An NS-3 Simulation-Based Study of Dependence of Throughput on Deployment Parameters in Ad-Hoc Wireless Networks

by

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Submitted to the Department of Computer Science and Engineering
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Abstract

Over the last few years, the importance of wireless ad-Hoc networks has increased. They are being studied significantly for academic research and commercial deployments. The ad-Hoc network is characterized by wireless multi-hop connectivity, no pre-existing infrastructure. It helps in providing a cost-effective wireless network along with large coverage area.

In this project, the network simulator NS-3 (dev) has been used to study the performance of wireless ad-Hoc network. We study the dependence of throughput on various deployment parameters like distance between the nodes, packet size, transmitted power and reception gain. The results would help us in choosing network parameter and protocols in designing wireless ad-Hoc networks.

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Approval Sheet

This report entitled An NS-3 Simulation-Based Study of Dependence of Throughput on Deployment Parameters in Ad-Hoc Wireless Networks by Droan Malik is approved for the degree of B.Tech in Computer Science and Engineering.

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Professor Shashi Prabh

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Declaration Sheet

I declare that this written submission represents my ideas in my own words and were others' ideas or words have been included, I have adequately cited and referenced the original sources. I also declare that I have adhered to all principles of academic honesty and integrity and have not misrepresented or fabricated or falsified any idea/data/fact/source in my submission. I understand that any violation of the above will be cause for disciplinary action by the Institute and can also evoke penal action from the sources which have thus not been properly cited or from whom proper permission has not been taken when needed

Droan Malik

Signature ....

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Chapter 1

Introduction

1.1 Overview

A wireless ad-Hoc network (WANET) or on-the-fly network is a peer to peer network that does not rely on any preexisting infrastructure. Instead each node participates in routing by forwarding packets from other nodes. There are no base stations;all nodes/network devices are free to associate with each other nodes in their range, making it a highly dynamic network network multi-hop topology. The route a packet takes is determined dynamically depending upon the network connectivity. changes made to the topology are adapted accordingly. This makes the ad-Hoc network extremely cost effective.

1.2 A Brief History

The first generation of wireless ad-Hoc network goes way back to the year 1972 [5]. It was also known as Packet Radio Network(PRNET). ALOHA (Areal Locations of Hazardous Atmospheres), CSMA (Carrier Sense Medium Access) and distance vector routing PRNET were used on a trial basis to provide different networking capabilities in a combat environment.

In the 1980s, ad-hoc networks were further improved and implemented as a part of SURAN (Survivable Adaptive Radio Networks) program. This provided a packetswitched network to the mobile battlefield in an environment without infrastructure which helped in improving radio performance and also made them cheaper and smaller.

In the 1990s, with the arrival of notebook computers, commercial ad-hoc networks were introduced. Along with that the idea of collection of mobile nodes was proposed at several research conferences.

The IEEE 802.11 subcommittee adopted the term ”ad-hoc networks” and research was started to look into the possibility of deploying ad-hoc networks in other areas of application.

Later on in the mid-1990s, the Mobile Ad-Hoc Networking working group was formed to standardize routing protocols for ad-hoc networks. The development of routing within the working group and the larger community resulted in the invention of reactive and proactive routing protocols.

Soon after, the IEEE 802.11 subcommittee standardized a medium access protocol that was based on collision avoidance and tolerated hidden terminals, making it usable for building mobile ad-hoc networks prototypes out of notebooks and 802.11 PCMCIA cards. HYPERLAN and Bluetooth were some other ad-hoc network standards that addressed and benefited ad-hoc networking.

1.3 Throughput

The throughput is the rate of successful message delivery over a communication channel. Its calculated by dividing the total received bytes by the difference between the time the first packet was sent and the last packet was received. The throughput of links varies because of various parameter link distances between the node, packet size being sent, power , and the reception gain. The nodes in this network compete for access to shared wireless medium which results in collision. Nodes in a mobile ad-Hoc network are free to roam about while communicating to one another The path between each pair of nodes can have multiple links.

1.4 Outline

The aim of this research is to evaluate the performance of wireless ad-Hoc network defined by IEEE 802.11. To do the above, throughput is evaluated by varying parameters like the distance between node, packet size, transmitted power and the reception gain.

Chapter 2 talks about the routing protocol used in the experiment. Chapter 3 discusses the RTS/CTS model which can help in reducing collisions. Chapter 4 talks about the software used (NS-3 dev) to carry the simulations. Chapter 5 contains a list of parameters used in the simulation along with the results obtained. Chapter 6 provides a conclusion.

Chapter 2

Routing in ad-hoc Network

Three protocolls have been accepted as experimental RFCs by the IETF [3]. Two of them include the AODV (Ad-Hoc On-Demand Distance Vector) and OLSR (Optimized Link State Routing Protocol) routing protocol. Both of them are based on well known algorithms from internet routing. AODV uses the principals from Distance Vector routing and the OLSR uses the principals of Link State routing. The third approach combines both of these protocols. This is called a hybrid protocol.

2.1 OLSR Routing Protocol

The simulations conducted in this project use the OLSR routing protocol. The OLSR is an IP routing protocol developed for mobile ad-hoc networks. It is a table driven, proactive protocol, i.e. it seeks to maintain a constantly updated topology [2]. The whole network is known to all the nodes.

The OLSR use the link-state scheme in an optimized manner to understand the topology of a network. Each node selects a set of neighbor nodes as MPR (Multipoint Relays). The nodes selected as MPRs are responsible for forwarding control traffic intended for diffusion into the entire network. [6]

Being a proactive, table-driven protocol, OLSR protocol deals with updating and maintaining information in different tables. The data in these tables is based on received control traffic. Control traffic is generated based on information retrieved from these tables. The rote calculation is also table-driven.[2]

The control messages include

2.1.1 HELLO

The HELLO messages are transmitted to all the neighbors and are used for neighbor sensing and MPR calculation.

2.1.2 TC

Topology Control messages (optimized in several ways using MPRs) are the link state signaling done by OLSR.

2.1.3 MID

For all nodes running OLSR on more than one interface, the Multiple Interface Declaration messages are transmitted. MID lists all IP addresses used by a node.

2.2 AODV Routing Protocol

The Ad-Hoc On-Demand Distance Vector routing protocol is a reactive, on-demand protocol. When a node has 0 transmit traffic to a host having no route, a RREQ (Route Request) message is generated, which is flooded to rest of the nodes. This results in dynamic control traffic. A route is considered found when the RREQ message reaches either the destination itself, or an intermediate node with a valid route entry for the destination.[4]

AODV defines three types of control messages for route maintenance:

2.2.1 RREQ

A node requiring a route to a node transmits the route request message. An expanding ring technique is used an optimization when flooding these messages. Every RREQ carries a time to live (TTL) value that states how many hops this message should be forwarded to. At the first transmission, this value is set to a predefined value and increased at retransmissions. Retransmissions occur if no replies are received.

Data packets waiting to be transmitted(i.e. the packets that initiated the RREQ) should be buffered locally and transmitted by a FIFO principal when a route is set.

2.2.2 RREP

A route reply message is unicasted back to the originator of a RREQ if the receiver is either the node using the requested address, or has a valid route to the requested address; as every route forwarding a RREQ caches a route back to the originator.

2.2.3 RERR

Nodes monitor the link status of next hops in active routes. When a link breakage in an active route is detected, a RERR message is used to notify other nodes of the loss of the link. In order to enable this reporting mechanism, each node keeps a “precursor list”, containing the IP address for each its neighbors that are likely to use it as a next hop towards each destination.

Chapter 3

RTS/CTS

CSMA/CD (CSMA with Collision Detection) breaks down in wireless networks due to hidden node and exposed nodes problems.

