluated that the higher volume of packets in CBR stream, RTS/CTS will work more optimal to increase the throughput.

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