Experimenting and Testing Clicker application on Aakash for wireless network


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by

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Declaration

I declare that this written submission represents my ideas in my own words and where other’s 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.

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Abstract

In this project I have studied the behaviour of wireless network while communicating with laptop and Aakash tablets for Clicker quiz. For this I have considered various interference factors which affects the performance of data transfer in wireless medium. In this interference from Bluetooth and WiFi was studied and its affect on throughput by conducting set of experiments. The performance of TPLink wireless router was also measured for its range and Signal strength by carrying out set of experiments. The available TPLink wireless router was also compared with other DLink wireless router to compare of the efficiency of the router. In the project Clicker code was also analysed and some improvements are suggested to improve throughput of the application. As Clicker quiz has to provide connectivity to various tablets scattered in a big hall, networking configurations of routers have also been suggested for better and reliable connectivity.
I would like to express my sincere gratitude to my guide Prof. D.B. Phatak for his constant encouragement and corrective guidance. He has been my primary source of motivation and advice during my project. I would like to thank Mr. Nagesh Karmali for constant guidance without which this project could have been more difficult. I also want to thank god and my parents for their blessings.
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Chapter 1

INTRODUCTION

The project is on allowing multiple tablets connectivity through WiFi for conduct of Clicker quiz on Aakash tablets in a classroom environment. Clicker quiz is a browser application for conducting quiz. It aims to improve learning methods in classroom environment by conducting questionnaire or quiz in the class during the lecture to assess how much lecture contents are grasped by students. This quiz application allows the professor to conduct a questionnaire for students, gathering answers from each students, and checking the responses. This aids professors in knowing how the class was conducted by him and knowing the grasping level of each student in the lecture. As the responses from each students are stored in database this quiz helps in taking attendance in the lecture. This quiz can be conducted in a large class size for students where the professor is able to view students understanding of the lecture topic with the help of their responses during the quiz. Quiz results in the class can be saved in database and can be displayed in various graphs like line diagram, bar chart, pie charts etc.

The aim of Clicker application development is to have an another channel of communication between student and professor, which helps the professor in conducting the classroom sessions more effectively by quiz application. It is an application in which large number of students attending the class will be able to participate in the classroom quiz with minimum hassles in very less amount of time. It also provides an opportunity for students from remote centers to participate in the classroom quiz conducted from central location or through IIT Bombay server. Clicker application enables the professor to change their teaching methodology based on students grasping level in the lecture by their quiz responses.

1.1 Problem statement

Only a few and limited number of Aakash tablets that can be reliably communicated to a single WiFi access point during Clicker Quiz. This project is a research towards allowing multiple Aakash tablets being able to establish connection and communicate reliably during the entire duration of quiz.

1.2 Approach

The Clicker database resides in IIT Bombay server where it is connected to wired routers. These routers are connected to other routers to provide connections in various departments. Inside the
department they are connected with wireless Access Points for wireless connectivity through ethernet
cable. These Access points in a classroom allows wireless medium for connectivity to all the tablets
participating in the quiz. The testing of quiz data transfer from server to the tablets is to be done
as follows:-

- Testing wired router for its performance and throughput.
- Testing wireless router for its performance and throughput.
- Studying the effects of interference on wireless network.
- Suggesting wireless routers topology for reliable connectivity.

1.3 Motivation

The motivation behind this work is to find the problem at the networking level and plugging it, so
that not even a single student is deprived of connection during the quiz and make clicker a widely
accepted quizzing application. If connectivity is available then the professor should be able to dispaly
important questions online instantaneously about the lecture covered by him. The remote centres
in India where several students spent their valuable time in getting online classes and attend Clicker
quiz should find it worth by having reliable connection to server.

