# Survey On Effectiveness Of RTS/CTS Mechanism In 802.11 Adhoc Wireless Networks

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## Abstract

***IEEE 802.11 is one of the most deployed technologies in wireless LANs. There are two access mechanism of IEEE 802.11 DCF; Basic access mechanism and RTS/CTS mechanism. To the best of my knowledge none of the researcher has done survey to find the effectiveness of several parameters with and without RTS/CTS mechanism. There are various tradeoffs when RTS/CTS mechanism is used. Parameters include packet payload, network traffic, and interference range, mobility of node and fairness issue. It has been concluded that RTS/CTS mechanism is very effective for large packet sizes whereas for small packet size it induces overhead in network performance due to control packets. Thus RTS/CTS mechanism outperforms basic access scheme when network traffic is heavy under ideal conditions. Network performance degrades with RTS/CTS mechanism when distance between sender and receiver exceeds transmitter range. We have concluded from our findings that RTS/CTS mechanism is helpful to reduce the number of retransmissions if hidden node problem persists.***

## 1. Introduction

IEEE 802.11 is the most deployed technology in the world for wireless LANs. It employs Distributed Coordination Function (DCF) as the essential MAC method [1]. DCF defines two access mechanisms; two-way handshaking technique called basic access and the optional four-way handshaking RTS/CTS mechanism.Collisions occur when all nodes are not able to hear each other at all times. In figure 1, suppose there are threenodes A, B and C. Both **A and C want to transmit data to B**. B is in transmitter range of both A and C, but A, C both are out of each other's transmitter range. If it transmits then their packets will collide at receiver. Thus we can say that A and C both are hidden from each other as they cannot sense each other's transmission. This problem is known as hidden terminal problem (or hidden node problem).In this situation, if Node A starts transmitting, collision will happen. As a result, both node Aand node C would need to retransmit their respective packets, which results in higher overhead and lower throughput.

A simple and elegant solution to the hidden node problem is to use small packets called RTS (Request to send) and CTS (Clear to send) for handshaking before transmission of data packet. RTS/CTS mechanism is also known as virtual carrier sensing. A node willing to transmit a packet will first transmit a short control packet called **RTS** (Request to send) and then destination node will respond (if the medium is free) with a response control packet called **CTS** (clear to send).The CTS also alerts other stations tohold off from accessing the medium while the station initiating the RTS transmits its data. Thus, the use of RTS/CTS reduces collisions and improves the performance of the network.