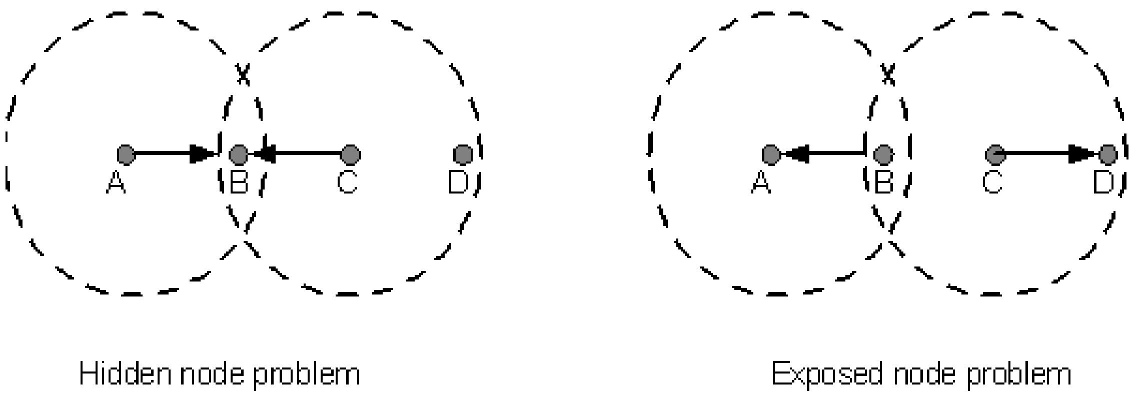

Figure 3-1:

3.1 Hidden Node Problem

In the case of wireless network it is possible that A is sending a message to B, but C is out of its range and hence while ”listening” on the network it will find the network to be free and might try to send packets to B at the same time as A. So, there will be a collision at B. The problem can be looked upon as if A and C are hidden from each other. Hence it is called the “hidden node problem”.[7]

3.2 Exposed Node Problem

If C is transmitting a message to D and B wants to transmit a message to A, B will find the network to be busy as B hears C transmitting. Even if B would have transmitted to A, it would not have been a problem at A or D. CSMA/CD would not allow it to transmit message to A, while the two transmissions could have gone in parallel.

3.3 Addressing hidden node problem (CSMA/CA)

Consider the figure above.Suppose A wants to send a packet to B. Then it will first send a small packet to B called "Request to Send" (RTS). In response, B sends a small packet to A called "Clear to Send" (CTS). Only after A receives a CTS, it transmits the actual data. Now, any of the nodes which can hear either CTS or RTS assume the network to be busy. Hence even if some other node which is out of range of both A and B sends an RTS to C (which can hear at least one of the RTS or CTS between A and B), C would not send a CTS to it and hence the communication would not be established between C and D. One issue that needs to be addressed is how long the rest of the nodes should wait before they can transmit data over the network. The answer is that the RTS and CTS would carry some information about the size of the data that B intends to transfer. So, they can calculate time that would be required for the transmission to be over and assume the network to be free after that.Another interesting issue is what a node should do if it hears RTS but not a corresponding CTS. One possibility is that it assumes the recipient node has not responded and hence no transmission is going on, but there is a catch in this. It is possible that the node hearing RTS is just on the boundary of the node sending CTS. Hence, it does hear CTS but the signal is so deteriorated that it fails to recognize it as a CTS. Hence to be on the safer side, a node will not start transmission if it hears either of an RTS or a CTS.

The assumption made in this whole discussion is that if a node X can send packets to a node Y, it can also receive a packet from Y, which is a fair enough assumption given the fact that we are talking of a local network where standard instruments would be used. If that is not the case additional complexities would get introduced in the system.

Chapter 4

Network Simulator

NS-3 is a discrete-event network simulator for Internet systems, targeted primarily for research and educational use. NS-3 is free software, licensed under the GNU GPLv2 license, and is publicly available for research, development, and use.

NS-3 has been developed to provide an open, extensible network simulation platform, for networking research and education. In brief, NS-3 provides models of how packet data networks work and performs, and provides a simulation engine for users to conduct simulation experiments. Some of the reasons to use NS-3 include to perform studies that are more difficult or not possible to perform with real systems, to study system behavior in a highly controlled, reproducible environment, and to learn about how networks work.

4.1 Simulation Environment Setup

The main parameters that where kept constant in the experiment include:

- Wifi Standard - IEEE 802.11 b
- Non-QoS
- Adhoc
- Mobility model - Grid (5 X5)

- Routing protocol - OLSR
- Energy Detection Threshold = -96 dBm
- CCA Mode Threshold = -99 dBm
- TxGain = 1dBm
- RxGain = 1dBm
- TxPower Level = 1

4.2 Procedure

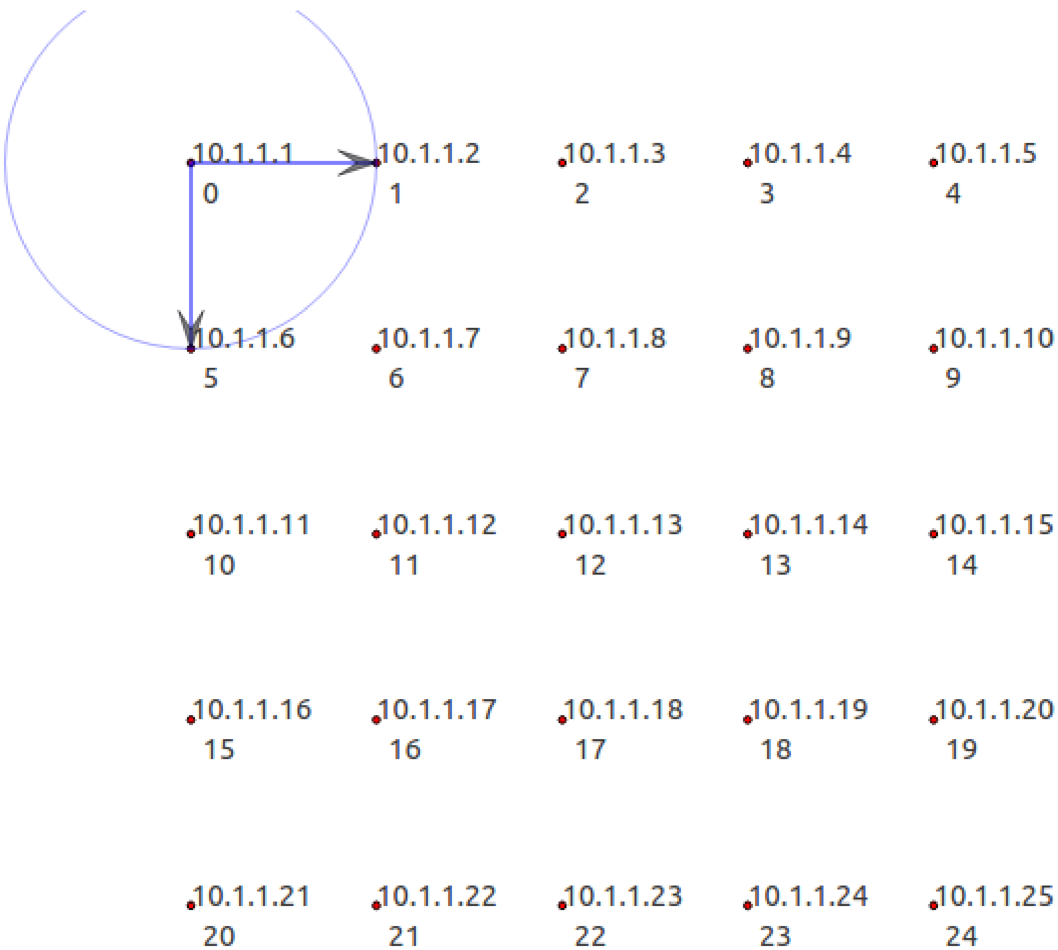

Figure 4-1: Network Topology

Various simulations where then conducted by using a bash script to run the core NS3 script a number of time. The dependence of throughput on various deployment parameters was thus calculated[1]. The parameters for calculating the variation in throughput taken into consideration where:

- Distance
- Packet Size
- Transmitter Power
- Receptor Gain

The throughput was also caculated by varing the number of flows (from one to three) and also by changing the DSSS rate from 1 Mbps to 2Mbps.

The complete code can be downloaded at https://github.com/droanmalik/adhocExperiment

Chapter 5

Result

5.1 Throughput in IEE 802.11 ad-Hoc network: Single flow investigation and DSSS rate being 1Mbps

In multi-hop ad-Hoc network, source node can inject much more traffic than that network can handle. This can lead to high packet loss rate and decrease in throughput. In this section, a 25 node grid topology (5 X 5) network is used. The nodes communicate using wireless radio based IEEE 802.11b, with data and basic rates set to 1Mb/s. OLSR Routing protocol is used. The flow of packet was from node 0 to node 25.