1.4 Organisation of Thesis

This section is followed by Chapter 2 where I have explained IEEE 802.11 protocol. It also explains
CSMA/CA scheme for data communication, Virtual carrier sense mechanism and Fragmentation
of packet for transmission. The concept of joining a wireless device to an Access Point is also
explained in detail. The literary survey done for the project is put in Chapter 3 of the thesis. It
has various content of journal papers related to this topic. Clicker Quiz Architecture is mentioned
in the Chapter 4 wherein installation and setting up of machine is explained. Thereafter flow of quiz
is explained followed by complete process of launching the quiz from server to the tablet. Chapter
5 covers experiment conducted on wired routers which are available at the backbone of any network
for providing server access for any application. Those experiment brings out the Throughput, Delay,
Latency and Jitter for these routers which ensures reliable connectivity and data rates. Chapter
6 covers basic concept of wireless routers like WiFi signals, configuring wireless router and wireless
router performance. Chapter 7 mentions about experiments and testing carried out by me on
wireless routers with various range and in presence of interference. Chapter 8 deals with testing of
Clicker application load in the communication process. chapter 9 contains testing of Clicker quiz
application with various configurations of AP. In the end conclusion summarises whole thesis work
done by me.
Chapter 2

Wireless Communication

To support connection for large number of tablets for Clicker quiz the network connectivity circuit is studied. IITB server is connected to wired routers which in turn is connected to an Access Points which gives connectivity to the tablets. For ensuring this the end to end connectivity, in between technologies were studied.

2.1 IEEE 802.11 standards

As per the IEEE 802.11 standards the wireless connection from router to one or more Access Points AP is provided through an Ethernet cable. These Access points then connects various user laptops, Tablets (Aakash) and mobile phones through WiFi protocols. These APs are also called as Base Service station BSS and form a cell like structure containing WiFi laptops / devices connected to it. A network of BSS is called as ESS Extended Service Station.

This protocol contains Physical layer and Data Link layer and operates in 2.4 GHz frequency band. Action performed by Physical layer are encoding/decoding of messages, preamble for synchronization, bit transmission and reception. It also assemble data on transmission with addresses and error detection fields. It disassembles frame and perform address resolution and error detection on reception. This protocol performs Fragmentation of data packets, Retransmission of data packets if undelivered and also provide Acknowledgements on correct reception of data packets.

2.2 CSMA/CA

The IEEE 802.11 protocol operates on CSMA/CA (Carrier Sense Multiple Access/ Collision Avoidance). In CSMA the station willing to transmit, transmits data in the network and if collision is detected then it waits for probability i period of time and then transmits if finds the medium free. Here CA is slightly different from CD (Collision Detection). In wireless medium implementation of CD is not possible due to increase cost due to Reception and Transmission on full duplex channel and secondly for Collision Detection a station has to monitor the channel and transmit when free, but when channel is free at recipients end cannot be confirmed in wireless.[4]

In Collision Avoidance if station willing to send data senses that the medium is not free then it waits for some time and then on sensing the medium free transmits the data to the receiving station and gets acknowledgement if message successfully delivered. If it does not gets acknowledgement
then it retransmits till the acknowledgement is received or is stopped from transmitting due to jamming the channel.

2.3 Virtual Carrier Sense Mechanism

To reduce the chances of collision among stations this scheme is implemented. In this the sending station sends a RTS Request to the receiving station for sending data, this request will consists of details of Sender , Receiver and time duration . The receiving device will send Clear to send CTS to the sender as a go ahead signal. The sender station will combine this CTS signal with the medium sensing in its nearby region of the sender so as to ensure availability of channel in free state. These RTS and CTS requests are very short sized packets and helps in collision avoidance.

2.4 Fragmentation of packets

In wireless network the packet size to be transmitted is to be of smaller size preferably due to high Bit Error Rate in radio frequencies. Higher size of packet has more probability of packet dropping whereas the smaller packet size will have small overhead which is helpful during resending. As wireless transmission involves frequency hopping, smaller the size of packet lesser chances of pending transmission of packet for next cycle.

This mechanism is different from simple transmit and wait till acknowledgement or retransmission stops after certain no of repetitions. In this 802.11 scheme the station is allowed to transmit to another station in between the retransmissions to the previous station. So a particular station can transmit to others while pending acknowledgement from previously transmitted station.

2.5 Joining of a device to the Access point

A device when tries to join a BSS or AP after turning ON or entering into its area then it does that in two ways:-

- Passive scanning:- This is done by receiving a beacon frame for synchronization from AP which is generally periodically transmitted.

- Active scanning:- This is done when the device itself tries to search the available Access Point for synchronization by sending probe request and waiting to get probe response frame from AP.

