# Experiment 9
Analysis of RTS/CTS in IEEE 802.11

Objective -

This experiment investigates the impact of enabling and disabling the optional Request to Send/Clear to Send (RTS/CTS) protocol in IEEE 802.11 (Wi-Fi) networks. The study measures how this feature affects key performance metrics, including data collision rates, overall network throughput, and packet delay.

Theory-

Wi-Fi's default anti-collision system is CSMA/CA. An optional feature, RTS/CTS, helps prevent collisions from "hidden nodes." It works by having a device send a quick "Request to Send" (RTS) before its main data packet. The Access Point responds with a "Clear to Send" (CTS), which tells all other devices to stay quiet, reserving the channel. The downside is that this adds overhead, slowing down the network if it's not busy, which is why it's not always enabled.
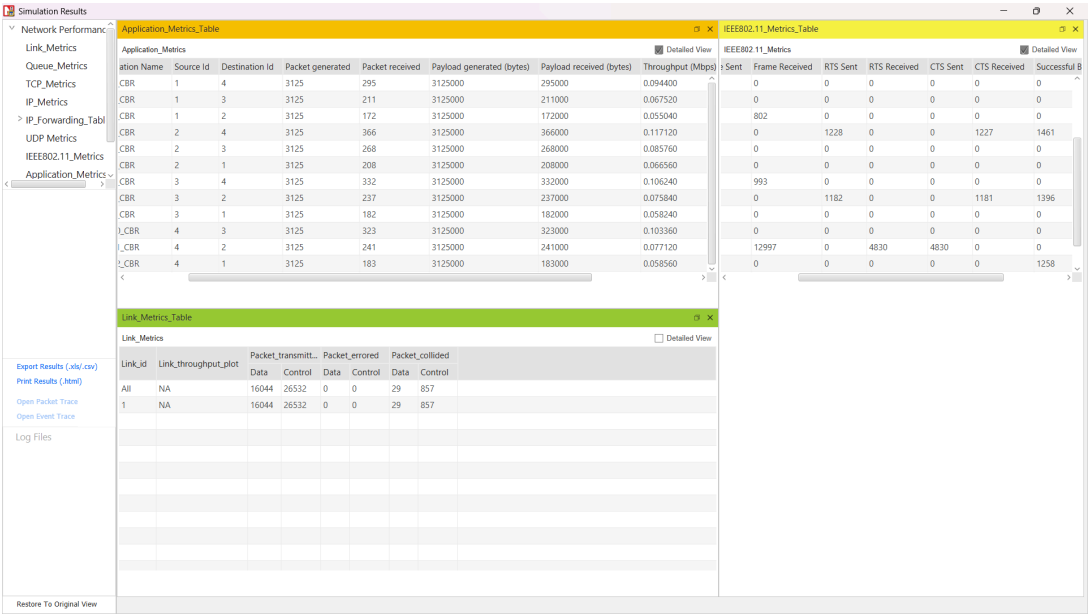
Experimental Setup-
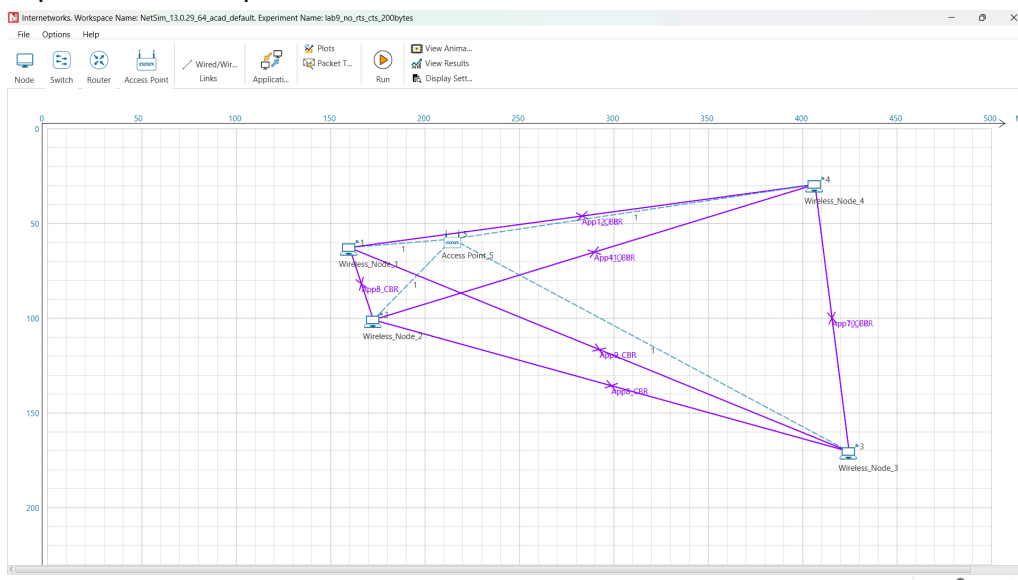
Observations-
A) NO RTS/CTS(1Mbps)
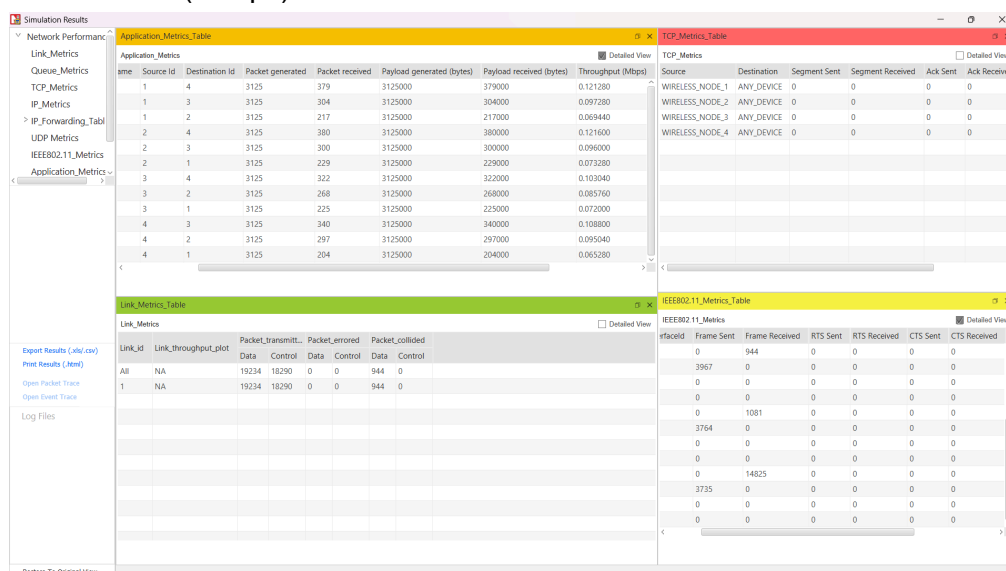
PARAMETERS	VALUES
TOTAL FRAMES SENT	14825
COLLISIONS OBSERVED	944
AVERAGE DELAY (ms)	1006.85
THROUGHPUT (kbps)	92.40