5.1.1 Throughput VS Distance with RTS/CTS tuned off

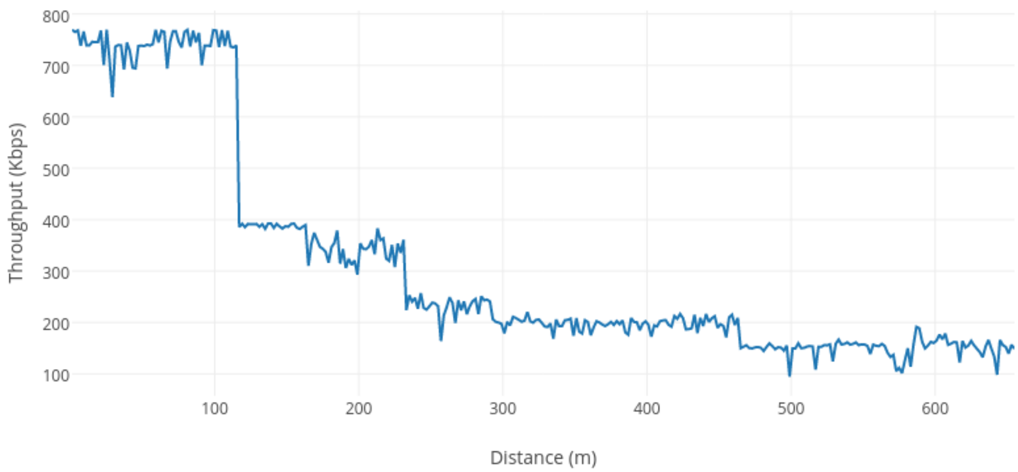

Figure 5-1: Throughput VS Distance with RTS/CTS tuned off

Constant parameters: Transmission Power: 16 dBm Packet Size: 600 bytes Reception Gain: -10 dB Packet Interval: 0.001 second Number of Packets: 100000000

Variable parameter: Distance: 1 m to 700 m

The RTS/CTS mechanism is turned off. Nodes are stationary. The OLSR routing protocol is used.

We notice that the throughput decreases as the distance between nodes increases. At a distance of 110 m the throughput drops significantly. The throughput for distance from 1 to 110m is higher as these can be covered in a single hop. The number of hops increases as the distance increase leading to decline in throughput.

5.1.2 Throughput VS Distance with RTS/CTS tuned On

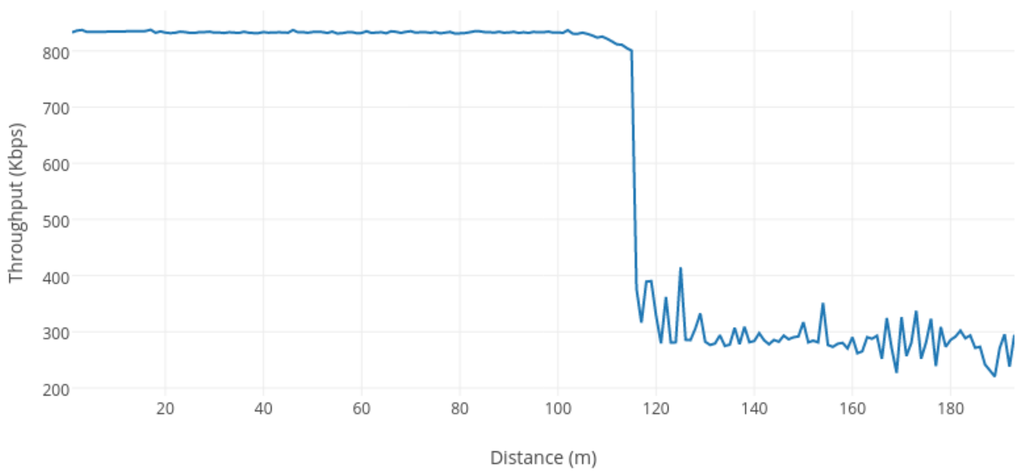

Figure 5-2: Throughput VS Distance with RTS/CTS tuned on

Constant parameters: Transmission Power: 16 dBm Packet Size: 600 bytes Reception Gain: -10 dB Packet Interval: 0.001 second Number of Packets: 100000000

Variable parameter: Distance: 1 m to 200 m

The RTS/CTS mechanism is turned on. Nodes are stationary. The OLSR routing protocol is used.

We notice that the throughput decreases as the distance between nodes increases. This shows that when the node distance is less than 110m, the packet can be transmitted and recieved in a single hop.

5.1.3 Comparing Throughput VS Distance for CTS/RTS turned on and off

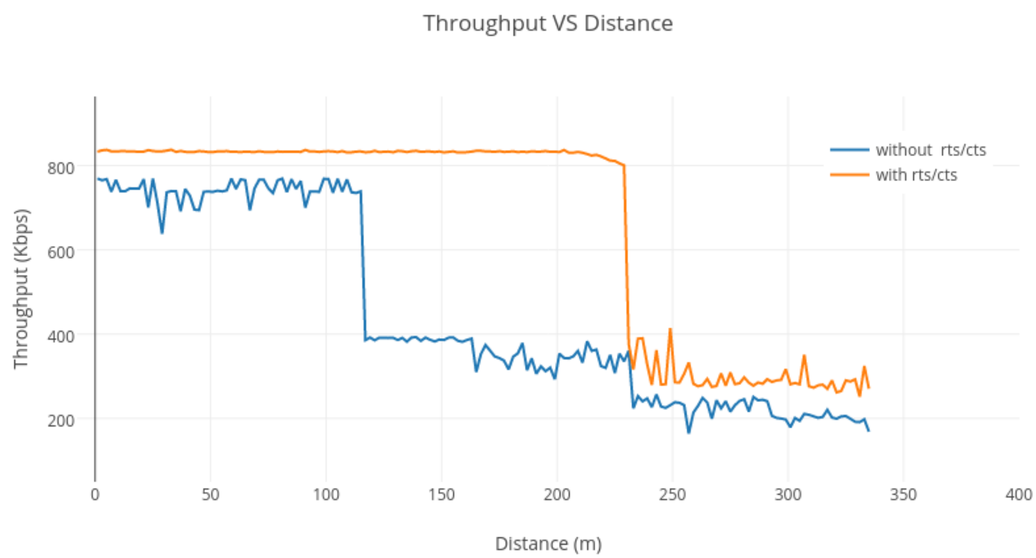

Figure 5-3: Comparing Throughput VS Distance for CTS/RTS turned on and off

On comparing the throughput with and without RTS/CTS mechanism, it was observed that the network with RTS/CTS performs much better than the network without RTS/CTS. This could be because of the decrease in the number of collisions and avoidance of the hidden node problem.

5.1.4 Comparing Throughput VS Packet Size with RTS/CTS turned off

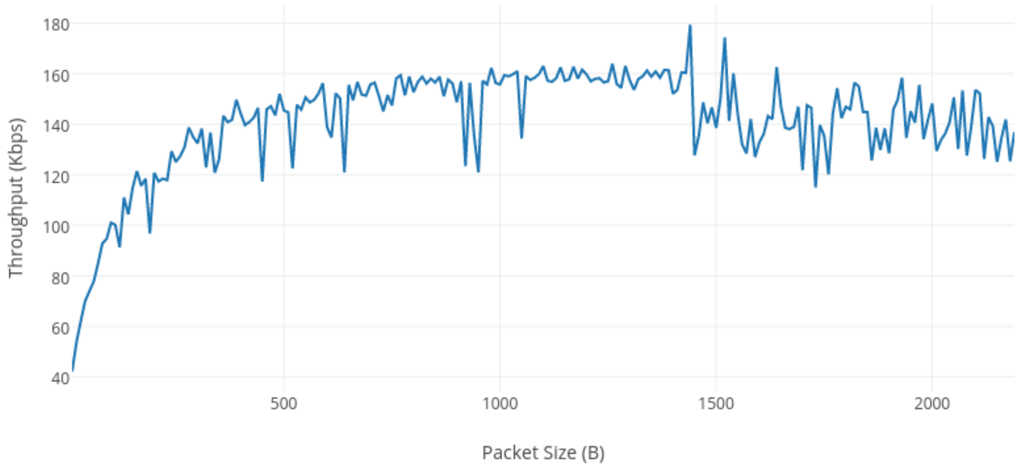

Figure 5-4: Comparing Throughput VS Packet Size with RTS/CTS turned off

Constant parameters: Transmission Power: 16 dBm Reception Gain: -10 dB Packet Interval: 0.001 seconds Number of Packets: 100000000 Distance: 500m Variable parameter: Packet Size: 1 to 2500 bytes

The RTS/CTS mechanism is turned on. Nodes are stationary. The OLSR routing protocol is used.