Once a device selects a particular AP, then authentication is done by sharing a password between them. Association Process starts after that by sharing information about device and AP capabilities and location. After the completion of this process the device can transmit or receive data.[4]
Chapter 3

Literature Survey

3.1 Network protocol analyser

Wireshark is an open-source network packet analyzer tool.[3] It is used for capturing data packets in communication process for troubleshooting, analysing and in academic purpose. In wireshark network interface controllers (NIC) cards can be set in promiscuous mode to see all data traffic available on that particular interface. The data traffic related to that machine interface card will be captured. It can capture in both wired or wireless network. The data captured can be saved in a file and can be further analysed for troubleshooting or analysing purpose. It also captures traffic addressed to other IP addresses in that network including broadcast and multicast traffic. Capturing with wireshark in promiscuous mode gives an option of selecting interface on the machine. In Windows/Linux/Ubuntu operating system machine it generally allows capture in promiscuous mode. In Linux/Ubuntu the additional facility of capturing packets in monitor mode can be available through putting the NIC card in the monitor mode from managed mode manually through terminal. In monitor mode we get the radio communication beacon frame which are periodically broadcasted by wireless access points with its SSID name. In this mode we can actually capture the CTS and RTS request being exchanged between the source and the destination. During analysis of Wireshark logs we can filter the data as per our requirements. Like we can filter data related to particular source IP or destination IP. We can filter all data related to TCP, UDP or http in this. Packets and acknowledgement sent for communication can also be captured. We can also see bad packet during the transfer for which the retransmission happens.

3.2 Effect of Bluetooth on Wireless

I have read a paper which focuses on how Bluetooth interference have effect on WLAN 802.11 b and g network by calculating throughput of Wireless LAN. Since this technology is based on CSMA/CD media access with acknowledgement from MAC layer and retransmissions which helps in noisy channel propagation and eventually undetected collisions. IEEE 802.11b network is based on (DSSS) Direct sequence spread spectrum and (CCK) Complementry code keying modulation whereas IEEE 802.11 g is based on OFDM Othogonal Frequency Division Multiplexing and CCK if backward compatibility (interaction with lower technology of b network) with 802.11 b network in needed.[11] Zigbee standard IEEE 802.15.4 operates at 2.4 GHz with maximum data rate of 250 kbps and when operating at 868/928 MHz data rate of 20-40 kbps. So these are more suited for low rate data transfers but have high battery life. Bluetooth uses short range radio link operating
in 2.4GHz like WiFi. It is based on frequency hopping spread spectrum. At any given point of

time Bluetooth is resident or occupies 1 MHz frequency. The Bluetooth signal changes frequency

or hops at rate of 1600 Hz over 79 centre frequencies. So like this since the hopping speed is so fast

of 1600 per sec thus we can say that Bluetooth occupies 79 MHz. Bluetooth is unavoidable to have

a interference effect on WiFi signals due to coverage of almost 79 MHz. Bluetooth is suitable for

high data rate transfer and have low battery life. [11]

3.3 Wireless link behaviour

The paper [12] conducts wireless testbed and emulates signal propagation. The test environment
carries out analysis of link level behaviour. The following tests were conducted:-

- For reference first a clear channel reception is considered here packet delivery rate is seen in
  reference to Received Signal Strength. 200 Packets are sent at varying signal strength and
  reception is monitored at 1,2,5.5,11 Mbps rates. It is observed that higher the RSS better
  the packet delivery and lower the data rate higher the reception. Receiver is very sensitive,
  higher the data rate it requires higher RSS.

- Capture with competing transmitters. In this two transmitters A and B are considered
  receiver receives traffic from both Ta and Tb. At 1 Mbps occurrence of collisions is very less
  where RSS of Ta and Tb are identical. So data sent at low rates for example beacons RTS /
  CTS and ACK are immune to interference. At higher rate 5.5 and 11 Mbps collisions occur
  are high.

- Off channel interference is been studied to detect that whether four channel can exists without
  interference in contrast to 3 channel 1, 6 and 11. We kept both Tx and Rx at channel 6 and
  Interferer varied from 1 to 6. Results observed that when the interference channel is 1, 2
  and 3 then the throughput is high even at less RSS of Tx at receiver. As the channel of I is
  made 4 and 5 the throughput further degraded is drastically affected at 6 even at higher RSS.
  The throughput is better at lower data rate 1 Mbps and continues to degrade for 2, 5.5 and
  11 Mbps. When experiment is done by having large delay in Interferer then performance is
  better that no delay cases. Conclusion is that a good receiver can adjust well with Interferer
  atleast being three channel separation away from Tx and Rx channel. So we can have four
  channel for reliable transmission like 1, 4, 7 and 11 and can get 33 percent improvement in
  capacity.