B) RTS/CTS ENABLED (1Mbps)

PARAMETERS	VALUES
TOTAL FRAMES SENT	12997
COLLISIONS OBSERVED	886
AVERAGE DELAY (ms)	999.69
THROUGHPUT (kbps)	98.35
RTS/CTS FRAMES EXCHANGED	4830

C) RTS/CTS ENABLED AND DISABLED (VARYING PACKET SIZE)

PACKET SIZE	THROUGHPUT (NO RTS/CTS)	THROUGHPUT (RTS/CTS)	COLLISION COUNT (NO RTS/CTS)	COLLISION COUNT (RTS/CTS)
200 bytes	33.07 Kbps	37.49 Kbps	996	1126
800 bytes	81.98 Kbps	83.52 Kbps	1125	1093
1500 bytes	82.38 Kbps	83.97 Kbps	879	850

a)   200 bytes packet size
i) no rts/cts

Simulation Results

Network Performanc...
- Link_Metrics
- Queue_Metrics
- TCP_Metrics
- IP_Metrics
- IP_Forwarding_Tabl
- UDP_Metrics
- IEEE802.11_Metrics
- Application_Metrics

Export Results (.xls/.csv)
Print Results (.html)
Open Packet Trace
Open Event Trace
Log Files
Restore To Original View

Application_Metrics_Table — Application_Metrics — ☑ Detailed View

on Name	Source Id	Destination Id	Packet generated	Packet received	Payload generated (bytes)	Payload received (bytes)	Throughput (Mbp...)
R	1	4	15625	859	3125000	171800	0.054976
R	1	3	15625	618	3125000	123600	0.039552
R	1	2	15625	136	3125000	27200	0.008704
R	2	4	15625	776	3125000	155200	0.049664
R	2	3	15625	574	3125000	114800	0.036736
R	2	1	15625	125	3125000	25000	0.008000
R	3	4	15625	780	3125000	156000	0.049920
R	3	2	15625	580	3125000	116000	0.037120
R	3	1	15625	146	3125000	29200	0.009344
BR	4	3	15625	861	3125000	172200	0.055104
BR	4	2	15625	612	3125000	122400	0.039168
BR	4	1	15625	133	3125000	26600	0.008512

TCP_Metrics_Table — TCP_Metrics — ☐ Detailed View

Source	Destination	Segment Sent	Segment Received	Ack Sent	Ack Received
WIRELESS_NODE_1	ANY_DEVICE	0	0	0	0
WIRELESS_NODE_2	ANY_DEVICE	0	0	0	0
WIRELESS_NODE_3	ANY_DEVICE	0	0	0	0
WIRELESS_NODE_4	ANY_DEVICE	0	0	0	0

Link_Metrics_Table — Link_Metrics — ☐ Detailed View

Link_id	Link_throughput_plot	Packet_transmitt... Data	Control	Packet_errored Data	Control	Packet_collided Data	Control
All	NA	34494	33498	0	0	996	0
1	NA	34494	33498	0	0	996	0

IEEE802.11_Metrics_Table — IEEE802.11_Metrics — ☑ Detailed View

DeviceId	InterfaceId	Frame Sent	Frame Received	RTS Sent	RTS Received	CTS Sent	C...
3	1	0	2053	0	0	0	
3	1	6723	0	0	0	0	
3	1	0	0	0	0	0	
3	1	0	0	0	0	0	
4	1	0	2415	0	0	0	
4	1	7478	0	0	0	0	
4	1	0	0	0	0	0	
5	1	0	27298	0	0	0	
5	1	6498	0	0	0	0	
5	1	0	0	0	0	0	
5	1	0	0	0	0	0	

ii) rts/cts

Simulation Results

Network Performanc...
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- Application_Metrics

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Restore To Original View

Application_Metrics_Table — Application_Metrics — ☑ Detailed View

Name	Source Id	Destination Id	Packet generated	Packet received	Payload generated (bytes)	Payload received (bytes)	Throughput (Mbps)
1	1	4	15625	966	3125000	193200	0.061824
1	1	3	15625	571	3125000	114200	0.036544
1	1	2	15625	102	3125000	20400	0.006528
2	2	4	15625	1154	3125000	230800	0.073856
2	2	3	15625	660	3125000	132000	0.042240
2	2	1	15625	142	3125000	28400	0.009088
3	3	4	15625	1037	3125000	207400	0.066368
3	3	2	15625	572	3125000	114400	0.036608
3	3	1	15625	99	3125000	19800	0.006336
4	4	3	15625	1019	3125000	203800	0.065216
4	4	2	15625	604	3125000	120800	0.038656
4	4	1	15625	104	3125000	20800	0.006656