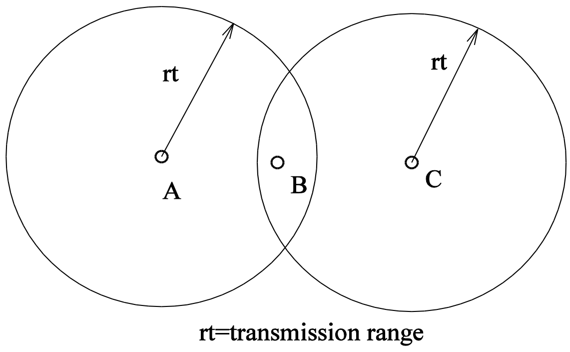


Figure 1 Hidden terminal problem

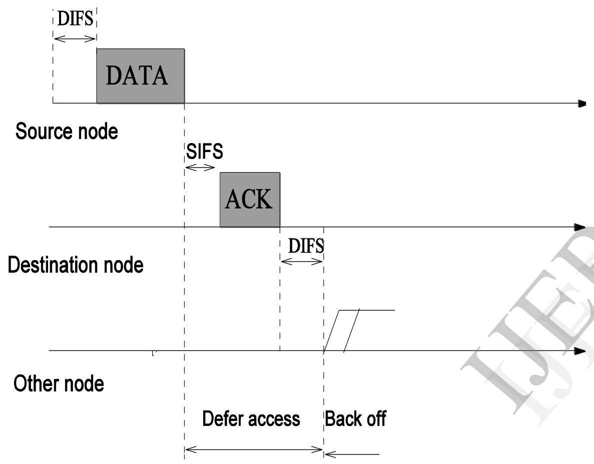


Figure 2Basic access mechanism

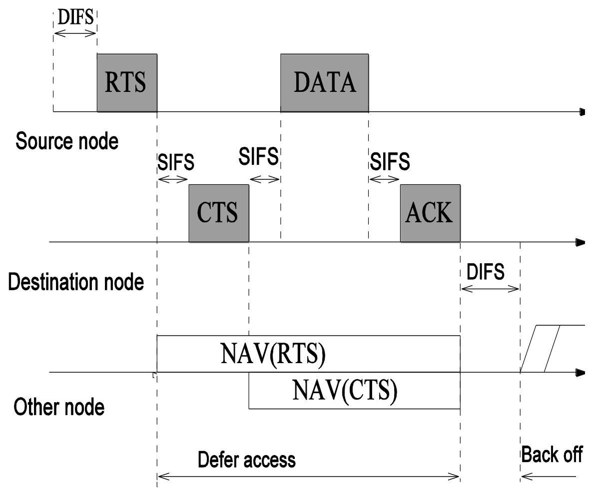


Figure 3 RTS/CTS mechanism

## 2. IEEE 802.11 DCF

As mentioned previously, IEEE 802.11 DCF includes two mechanisms for packet transmission, i.e. basic access mechanism and request-to-send/clear-to-send (RTS/CTS) access mechanism.

### 2.1 Basic access mechanism

The basic access mechanism is illustrated in figure 2. When the sender wishes to transmit a new packet, it needs to monitor the channel first. If the channel is sensed to be idle for a period of time equal to the Distribute Inter Frame Space (DIFS), it begins the transmission. Otherwise, if the channel is busy (either immediately or during the DIFS), the station persists to monitor the channel until it is measured idle for a DIFS. At this point, the station will generate a random number of backoff slot time of backoff window size (CW) before transmitting, to minimize the probability of collision with packets being transmitted by other stations. During the backoff procedure if the channel is idle for a DIFS interval, then the backoff timer is decremented as long as the channel is sensed idle, “frozen” when a transmission is detected on the channel and resumed when the channel is sensed idle again for more than a DIFS. The station starts the transmission when the backoff timer reaches to zero. When the receiver receives the packet correctly, it waits for a short inter-frame space (SIFS) interval and then transmits acknowledgement (ACK) back to the sender. In case the sender does not receive the ACK, it considers the previous transmission is failed and schedules to retransmit the data packet. If the data packet is not transmitted successfully, the backoff window CW would be doubled until it reaches the maximum value $CW_{max}$.

### 2.2 IEEE 802.11 RTS/CTS Access Method

The RTS/CTS access method is an additional four-way handshaking technique and very effective in solving the hidden terminal problem. The RTS/CTS mechanism is shown in figure 3. When the sender wants to transmit a packet, it sends a short frame called request to send (RTS) instead of the packet first after the channel has been sensed idle for a DIFS. When the receiver detects the RTS, it responses, after a SIFS, with a clear to send (CTS) frame. A successful RTS/CTS exchange reserves the channel for the sender-receiver pair. Other stations adjust their network allocation vectors (NAVs) based on the duration field of the RTS or of the CTS. The sender starts to transmit the packet after a SIFS only if it received the CTS frame correctly. Same as basic access method, the receiver will send back an ACK to acknowledge after received the packet successfully. If the CTS is not received within a given time frame, the sender retransmits the RTS according to the backoff rules similar to the basic access method.

## 3. Effect of following parameters on RTS/CTS mechanism

Several parameters including packet payload, network size large interference range, mobility of node and fairness affects the network performance with and without RTS/CTS mechanism. A survey is done based on these parameters to find the effectiveness of RTS/CTS mechanism. Throughput and access delay as performance metrics.

### 3.1 Effect of packet payload

Packet payload is the payload size of the data packet. Throughput performance is strongly dependent on load offered to the system.RTS/CTS mechanism has positive and negative effects in different situations. When packet size is 68 Bytes throughput is more when RTS/CTS is off .Access delay is more when RTS/CTS is on for 68 Bytes in presence of hidden terminals [2].Hidden terminal is not assumed in [3, 4, 5].The throughput performance is more effective when payload size is more than 6000 bits with RTS/CTS on in presence and absence of hidden terminal. This is due to the fact that collisions take place with small RTS packets only. Overall performance is not affected under low load as compared to high load when collisions take place due to hidden terminal problem. Authors in [2] also simulated on per station basis i.e. one station uses RTS/CTS mechanism, others do not. It has been shown that there is no individual gain for each station but there is small degradation in overall performance.