- Off channel reception is done to see performance at receiver when it is varied from 1 to 6
  channel, Tx is fixed at 6 and there is no Interferer. Test was done for -102 to -72 dBm.
  Results shows that there was no reception when receiver is at channel 1 and 2. Reception at
  channel 6 was best and for 5, 4 and 3 degraded thereafter and even require higher RSS to get
  received at 1 Mbps. The result is even worst for 2 Mbps and packet delivery is not increasing
  monotonically with RSS. For 5.5 and 11 Mbps only R at 6 is received. Off channel reception
  is not possible as the receiver filter is available at modulated signals center frequency. 1 Mbps
  uses BPSK modulation hence is robust whereas remaining uses QPSK which is more prone to
  off channel reception. So Off channel reception is possible at 1 Mbps when RSS is extremely
  strong.
3.4 Interference among wireless technologies

I read the [10] in which aim of the experiments conducted is to know which technology and wireless equipments can cause interference and lower the performance of the network. The signal coverage throughput and frequency of operation is also seen. Interference sources like Bluetooth mobile, Bluetooth headsets, baby monitor, video game controller, radio frequency jamming devices and microwave was considered in the experiments. Tests were carried out for TCP (FTP and http downloads) and UDP traffic (real time video transmissions) for interference like Bluetooth Bluetooth headset with PC baby monitor and wireless video game controller.

Experiment was done with different interferer. Microwave caused 80 percent drop in throughput, Baby monitor showed 100 percent drop, Bluetooth transfer showed 50 percent drop, Bluetooth wireless headset caused 0 percent drop and wireless video game controller caused 50 percent drop (TCP traffic) in throughput approximately. The performance of the device under test depends on the type of traffic downloaded and other devices operating in vicinity. These experiments were conducted where frequency band is less polluted and can be extrapolated in environment where more pollution in frequency band due to wireless activity exists.[10]

3.5 Wireless Signal Strength

Signal strength is a major function of WiFi connection by which we can measure the availability of connection in the experimenting room. Signal strength in WiFi connection is generally about -50 to -60 dBm. Remember this is a negative value so lesser the values better the availability of connection in WiFi. The range of antenna depends on power gain of antenna. It means that how effective is the antenna in comparision to standard reference antenna. Higher gain is achieved if its transmitting power is high and it increases range. This is a antenna feature so it is also dependent on the direction of polarisation of antenna. Two types of antennas are described below:-

- Omnidirectional Antenna:- These are used in WiFi routers APs and and mobile phones. The general antenna gain lies between 2-9 dBi (decibel relative figure to antenna gain of isotropic referencetial antenna).

- Directional Antenna:- Their gain is higher than omnidirectional antenna as their power of transmission is directed to one direction. These are used to increase the range of Wifi signals in a particular direction. For example Cantenna and Yagi-Uda are directional antenna with 12 dBi and beam width of 30 degrees at 2.4 Ghz of frequency.
Chapter 4

Clicker Quiz Architecture

Clicker quiz architecture was studied for further testing on Aakash tablet. Clicker application is a web based software based on client-server model. In a class Professor access Clicker system installed on desktop or laptop whereas students access it through Aakash tablets assigned to each student with specific tablet ID. Both professor and students access Clicker application using web URL which is stored in IIT Bombay server. The Clicker architecture is shown in figure 4.1.

Aakash tablet gets WiFi signal from an Access Point and user sends a request for connection which is further authenticated by sharing a password of AP if it is secured otherwise connects directly. Once all the students were logged in then the professor can launch the quiz for students which can be displayed from projector also. Students has to connect to server IP address having Clicker quiz. Clicker quiz page will be displayed on the tablet and student will receive questions on launch of quiz by professor. After the duration of quiz is over then responses from the student
will be submitted to the server by the application and result will be displayed.[17]. The webpage accessed by the professor for launch of quiz is shown in figure 4.2.