TCP_Metrics_Table — TCP_Metrics — ☐ Detailed View

Source	Destination	Segment Sent	Segment Received	Ack Sent	Ack Receiv...
WIRELESS_NODE_1	ANY_DEVICE	0	0	0	0
WIRELESS_NODE_2	ANY_DEVICE	0	0	0	0
WIRELESS_NODE_3	ANY_DEVICE	0	0	0	0
WIRELESS_NODE_4	ANY_DEVICE	0	0	0	0

Link_Metrics_Table — Link_Metrics — ☐ Detailed View

Link_id	Link_throughput_plot	Packet_transmitt... Data	Control	Packet_errored Data	Control	Packet_collided Data	Control
All	NA	27811	40641	0	0	30	1096
1	NA	27811	40641	0	0	30	1096

IEEE802.11_Metrics_Table — IEEE802.11_Metrics — ☑ Detailed View

Id	Frame Sent	Frame Received	RTS Sent	RTS Received	CTS Sent	CTS Received	Suc...
0		2250	0	0	0	0	0
5143		0	1473	0	0	1473	1
0		0	0	0	0	0	0
0		3157	0	0	0	0	0
5005		0	1429	0	0	1428	1
0		0	0	0	0	0	0
0		20751	0	5882	5882	0	0
7335		0	0	0	0	0	1
0		0	0	0	0	0	0
0		0	0	0	0	0	0

b)   800 bytes packet size
i) no rts/cts

Simulation Results

Network Performanc...
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Application_Metrics_Table — Application_Metrics — ☑ Detailed View

Application Name	Source Id	Destination Id	Packet generated	Packet received	Payload generated (bytes)	Payload received (bytes)	Throughput (M...
App1_CBR	1	4	3907	384	3125600	307200	0.098304
App2_CBR	1	3	3907	322	3125600	257600	0.082432
App3_CBR	1	2	3907	213	3125600	170400	0.054528
App4_CBR	2	4	3907	424	3125600	339200	0.108544
App5_CBR	2	3	3907	326	3125600	260800	0.083456
App6_CBR	2	1	3907	236	3125600	188800	0.060416
App7_CBR	3	4	3907	391	3125600	312800	0.100096
App8_CBR	3	2	3907	319	3125600	255200	0.081664
App9_CBR	3	1	3907	231	3125600	184800	0.059136
App10_CBR	4	3	3907	425	3125600	340000	0.108800
App11_CBR	4	2	3907	324	3125600	259200	0.082944
App12_CBR	4	1	3907	248	3125600	198400	0.063488

TCP_Metrics_Table — TCP_Metrics — ☐ Detailed View

Source	Destination	Segment Sent	Segment Received	Ack Sent	Ack Rec...
WIRELESS_NODE_1	ANY_DEVICE	0	0	0	0
WIRELESS_NODE_2	ANY_DEVICE	0	0	0	0
WIRELESS_NODE_3	ANY_DEVICE	0	0	0	0
WIRELESS_NODE_4	ANY_DEVICE	0	0	0	0

Link_Metrics_Table — Link_Metrics — ☐ Detailed View

Link_id	Link_throughput_plot	Packet_transmitt... Data	Control	Packet_errored Data	Control	Packet_collided Data	Control
All	NA	21620	20495	0	0	1125	0
1	NA	21620	20495	0	0	1125	0