We noticed that the initially as the packet size is increased, the throughput increases till 1500 packet size. As the size of the transmitted packet increased beyond some limit, the throughput starts to degrade. The throughput falls when the packet size exceed a certain limit as the size of the packet is so large that even a single packet loss can decrease the throughput drastically.

5.1.5 Comparing Throughput VS Power with RTS/CTS turned off

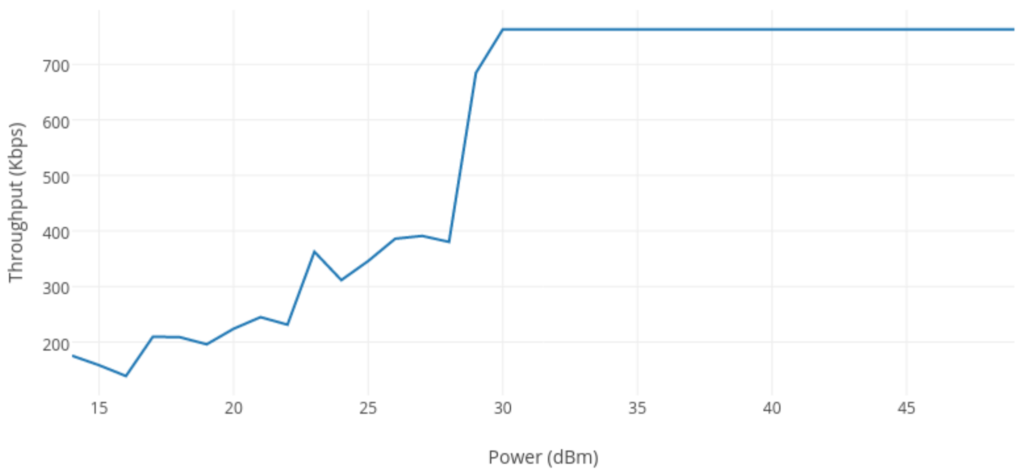

Figure 5-5: Comparing Throughput VS Power with RTS/CTS turned off

Constant parameters: Distance: 500 m Packet Size: 600 bytes Reception Gain: -10 dB Packet Interval: 0.001 seconds Number of Packets: 100000000

Variable parameter: Transmitted Power: 1 dBm to 50 dBm

The RTS/CTS mechanism is turned off. Nodes are stationary. The OLSR routing protocol is used.

As the transmitted power increases ,packets are propagated over larger distances. For long distances, increasing the transmitted power increases the throughput. However increasing the power can also lead to interference from the neighbors that use the same frequency

5.1.6 Comparing Throughput VS Power with RTS/CTS turned on

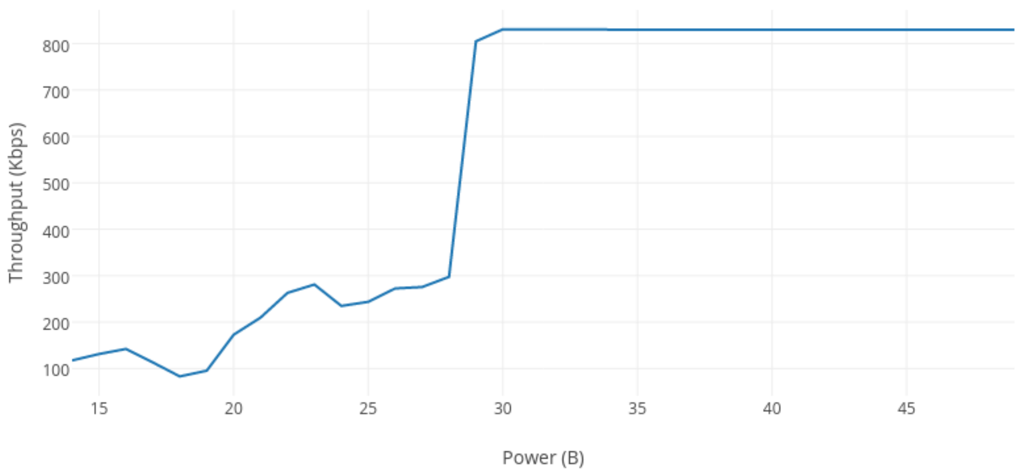

Figure 5-6: Comparing Throughput VS Power with RTS/CTS turned on

Constant parameters: Distance: 500 m Packet Size: 600 bytes Reception Gain: -10 dB Packet Interval: 0.001 seconds Number of Packets: 100000000

Variable parameter: Transmitted Power: 1 dBm to 50 dBm

The RTS/CTS mechanism is turned on. Nodes are stationary. The OLSR routing protocol is used.

As the transmitted power ,packets are propagated over larger distances. For long distances, increasing the transmitted power increases the throughput.

5.1.7 Comparing Throughput VS Power for CTS/RTS turned on and off together

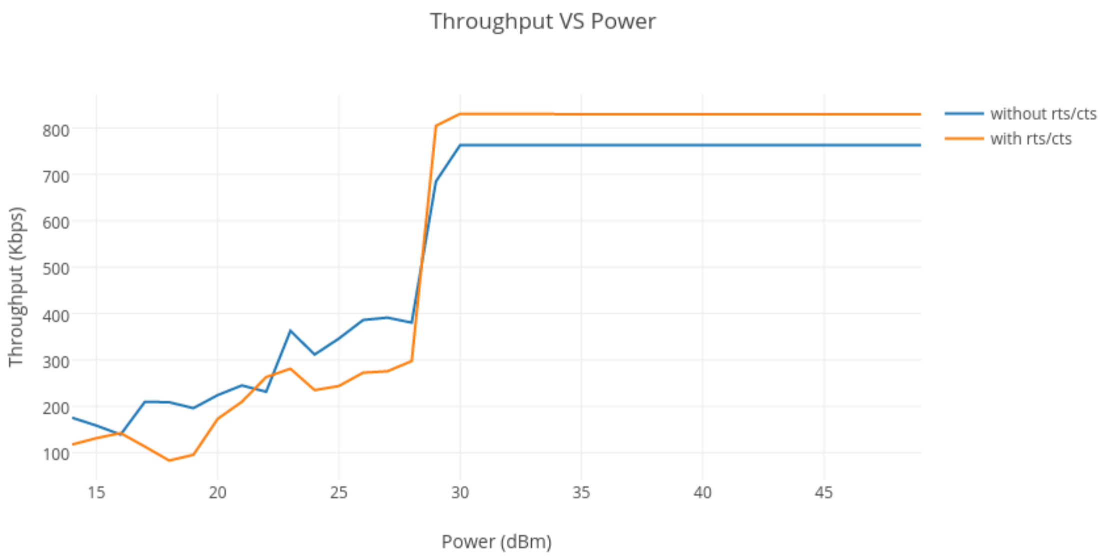

Figure 5-7: Comparing Throughput VS Power for CTS/RTS turned on and off together

On comparing the throughput with and without RTS/CTS mechanism, it was observed that the network without RTS/CTS performs much better than the network without RTS/CTS till around 27dBm. After 27dBm, network with RTS/CTS performs better.