![Clicker Webpage](image)

Figure 4.2: Clicker Webpage

### 4.1 Installation of softwares for Clicker on Server

The file can be downloaded from parent directory Aakash with username and password. We need to install certain opensource softwares like Apache Tomcat7, EclipseIndigo, JDK and JRE and keep it in a separate install folder on our Ubuntu machine. All software related to configuration of clicker needs to be downloaded in this folder.

- Download the eclipse-jee-indigo-SR2-linux-gtk.tar.gz and untar in the Install folder.
- Download the apache-tomcat-7.0.35.tar.gz, place the file in same Install folder and extract it, which will create folder apache-tomcat-7.0.35.
- Download the JDK 7 and JRE 7 tar.gz file extract them in same Install folder, which will create two folder jdk1.7.0 and jre1.7.0.
- Download tomcat plugin for eclipse IDE tomcatPluginV33.zip and save in same Install folder and extract it to get folder com.sysdeo.eclipse.tomcat-3.3.0. Copy this folder and paste it inside plugins folder present in eclipse folder.
• Set up enviromental variable for Tomcat 7, JDK 7 and JRE 7 in bashrc file of your system opening through terminal and typing command gedit .bashrc. After that save the .bashrc file and close it.

• Then in terminal type source .bashrc and restart the machine.

• In Eclipse folder there will be an executable file named eclipse. Double click on this file will start eclipse IDE and create a default workspace.

• Install Sqlworkbench on the machine. this will enable viewing sql dump files where all quiz related data is stored.

• In Sql workbench on left hand penal you can see localhost database where all the quiz related tables are stored and can be updated if required.

• On right hand side of the workbench we need to login Clickerui@localhost database.

• Through terminal we need to go to folder home/Install/apache-tomcat-7.0.39/bin. Then run command ”./startup.sh” to start apache tomcat.

• Connect Server laptop to the wireless router through ethernet and tablet to that wireless router. Click Clicker application on the tablet and connect to server machine by providing server IP address in the application.

• Open web browser type ”localhost:8080/AakashClickerV3” to get the Clicker quiz page and authenticate by enter username and password.

• Then you can launch quiz and quiz will be displayed on tablet. From server we can create, update questions and create quiz.

4.2 Launch of Clicker quiz

The Clicker quiz can be conducted in two ways i.e directly from the server laptop and another by logging to IITB website.

4.2.1 Launching of quiz directly from local server laptop in classroom

• During the launch of quiz initially all the tablets are connected through wireless to the Wireless Access Point which is in turn connected to server laptop with ethernet cable which is having quiz module.

• The quiz module is launched from the server laptop which can be accessed from the Aakash tablet by login to the Clicker application installed on it.

• By accessing Clicker application from tablet an http request to the server is made and an unicast connection is maintained between server and tablet.

• When a student login his roll no then his Roll no and MAC address of his tablet is transferred to the laptop server via AP. These details are verified, authenticated and are saved in database as a table. Then the Aakash tablet establishes http connection with clicker.php application and the quiz database.
Student verification will be achieved on crosschecking eligibility of student for quiz done by studentlogin.java file. This will result in opening of quiz page on student tablet.

Verification of instructor is done by login.java in case of success.

After that if somebody else wants to login with previously login Roll No then it will show Student already logged in.

For transfer of quiz to student tablet is through Clicker application which checks student id for registered student.

Quiz is launched by instructor from file QuizUrl.jsp through launch quiz button to the connected tablets and a timer starts at the launch of quiz.

Time on the tablet is synchronised with the server laptop by Update time function which keeps updating the tablets time with reference to the server.

The timer value will be checked and quiz will end on expiry of timer value.

When a student submits the quiz then the tablet access the QuizEnd.jsp and listener.jsp file is updated in backend.

Result of a student quiz is updated by accessing QuizResult.jsp by the tablet.

Response chart is a tool which allows to draw a graph of responses by students can be done by ResponseChart.jsp

Session variable and Application variable play their roles in transferring of data during the submission of responses when the Quiz is conducted.

Helps available on clicker application is available on Quiz helper.java

4.2.2 Launching of quiz from clicker website at IIT Bombay server

In this case the professor will get connected to IITB server www.iitb.ac.in/clicker from where the clicker application is launched. Initially the Quiz will be downloaded through XML at the local server machine and then distributed to connected tablets. Similarly at the end of quiz all responses are collected by the local server and will be transmitted to IITB clicker website.