IEEE802.11_Metrics_Table — IEEE802.11_Metrics — ☑ Detailed View

DeviceId	InterfaceId	Frame Sent	Frame Received	RTS Sent	RTS Received	CTS Sen...
3	1	0	1073	0	0	0
3	1	4398	0	0	0	0
3	1	0	0	0	0	0
4	1	0	1199	0	0	0
4	1	4515	0	0	0	0
4	1	0	0	0	0	0
5	1	0	16652	0	0	0
5	1	4141	0	0	0	0
5	1	0	0	0	0	0

ii) rts/cts

Application_Metrics_Table

Application_Metrics

Application Name	Source Id	Destination Id	Packet generated	Packet received	Payload generated (bytes)	Payload received (bytes)	Throughput (M...
App1_CBR	1	4	3907	453	3125600	362400	0.115968
App2_CBR	1	3	3907	279	3125600	223200	0.071424
App3_CBR	1	2	3907	218	3125600	174400	0.055808
App4_CBR	2	4	3907	447	3125600	357600	0.114432
App5_CBR	2	3	3907	305	3125600	244000	0.078080
App6_CBR	2	1	3907	263	3125600	210400	0.067328
App7_CBR	3	4	3907	429	3125600	343200	0.109824
App8_CBR	3	2	3907	282	3125600	225600	0.072192
App9_CBR	3	1	3907	193	3125600	154400	0.049408
App10_CBR	4	3	3907	469	3125600	375200	0.120064
App11_CBR	4	2	3907	342	3125600	273600	0.087552
App12_CBR	4	1	3907	235	3125600	188000	0.060160

TCP_Metrics_Table

TCP_Metrics

Source	Destination	Segment Sent	Segment Received	Ack Sent	Ack
WIRELESS_NODE_1	ANY_DEVICE	0	0	0	0
WIRELESS_NODE_2	ANY_DEVICE	0	0	0	0
WIRELESS_NODE_3	ANY_DEVICE	0	0	0	0
WIRELESS_NODE_4	ANY_DEVICE	0	0	0	0

Link_Metrics_Table

Link_Metrics

Link_id	Link_throughput_plot	Packet_transmitt... Data	Control	Packet_errored Data	Control	Packet_collided Data	Control
All	NA	17731	29151	0	0	33	1060
1	NA	17731	29151	0	0	33	1060

IEEE802.11_Metrics_Table

IEEE802.11_Metrics

InterfaceId	Frame Sent	Frame Received	RTS Sent	RTS Received	CTS Sent	CTS
1	0	1053	0	0	0	
1	3370	0	1275	0	0	
1	0	0	0	0	0	
1	0	1329	0	0	0	
1	3516	0	1327	0	0	
1	0	0	0	0	0	
1	0	13783	0	5197	5197	
1	4193	0	0	0	0	
1	0	0	0	0	0	
1	0	0	0	0	0	

c) 1500 bytes packet size
i) no rts/cts

Application_Metrics_Table

Application_Metrics

...me	Source Id	Destination Id	Packet generated	Packet received	Payload generated (bytes)	Payload received (bytes)	Throughput (Mbps)
	1	4	4168	446	3126000	397280	0.127130
	1	3	4168	318	3126000	275000	0.088000
	1	2	4168	79	3126000	76040	0.024333
	2	4	4168	420	3126000	386540	0.123693
	2	3	4168	291	3126000	227740	0.072877
	2	1	4168	114	3126000	95720	0.030630
	3	4	4168	524	3126000	467460	0.149587
	3	2	4168	323	3126000	256120	0.081958
	3	1	4168	104	3126000	94060	0.030099
	4	3	4168	516	3126000	445400	0.142528
	4	2	4168	326	3126000	281000	0.089920
	4	1	4168	103	3126000	86740	0.027757

TCP_Metrics_Table

TCP_Metrics

Source	Destination	Segment Sent	Segment Received	Ack Sent	Ack Received
WIRELESS_NODE_1	ANY_DEVICE	0	0	0	0
WIRELESS_NODE_2	ANY_DEVICE	0	0	0	0
WIRELESS_NODE_3	ANY_DEVICE	0	0	0	0
WIRELESS_NODE_4	ANY_DEVICE	0	0	0	0

Link_Metrics_Table

Link_Metrics

Link_id	Link_throughput_plot	Packet_transmitt... Data	Control	Packet_errored Data	Control	Packet_collided Data	Control
All	NA	21607	20727	0	0	879	0
1	NA	21607	20727	0	0	879	0