5.1.8 Comparing Throughput VS RxGain with RTS/CTS turned on

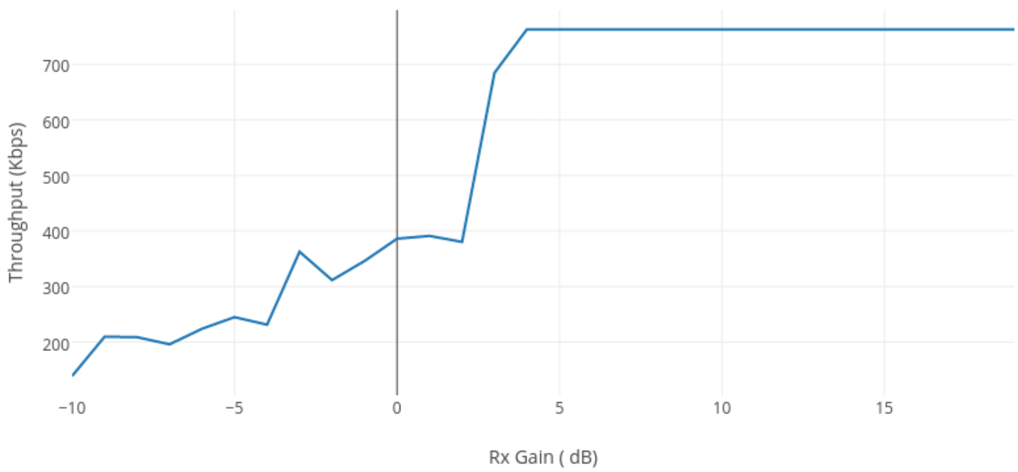

Figure 5-8: Comparing Throughput VS RxGain with RTS/CTS turned on

Constant parameters: Distance: 500 m Packet Size: 600 bytes Packet Interval: 0.001 seconds Number of Packets: 100000000 Transmitted Power: 1 dBm to 50 dBm

Variable parameter: Reception Gain: -10 dB to 20dB

The RTS/CTS mechanism is turned on. Nodes are stationary. The OLSR routing protocol is used.

As the RxGain increases, the throughput also increases and after 4dB becomes constant.

5.1.9 Comparing Throughput VS RxGain with RTS/CTS turned off

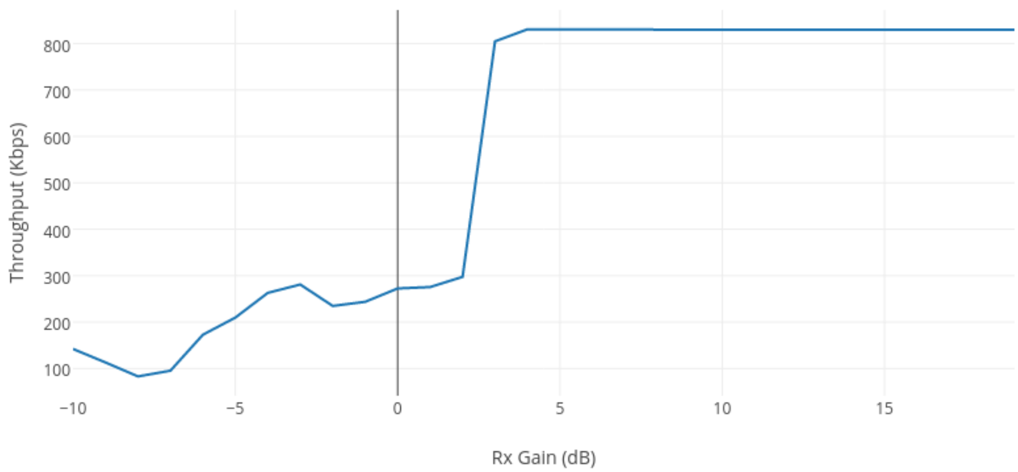

Figure 5-9: Comparing Throughput VS RxGain with RTS/CTS turned off

Constant parameters: Distance: 500 m Packet Size: 600 bytes Packet Interval: 0.001 seconds Number of Packets: 100000000 Transmitted Power: 1 dBm to 50 dBm

Variable parameter: Reception Gain: -10 dB to 20dB

The RTS/CTS mechanism is turned on. Nodes are stationary. The OLSR routing protocol is used.

As the RxGain increases, the throughput also increases and after 3dB becomes constant.

5.1.10 Comparing Throughput VS Rx-gain for CTS/RTS turned on and off together

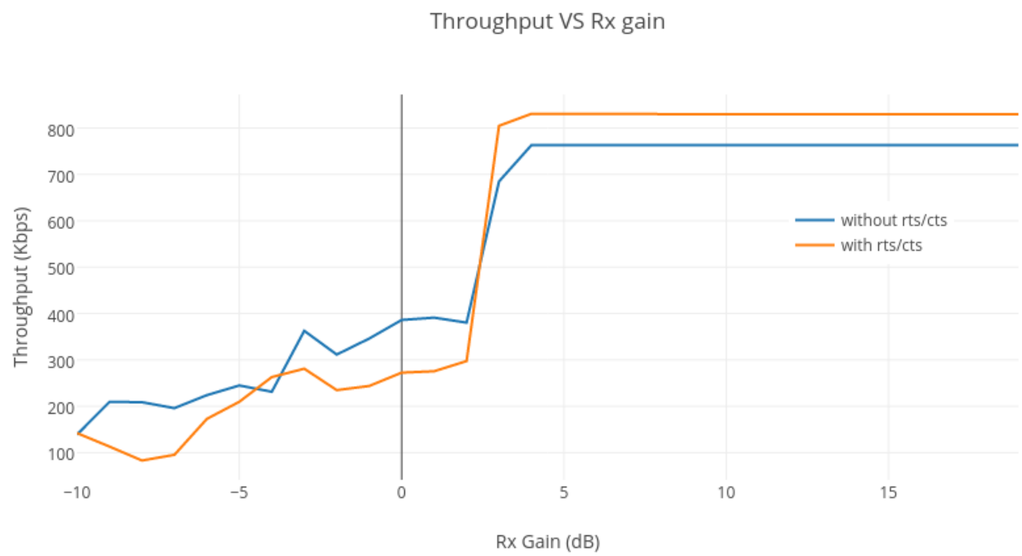

Figure 5-10: Comparing Throughput VS Rx-gain for CTS/RTS turned on and off together

On comparing the throughput with and without RTS/CTS mechanism, it was observed that the network without RTS/CTS performs much better than the network with RTS/CTS till around 3 dB. After 3 dB, network with RTS/CTS performs better.

5.2 Throughput in IEE 802.11 ad-Hoc network :Single flow investigation and DSSS rate being 2Mbps

In multi-hop ad-Hoc network, source node can inject much more traffic than that network can handle. This can lead to high packet loss rate and decrease in throughput. In this section, a 25 node grid topology (5 X 5) network is used. The nodes communicate using wireless radio based IEEE 802.11b, with data and basic rates set to 2Mb/s. OLSR Routing protocol is used. The flow of packet was from node 0 to node 25.

5.2.1 Comparing Throughput VS Packet Size with RTS/CTS turned off

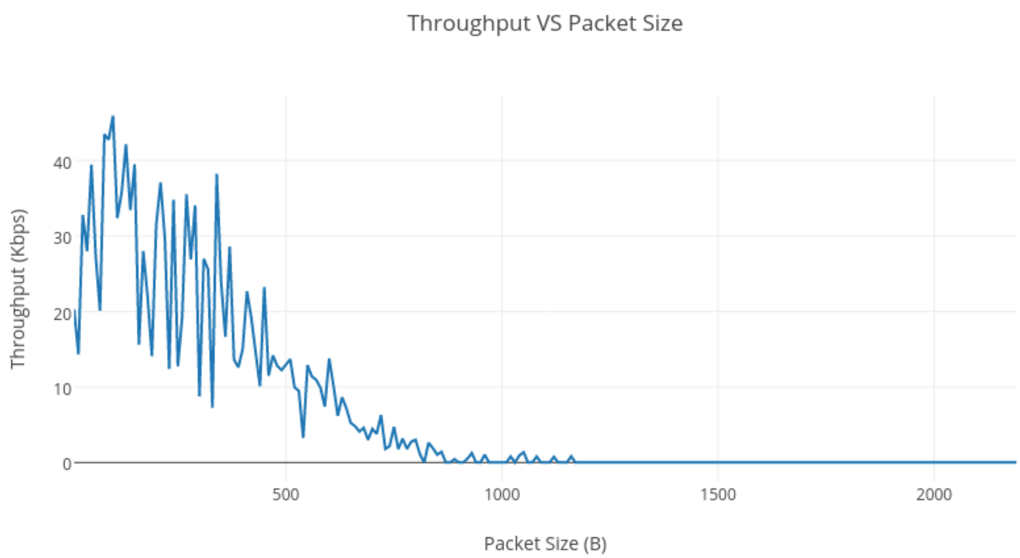

Figure 5-11: Comparing Throughput VS Packet Size with RTS/CTS turned off

Constant parameters: Transmission Power: 16 dBm Reception Gain: -10 dB Packet Interval: 0.001 seconds Number of Packets: 100000000 Distance: 500m

Variable parameter: Packet Size: 1 to 2500 bytes

The RTS/CTS mechanism is turned on. Nodes are stationary. The OLSR routing protocol is used.