This is the correct method which is used to launch the quiz inside IITB campus by connecting directly to IITB website www.iitb.ac.in/clicker by any professor.

4.3 Problems Identified during conduct of quiz

Clicker quiz was conducted in an open hall and several problems were identified during the conduct of clicker quiz. Some of them are related with the wireless signal strength and others due to its functionality issues are listed below:-

It is found that when tablets seeking connection goes high in number beyond 40 then server side application gets stuck and is not able to process the request of given users.
• It was also found that some users gets connected to server but the quiz is not displayed in tablet after launch of quiz.

• There is lag in display of quiz after it is launched which causes less time available for student to answer the quiz.

• There is no submit button after every question and for final submission to end the quiz as available in many online examinations. Students will have to wait for full duration of quiz for submitting answers and display of results.

• If during the quiz tablets hangs and user refreshes the page then all selected answers goes away.

• The tablet needs to be connected to the server always during the entire duration of quiz making it heavily network dependent.

• There is considerable amount of delay when there are multiple tablets competing for submission of responses and getting the result.

4.4 Problem chosen for solving

It was thoroughly deliberated that most of the problems faced in connecting multiple users through WiFi simultaneously can be solved with better hardware and network devices. It can be achieved by using multiple access point for availability of strong wireless signal in the room. This solves problem like delay in display of quiz, delay in response submission, supporting multiple users tablet in class capacity size of 200, hanging of tablets due to retransmissions and ensured connectivity during the entire period of quiz.
Chapter 5

Testing of Routers

Routers form a backbone of any network system. Here also as the Clicker quiz is available on IIT Bombay server. So classroom where the quiz is being conducted will have to open the IITB website for Clicker application. Thus in the backend of the classroom atleast one routers resides through which one can access IITb server. The route which quiz packets follow from IITB server to the AP is shown in the figure 5.1. Inorder to measure various network parameters Cisco ASR 1000 and Juniper Mx80 routers available in GNL lab were tested for throughput, frame loss, burst profile, jitter and latency. This test measured the IPv4 forwarding performance router using the RFC2544 test methodology. A traffic is inserted between one of the 1GB Ethernet ports of the router. The test was carried out for various packet sizes for frame lengths 64, 128, 256, 512, 1,024, 1,280 and 1,518. Teraterm software was used to access router and to run commands. JDSU 6000 tester was used to generate traffic and for measuring various parameters as per RFC 2544. [17]

![Figure 5.1: Route upto IITB server from AP](image)

5.1 Configuring wired router

Command line interface CLI commands runs either on Console device attached to the Router console port on the front panel or through Telnet connection to router ethernet port on the front panel. CLI has two modes, Configuration Mode for configuring the router and Operational Mode used for displays the current status of the device. Setup a direct console connection to the device. Router network is accessed using SSH or Telnet. Various protocols like RIP OSPF and Static routing were configured on the router and parameters were observed. Tera term software [2] aids in accessing the router for configuration as per the topology. Static routing is applied for configuration of path selection of routers in this topology. In this routing there is no communication between
routers regarding the current topology of the network. This is done by manually adding routes to the routing table of the router. In this systems, routes in a network are described by set paths in the router. The routes are set into the router by the network administrator. Tera term software aids in accessing the router for configuration. The topology used for testing is shown in figure 5.2.

![Router topology for testing](image)

**Figure 5.2: Router topology for testing**

## 5.2 Throughput

Throughput is the maximum amount of data which can be transmitted by source over the channel to the destination address. It is the average rate of successful message delivery over a link at its bandwith. Routers throughput was tested for various frame sizes. I have observed 100 percent throughput for various frame sizes as shown in figure 5.3.