The trade-off between pros and cons of RTS/CTS show that it is profitably applied in conjunction with the adaptive contention window only for long packets (6000 bits), while in the basic standard; it provides benefits for packets longer than 2000 bits [6].Authors in [6] proposed an *Adaptive Contention Window* mechanism, which dynamically selects the optimal backoff window. They showed that adaptive technique shows better performance only when the packet size is short. They found in adaptive mechanisms that performance degrades even though the RTS/CTS mechanism is applied in presence of hidden terminals. Thus RTS/CTS mechanism proves better for large packet sizes. Small packet sizes induce overhead in network performance.

### 3.2 Effect of Network traffic

There is a great influence on network performance when network traffic is considered i.e. number of nodes or stations. It is more desirable to apply RTS/CTS mechanism when network size increases considerably. The authors in [3] illustrates that the basic access performs better than RTS/CTS when the number of contending stations is relatively small ($n$=5) for all packet size values.RTS threshold decreases as number of contending stations increases.

Authors in [8] used Bianchi model [7] and analysed throughput for 1Mbps and 6Mbps with different maximum backoff stages with varying network size. It has been observed that saturation throughput increases with maximum back off stages.RTS/CTS mechanism shows better performance as number of station increases for 1000 octet packet size. Basic access mechanism outperforms RTS/CTS mechanism only when number of nodes is less than 20[9].Thus RTS/CTS mechanism outperforms basic access scheme when network traffic is heavy under ideal conditions.

### 3.3 Effect of large interference range

Interference range is the range in which nodes in receiving mode is interfered by unrelated senders. Figure 4 shows that d is distance between sender and receiver, $R_i$is the interference range and $R_{tx}$ is transmission range in which nodes can successfully receive nodes at receiver.RTS/CTS mechanism is ideally used to reduce collisions due to hidden terminal problem only when hidden nodes are within the interference range of receiver. But practically it is not possible due to large interference range.

Authors in [10] has proved mathematically that network performance degrades with RTS/CTS mechanism when distance between sender and receiver i.e. d exceeds transmitter range. Authors have assumed 10db as capture threshold. Interference range is receiver centred. Large physical carrier sensing range helps in reducing interference. There is hardware limitation when large carrier sensing is considered. Single chain topology with 190 meters of inter nodal distance is shown in figure 5. Transmission range is 250 meters and interference range is 550 meters.

Channel utilization is 1/3 of capacity of chain without large interference range. This is because when node 1 transmits, node 2 and node 3 cannot transmit simultaneously.

Channel utilization is ¼ of capacity of chain with large interference range. The reason lies behind the fact that now node 4 also cannot simultaneously transmit along with node 2 and node 3.Large interference range results in more collisions on control frames and data frames which results in TCP instability and unfairness [11].Authors in [10] proposed CCR (Conservative CTS reply) scheme to combat large interference range. In this scheme a node only replies a CTS packet for a RTS when the receiving power of that RTS packet is larger than a certain threshold (CTS-REPLY-THRESHOLD), even if the RTS packet is received successfully and this node is idle. This CTS-REPLY-THRESHOLD should be larger than the threshold required for a node to successfully receive a packet. Many simulation experiments were performed which reduced most number of collisions.

Authors in [12] proposed Adaptive MAC layer scheme (AMAC) by analysing [10] .They simulated various experiments on chain topology and random topology to find the throughput and data packet corruption ratio. We observe that AMAC scheme is more effective in terms of throughput as compared to CCR scheme as it needs more hops to reach destination.

Thus collisions caused by large interference range are mostly reduced when RTS/CTS mechanism is applied with AMAC or CCR scheme.