We noticed that the initially as the packet size is increased, the throughput increases till 200 B packet size. As the size of the transmitted packet increased beyond some limit, the throughput starts to degrade

5.2.2 Comparing Throughput VS Power with RTS/CTS turned off

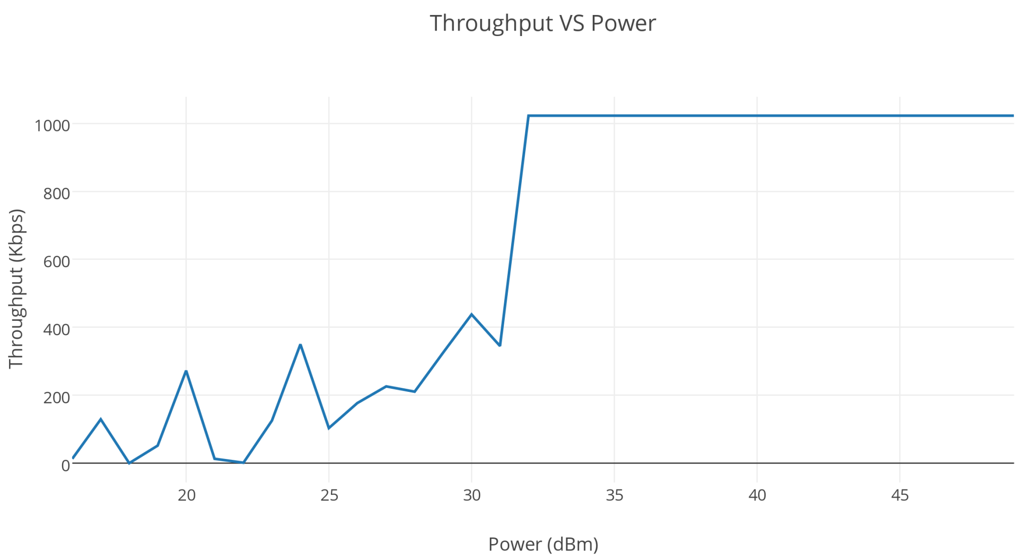

Figure 5-12: Comparing Throughput VS Power with RTS/CTS turned off

Constant parameters: Distance: 500 m Packet Size: 600 bytes Reception Gain: -10 dB Packet Interval: 0.001 seconds Number of Packets: 100000000

Variable parameter: Transmitted Power: 1 dBm to 50 dBm

The RTS/CTS mechanism is turned off. Nodes are stationary. The OLSR routing protocol is used.

As the transmitted power increases ,packets are propagated over larger distances. For long distances, increasing the transmitted power increases the throughput. However increasing the power can also lead to interference from the neighbors that use the same frequency

5.2.3 Comparing Throughput VS Power with RTS/CTS turned on

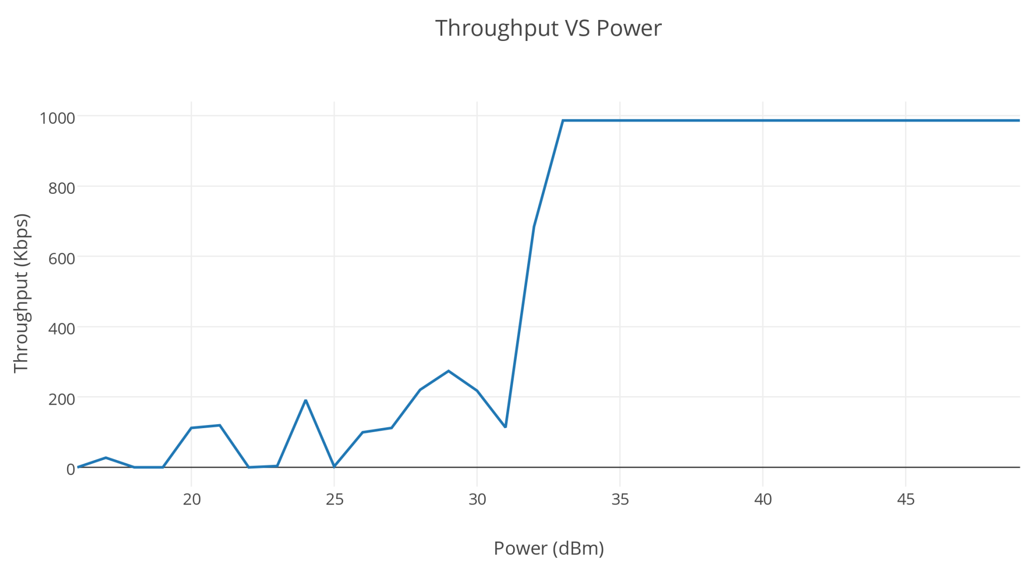

Figure 5-13: Comparing Throughput VS Power with RTS/CTS turned on

Constant parameters: Distance: 500 m Packet Size: 600 bytes Reception Gain: -10 dB Packet Interval: 0.001 seconds Number of Packets: 100000000

Variable parameter: Transmitted Power: 1 dBm to 50 dBm

The RTS/CTS mechanism is turned on. Nodes are stationary. The OLSR routing protocol is used.

As the transmitted power ,packets are propagated over larger distances. For long distances, increasing the transmitted power increases the throughput.

5.2.4 Comparing Throughput VS Power for CTS/RTS turned on and off together

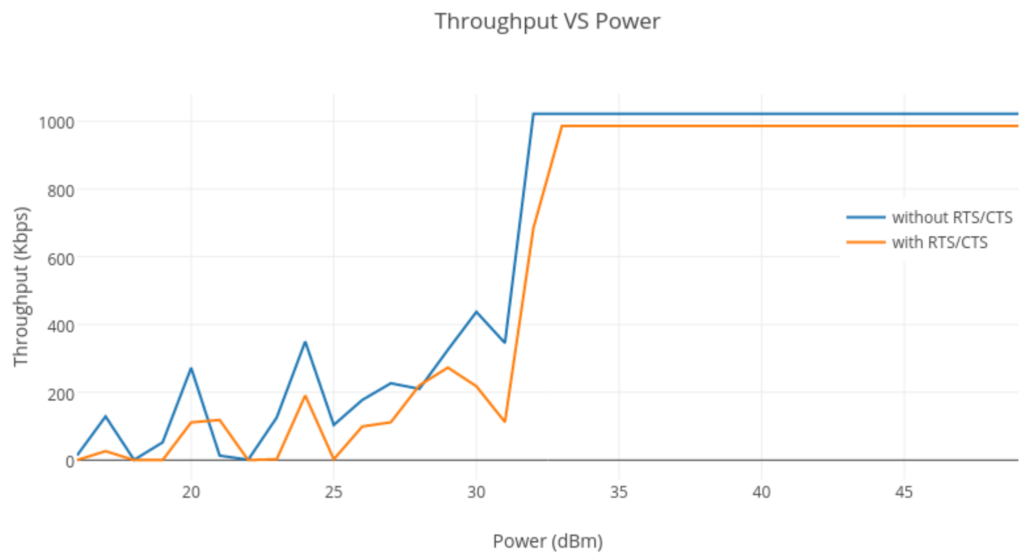

Figure 5-14: Comparing Throughput VS Power for CTS/RTS turned on and off together

Network without RTS/CTS enabled shows better throughput than the network with RTS/CTS. Thus a RTS/CTS enabled network does not always produce better throughput than a network with RTS/CTS disabled.