![Throughput measurement of router](image)

<table>
<thead>
<tr>
<th>Frame Length (Bytes)</th>
<th>Cfg Rate (Mbps)</th>
<th>Measured Rate (Mbps)</th>
<th>Measured Rate (%)</th>
<th>Measured Rate (frms/sec)</th>
<th>Pause Detected</th>
</tr>
</thead>
<tbody>
<tr>
<td>64</td>
<td>1000.000</td>
<td>1000.000</td>
<td>99.996</td>
<td>1488036</td>
<td>No</td>
</tr>
<tr>
<td>128</td>
<td>1000.000</td>
<td>1000.000</td>
<td>99.996</td>
<td>844561</td>
<td>No</td>
</tr>
<tr>
<td>256</td>
<td>1000.000</td>
<td>1000.000</td>
<td>99.996</td>
<td>452881</td>
<td>No</td>
</tr>
<tr>
<td>512</td>
<td>1000.000</td>
<td>1000.000</td>
<td>99.996</td>
<td>234953</td>
<td>No</td>
</tr>
<tr>
<td>1024</td>
<td>1000.000</td>
<td>1000.000</td>
<td>99.996</td>
<td>119727</td>
<td>No</td>
</tr>
<tr>
<td>1280</td>
<td>1000.000</td>
<td>1000.000</td>
<td>99.996</td>
<td>96150</td>
<td>No</td>
</tr>
<tr>
<td>1518</td>
<td>1000.000</td>
<td>1000.000</td>
<td>99.997</td>
<td>81272</td>
<td>No</td>
</tr>
</tbody>
</table>

**Figure 5.3: Throughput measurement of router**
5.3 Frame Loss

It is the number of frames lost in transit from source to the destination. It measures network behaviour in overload condition. Tested Juniper MX80 routers for frame loss at 100 percent bandwidth during the testing of router. I have not observed any frame loss at various frame sizes 64, 128, 256, 512, 1,024, 1,280 and 1,518 byte as shown in the figure 5.4.

<table>
<thead>
<tr>
<th>Cfg Rate (%)</th>
<th>Throughput Rate (%)</th>
<th>Frame Loss Rate (%)</th>
<th>Frames Lost</th>
<th>Pause Detected</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>100.00</td>
<td>0.00</td>
<td>0</td>
<td>No</td>
</tr>
<tr>
<td>90</td>
<td>90.00</td>
<td>0.00</td>
<td>0</td>
<td>No</td>
</tr>
</tbody>
</table>

Figure 5.4: Frame loss in router

5.4 Jitter

Jitter is delay in transmitting second packet after the first packet is delivered. It is calculated with different frame sizes. Average jitter experienced by packets is 0 sec as shown in the figure 5.5.

<table>
<thead>
<tr>
<th>Frame Length (Bytes)</th>
<th>Pkt Jitter (μs)</th>
<th>Measured Rate (Mbps)</th>
<th>Measured Rate (%)</th>
<th>Measured Rate (frms/sec)</th>
<th>Pause Detected</th>
</tr>
</thead>
<tbody>
<tr>
<td>64</td>
<td>Avg 0</td>
<td>1000.0</td>
<td>99.996</td>
<td>1488036</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>Max Avg 0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>128</td>
<td>Avg 0</td>
<td>1000.0</td>
<td>99.996</td>
<td>844561</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>Max Avg 0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>256</td>
<td>Avg 0</td>
<td>1000.0</td>
<td>99.996</td>
<td>452881</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>Max Avg 0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>512</td>
<td>Avg 0</td>
<td>1000.0</td>
<td>99.996</td>
<td>234953</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>Max Avg 0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1024</td>
<td>Avg 0</td>
<td>1000.0</td>
<td>99.996</td>
<td>119727</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>Max Avg 0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1280</td>
<td>Avg 0</td>
<td>1000.0</td>
<td>99.996</td>
<td>96150</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>Max Avg 0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1618</td>
<td>Avg 0</td>
<td>1000.0</td>
<td>99.997</td>
<td>81373</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>Max Avg 0</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Figure 5.5: Jitter of router
5.5 Burst Profile

It is maximum number of frames received before a frame is lost. It tests buffering capability of router. I tested Juniper routers with 2 sec and burst of data to test traffic of burst can be supported on these routers. No pause was detected in the transmission due to burst of traffic as shown in the figure 5.6.