IEEE802.11_Metrics_Table

IEEE802.11_Metrics

DeviceId	InterfaceId	Frame Sent	Frame Received	RTS Sent	RTS Received	CTS Sent	CTS
3	1	0	1125	0	0	0	0
3	1	4884	0	0	0	0	0
3	1	0	0	0	0	0	0
3	1	0	0	0	0	0	0
4	1	0	1390	0	0	0	0
4	1	4884	0	0	0	0	0
4	1	0	0	0	0	0	0
5	1	0	17164	0	0	0	0
5	1	3807	0	0	0	0	0
5	1	0	0	0	0	0	0
5	1	0	0	0	0	0	0

ii) rts/cts

Application_Metrics_Table

Application_Metrics

plication Name	Source Id	Destination Id	Packet generated	Packet received	Payload generated (bytes)	Payload received (bytes)	Throughput (Mbps)
pp1_CBR	1	4	4168	463	3126000	426820	0.136582
pp2_CBR	1	3	4168	293	3126000	240920	0.077094
pp3_CBR	1	2	4168	92	3126000	73380	0.023482
pp4_CBR	2	4	4168	493	3126000	434720	0.139110
pp5_CBR	2	3	4168	316	3126000	273500	0.087520
pp6_CBR	2	1	4168	101	3126000	89620	0.028678
pp7_CBR	3	4	4168	457	3126000	419400	0.134208
pp8_CBR	3	2	4168	284	3126000	221760	0.070963
pp9_CBR	3	1	4168	88	3126000	71840	0.022989
pp10_CBR	4	3	4168	440	3126000	401540	0.128493
pp11_CBR	4	2	4168	277	3126000	242060	0.077459
pp12_CBR	4	1	4168	101	3126000	91080	0.029146

TCP_Metrics_Table

TCP_Metrics

Source	Destination	Segment Sent	Segment Received	Ack Sent	Ack R
WIRELESS_NODE_1	ANY_DEVICE	0	0	0	0
WIRELESS_NODE_2	ANY_DEVICE	0	0	0	0
WIRELESS_NODE_3	ANY_DEVICE	0	0	0	0
WIRELESS_NODE_4	ANY_DEVICE	0	0	0	0

Link_Metrics_Table

Link_Metrics

Link_id	Link_throughput_plot	Packet_transmitt... Data	Control	Packet_errored Data	Control	Packet_collided Data	Control
All	NA	21273	21471	0	0	766	84
1	NA	21273	21471	0	0	766	84

IEEE802.11_Metrics_Table

IEEE802.11_Metrics

Id	InterfaceId	Frame Sent	Frame Received	RTS Sent	RTS Received	CTS Sent	C
1	1	0	1049	0	0	0	
1	1	4513	0	124	0	0	
1	1	0	0	0	0	0	
1	1	0	0	0	0	0	
1	1	0	1413	0	0	0	
1	1	4233	0	111	0	0	
1	1	0	0	0	0	0	
1	1	0	17102	0	440	440	
1	1	3642	0	0	0	0	
1	1	0	0	0	0	0	