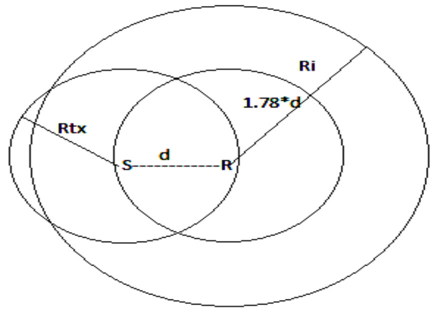


Figure 4 Effectiveness of RTS/CTS when d is larger than transmitting range

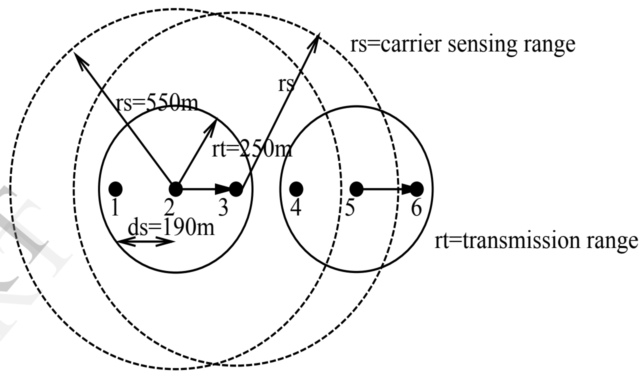


Figure 5 Effect of interference to capacity of chain



### 3.4 Effect of mobility of node

Authors in [13] performed simulations considering mobility of node with and without RTS/CTS mechanism. Hidden nodes are considered with simulation time of 800 seconds in chain topology. It is inferred from [13] that as node moves during 350 seconds to 650 seconds collisions occurred and hence retransmission of packets takes place. The author also concludes that retransmission attempts are 8 times lesser when RTS/CTS scheme is disabled. This happens because when RTS/CTS scheme is enabled, control packets transmission takes place which reduces number of collisions and therefore retransmissions of data packets reduces. Thus there is significant drop in collisions when RTS/CTS scheme is enabled. Hence RTS/CTS mechanism plays a vital role in hidden node problem when mobile nodes are considered.

### 3.5 Effect of fairness

Fairness is one of the major issues in adhoc networks. Fairness means sharing of channel utilization. In paper [14], authors have proposed new backoff scheme in 802.11 MAC standards. Fair share estimation is calculated at all nodes present in network. In new backoff scheme, if a node estimates that it has got more share, it will double its contention window size until it reaches a maximum value ($CW_{max}$) so that its neighbours can have more chances to recover earlier from backoff procedure and win access to the channel and vice versa. If a node estimates that it has got only its fair share, it will hold onto its current contention window size. Simulations results show that the new backoff scheme has achieved far better fairness than original backoff scheme. But this fairness is achieved at some cost of lower throughput.

In paper [15], authors have introduced fairness index that is useful in all resource allocation schemes. Jain's fairness index is unit for fairness as considered in [15].Particularly in distributed systems, where a set of resources is to be shared by a number of users, fair allocation is important. If goal is to provide the same throughput to all nodes, the fairness index is calculated as follows:

$$fairness\ index = \frac{(\sum T_i)^2}{\left(n\,(T_i{}^2)\right)}$$

where T is the throughput of a particular flow and n is the no of flows in the system. Authors in [5] have evaluated the fairness in grid and cross topologies. Fairness increased about 20% when RTS/CTS scheme is enabled.

Jain's fairness index decreases as number of hosts increases. This happens mainly due to the fact that after a collision, the first host that successfully transmits a frame is favored compared to the others but fairness index remains acceptable [17].Thus RTS/CTS scheme is beneficial in achieving fairness in grid and random topologies but it is not beneficial in chain topologies.

## 4. Conclusion and Future Scope

As we have seen several parameters has significant impact to network performance when RTS/CTS mechanism is taken into consideration. The main idea of enhancing the default RTS/CTS mechanism is to decrease the delay incurred by the additional load of the RTS and CTS packets before the actual transmission of the data packets and in turn increase the performance of the network. Use of RTS/CTS is beneficial in different situations. Thus it is not necessary to use RTS/CTS mechanism as it incurs network performance degradation when small size packets are transmitted.

Future scope in evaluating the performance of ad hoc networks with and without RTS/CTS mechanism in different possible directions can be done. It includes evaluating the effect on RTS/CTS when nodes are transmitted at different power levels. Evaluating the performance when arrival of order of frames at receiver is considered i.e. capture effect takes place.



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