5.2.5 Comparing Throughput VS Rx-gain with RTS/CTS turned off

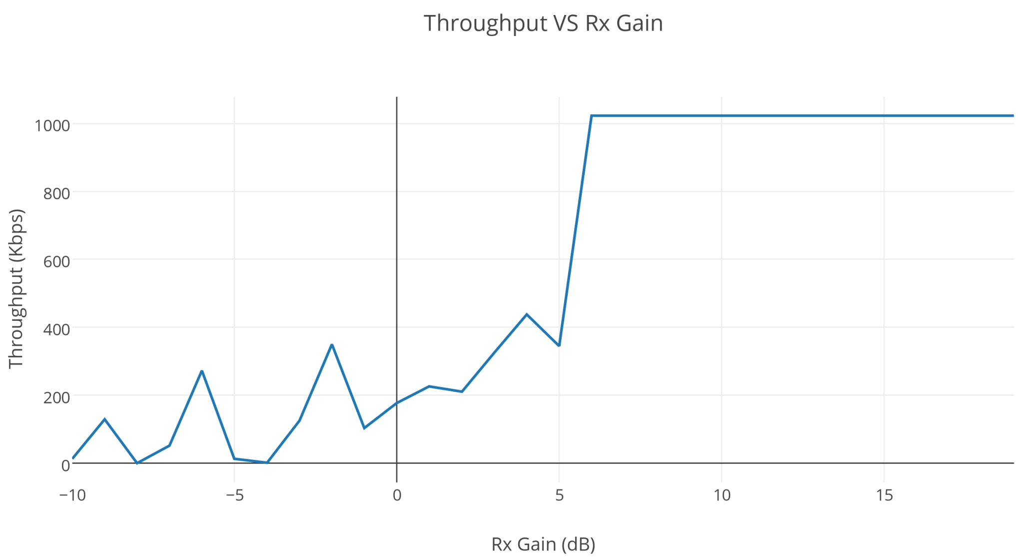

Figure 5-15: Comparing Throughput VS Rx-gain with RTS/CTS turned off

Constant parameters: Distance: 500 m Packet Size: 600 bytes Packet Interval: 0.001 seconds Number of Packets: 100000000 Transmitted Power: 1 dBm to 50 dBm

Variable parameter: Reception Gain: -10 dB to 20dB

The RTS/CTS mechanism is turned off. Nodes are stationary. The OLSR routing protocol is used.

As the Rx-gain increases, the throughput also increases and after 6dB becomes constant.

5.2.6 Comparing Throughput VS Rx-gain with RTS/CTS turned on

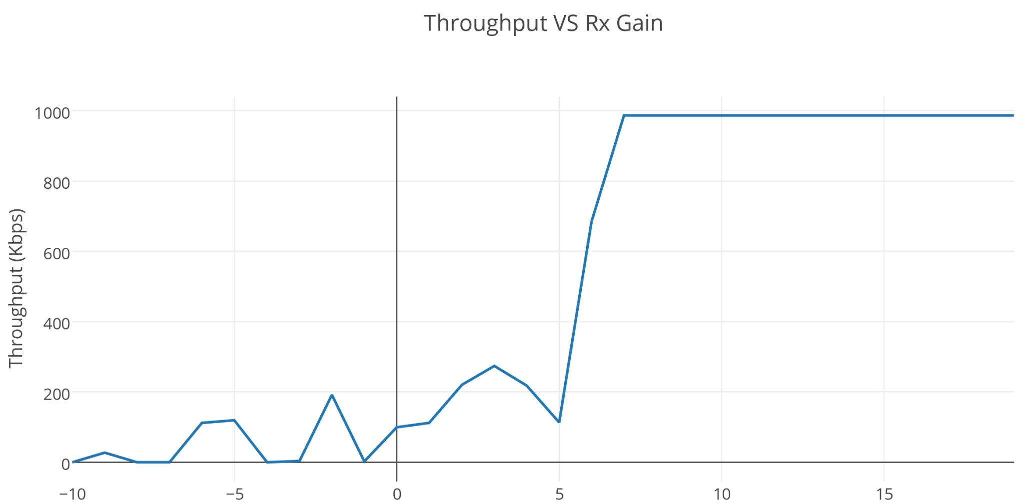

Figure 5-16: Comparing Throughput VS Rx-gain with RTS/CTS turned on

Constant parameters: Distance: 500 m Packet Size: 600 bytes Packet Interval: 0.001 seconds Number of Packets: 100000000 Transmitted Power: 1 dBm to 50 dBm

Variable parameter: Reception Gain: -10 dB to 20dB

The RTS/CTS mechanism is turned on. Nodes are stationary. The OLSR routing protocol is used.

As the Rx-gain increases, the throughput also increases and after 8dB becomes constant.

5.2.7 Comparing Throughput VS Rx-gain for CTS/RTS turned on and off together

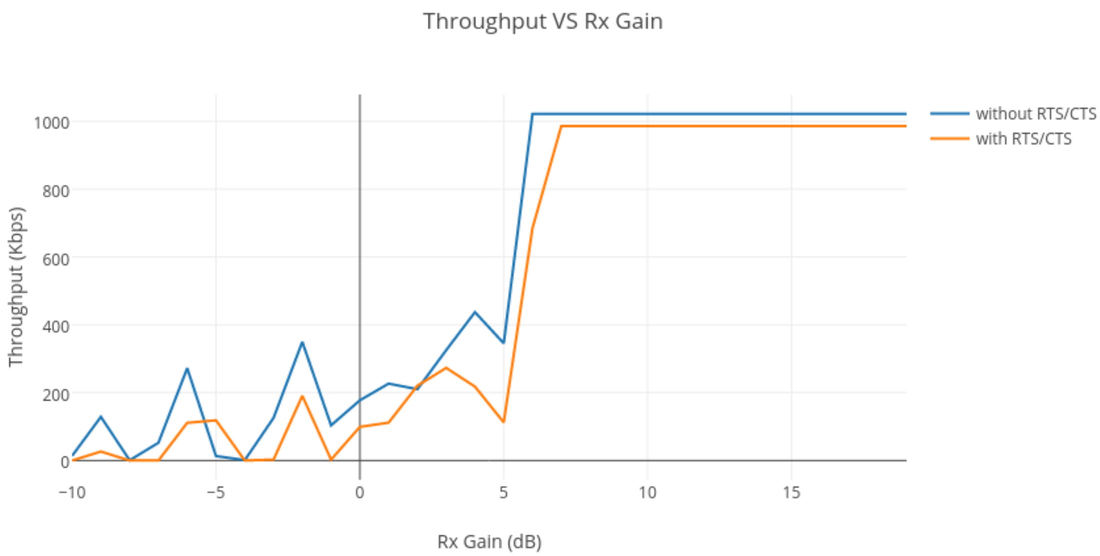

Figure 5-17: Comparing Throughput VS Rx-gain for CTS/RTS turned on and off together

On comparing the throughput with and without RTS/CTS mechanism, it was observed that the network without RTS/CTS performs marginally better than the network with RTS/CTS.

5.3 Throughput in IEEE 802.11 ad-Hoc network:Multi flow investigation and DSSrate = 1 Mbps

In multi-hop ad-Hoc network, source node can inject much more traffic than that network can handle. This can lead to high packet loss rate and decrease in throughput. In this section, a 25 node grid topology (5 X 5) network is used. The nodes communicate using wireless radio based IEEE 802.11b, with data and basic rates set to 1Mb/s. OLSR Routing protocol is used. The flow of packet was from node 0 to node 25. The flow is from Node 0 to Node 11, Node 20 to Node 17, Node 24 to Node 12. This setup increases interference.