Comparing Collision Counts and Throughput with packet sizes and RTS/CTS enabled/disabled.
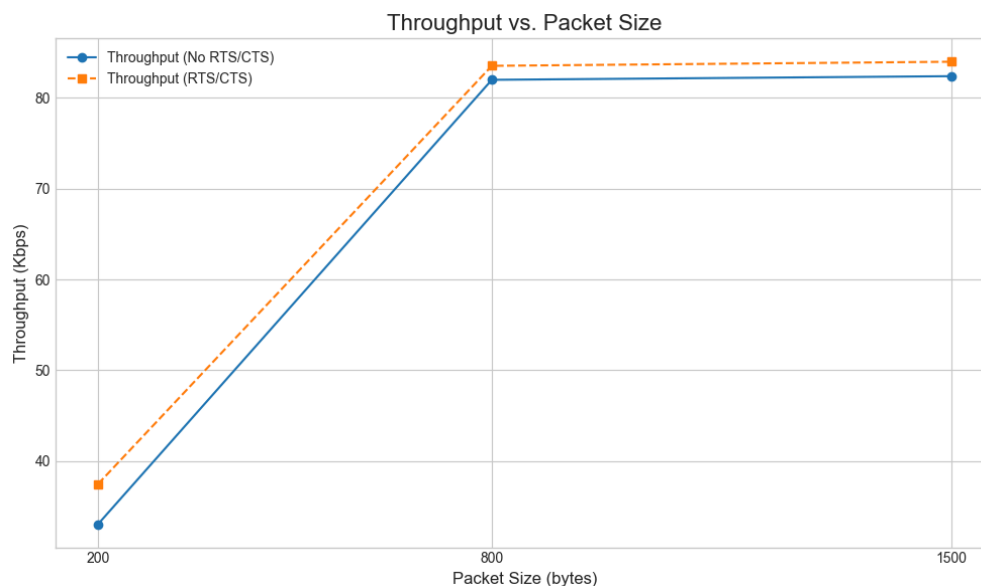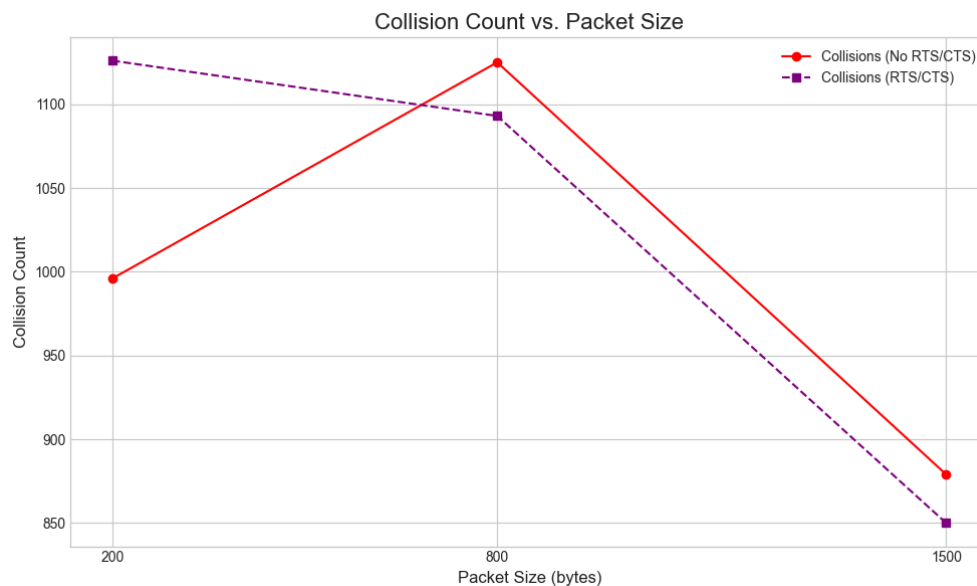
Analysis-

A key finding from our simulation is the conditional effectiveness of the RTS/CTS protocol, which presents a clear trade-off dependent on packet size. When handling small, 200-byte packets, activating the protocol was detrimental to network stability, causing the collision count to climb from 996 to 1126.

Conversely, the protocol's intended benefits were realized with larger data payloads. At 800 bytes, a reduction in collisions directly translated into a tangible throughput improvement from 81.98 Kbps to 83.52 Kbps. For the largest, 1500-byte packets, the inherent overhead of the RTS/CTS handshake became a limiting factor, causing a slight decrease in throughput despite successfully lowering the collision count from 879 to 850.

Ultimately, these findings support a strategic application of RTS/CTS, confirming its value in enhancing the reliability of transmissions involving large packets while being ill-suited for traffic characterized by small, frequent data transfers.