5.3.1 Comparing Throughput VS Packet Size with RTS/CTS turned off

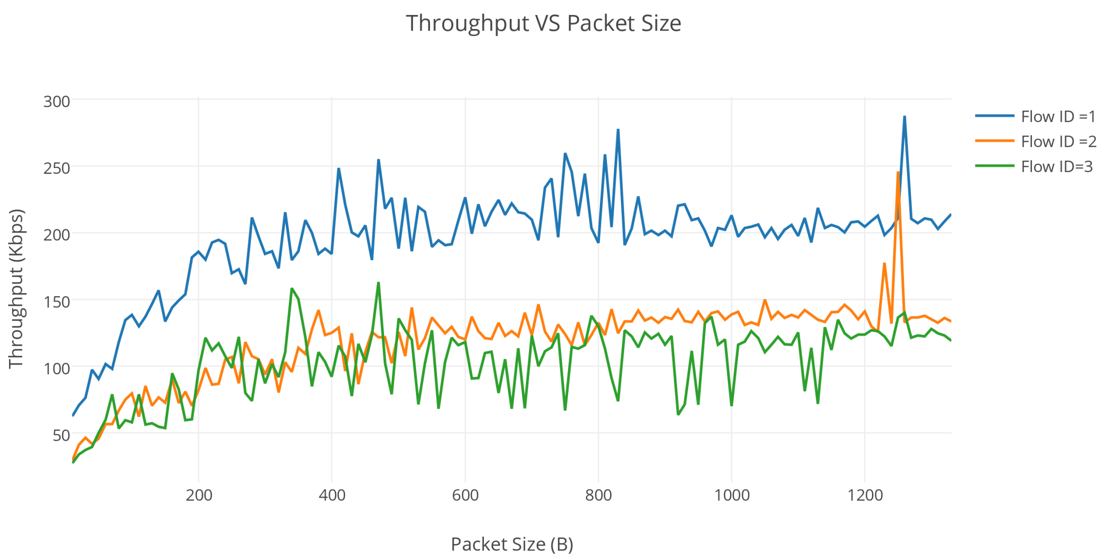

Figure 5-18: Comparing Throughput VS Packet Size with RTS/CTS turned off

Constant parameters: Transmission Power: 16 dBm Reception Gain: -10 dB Packet Interval: 0.001 seconds Number of Packets: 100000000 Distance: 500m

Variable parameter: Packet Size: 1 to 1400 bytes

The RTS/CTS mechanism is turned on. Nodes are stationary. The OLSR routing protocol is used.

We notice that the overall throughput is almost equal when compared to the networks with one flow.

5.3.2 Comparing Throughput VS Power with RTS/CTS turned off

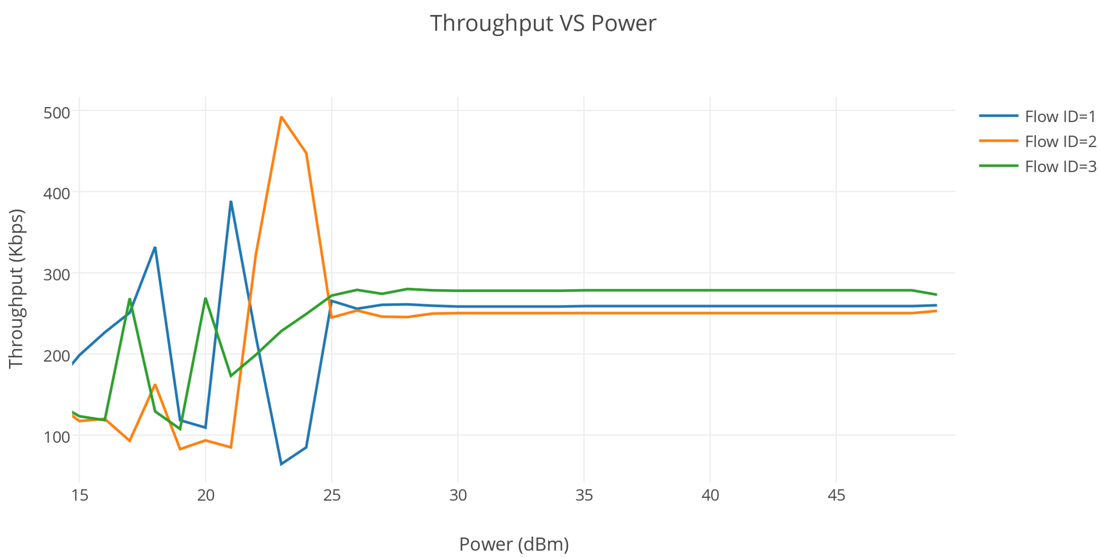

Figure 5-19: Comparing Throughput VS Power with RTS/CTS turned off

Constant parameters: Distance: 500 m Packet Size: 600 bytes Reception Gain: -10 dB Packet Interval: 0.001 seconds Number of Packets: 100000000

Variable parameter: Transmitted Power: 1 dBm to 50 dBm

The RTS/CTS mechanism is turned off. Nodes are stationary. The OLSR routing protocol is used.

We notice that the overall throughput is almost equal when compared to the networks with one flow. The throughput becomes constant after 25 dBm

5.3.3 Comparing Throughput VS RxGain with RTS/CTS turned off

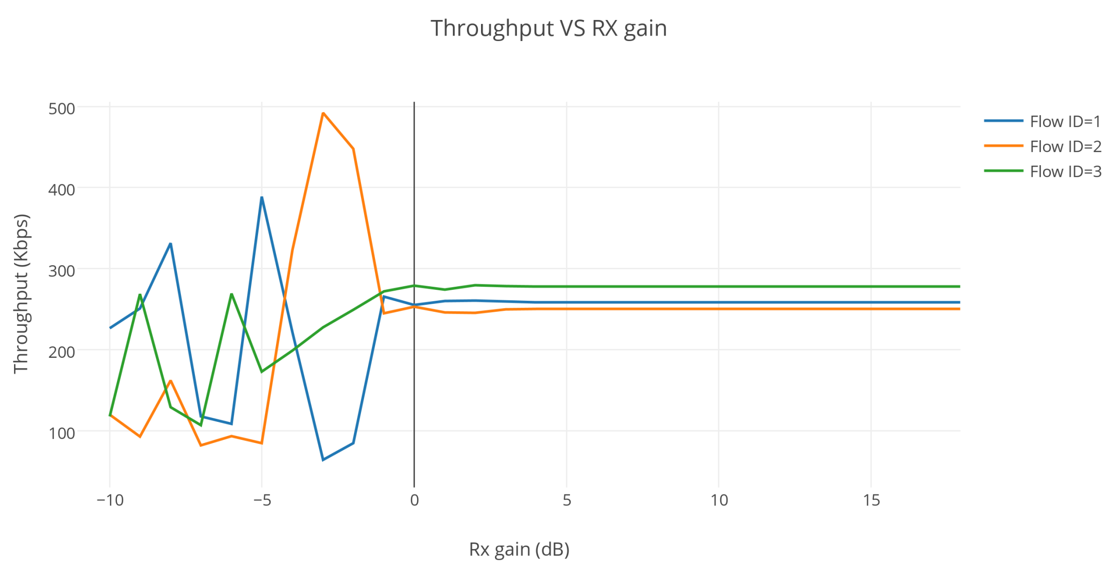

Figure 5-20: Comparing Throughput VS RxGain with RTS/CTS turned off

Constant parameters: Distance: 500 m Packet Size: 600 bytes Packet Interval: 0.001 seconds Number of Packets: 100000000 Transmitted Power: 1 dBm to 50 dBm

Variable parameter: Reception Gain: -10 dB to 20dB

The RTS/CTS mechanism is turned off. Nodes are stationary. The OLSR routing protocol is used.

We notice that the overall throughput is almost equal when compared to the networks with one flow. The throughput becomes constant after 5 dB

Chapter 6

Conclusion

These simulations with wireless adhoc networks suggests that their capacity can be surprisingly low because of the requirement that the nodes need to forward each others packets. This achievable throughout can depend on various deployment parameters like distance between nodes, packet size being sent, number of interference(number of flows), transmitted power and reception gain. This paper examined these parameters by running simulations in NS-3. A comparison between network with RTS/CTS and without RTS/CTS enabled was made for a single as well as multiple flows.The generated simulation results can be used to see the trade-offs in choosing various protocols. These results can be used in making decisions of the protocols to be used depending on the network requirement and characteristic.

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