<table>
<thead>
<tr>
<th>Frame Length (Bytes)</th>
<th>Average Burst (frms)</th>
<th>Average Burst (secs)</th>
<th>Pause Detected</th>
</tr>
</thead>
<tbody>
<tr>
<td>64</td>
<td>2976190</td>
<td>2.000</td>
<td>No</td>
</tr>
<tr>
<td>128</td>
<td>1689189</td>
<td>2.000</td>
<td>No</td>
</tr>
<tr>
<td>256</td>
<td>905797</td>
<td>2.000</td>
<td>No</td>
</tr>
<tr>
<td>512</td>
<td>469925</td>
<td>2.000</td>
<td>No</td>
</tr>
<tr>
<td>1024</td>
<td>239464</td>
<td>2.000</td>
<td>No</td>
</tr>
<tr>
<td>1280</td>
<td>192308</td>
<td>2.000</td>
<td>No</td>
</tr>
<tr>
<td>1518</td>
<td>162549</td>
<td>2.000</td>
<td>No</td>
</tr>
</tbody>
</table>

Figure 5.6: Burst profile of router

5.6 Latency

It measures the time of travel of a packet from destination to source including processing delay and propagation delay. Latency is measured at 100 percent with different frame sizes. Results are shown in the figure 5.7.

<table>
<thead>
<tr>
<th>Frame Length (Bytes)</th>
<th>Latency (μs)</th>
<th>Measured Rate (Mbps)</th>
<th>Measured Rate (%)</th>
<th>Measured Rate (frms/sec)</th>
<th>Pause Detected</th>
</tr>
</thead>
<tbody>
<tr>
<td>64</td>
<td>37</td>
<td>1000.0</td>
<td>99.996</td>
<td>1488036</td>
<td>No</td>
</tr>
<tr>
<td>128</td>
<td>41</td>
<td>1000.0</td>
<td>99.996</td>
<td>841551</td>
<td>No</td>
</tr>
<tr>
<td>256</td>
<td>47</td>
<td>1000.0</td>
<td>99.996</td>
<td>452381</td>
<td>No</td>
</tr>
<tr>
<td>512</td>
<td>59</td>
<td>1000.0</td>
<td>99.996</td>
<td>234953</td>
<td>No</td>
</tr>
<tr>
<td>1024</td>
<td>80</td>
<td>1000.0</td>
<td>99.996</td>
<td>119727</td>
<td>No</td>
</tr>
<tr>
<td>1280</td>
<td>92</td>
<td>1000.0</td>
<td>99.996</td>
<td>96150</td>
<td>No</td>
</tr>
<tr>
<td>1518</td>
<td>101</td>
<td>1000.0</td>
<td>99.997</td>
<td>81272</td>
<td>No</td>
</tr>
</tbody>
</table>

Figure 5.7: Latency of router
5.7 Analysis of Results

The wired router tested and found that throughput is 100 percent at 1GB bandwidth which means that they can successfully transfer 1GB of data to other end without loss. There is no frame loss in transmitting frames from source to destination. Jitter of 0 sec is measured which means there is no delay in data packet transmission one after another from source. There is no pause detected in case of burst of data, which shows that routers have enough storing capacity. Latency or time delay in reaching to destination at frame length 1518 bytes is 101 microseconds which is to be factored in for our Clicker application but is very miniscule.
Chapter 6

Wireless routers

Range of WiFi signals  WiFi signals are prone to deterioration due to various environmental factors. Poor WiFi signal of an AP reflects to poor range of wireless connectivity. There are various factors which affect the range of Wireless signals of a router.

6.1 Factors affecting range of WiFi signals

- The obstruction in the building/room, as the signals are reflected back by the walls and other infrastructure in the room. If the room is open and there is no obstruction then signals will be better.
- While accessing WiFi from other room then width of wall and objects like wooden/metallic doors coming in between will reduce the signal strength.
- The more the number of people in the room the signals will be more obstructed by the individuals.
- The range also depends on the power of the transmitter, More the power of transmitter the larger the strength of the signal.
- Antenna gain dBi of Transmitter and Receiver antenna of the Access Point.
- The data rate to be used for transmission of files. Higher data rates are less reliable then lower data rate. The use of high data rate for small frame size and lesser frames will occupy more bandwidth and will lead to congestion.

6.2 Solutions for increasing range of WiFi Signals

- Using WiFi network in an open room with minimum obstruction is to be done for better signal strength
- Access Point having high power transmitter will have better range is to be used.
- Antennas of high antenna gain (dBi) to be used.
- More than one Access Point in different locations within a big room and equal tagging of tablets with nearby Access Point will increase the range of signals.
• Smaller frames are to be transmitted for better reception and transmission and to avoid resending and congestion.

• Data rate is to be optimized as per size of packet to avoid congestion.

The problem of signal range can also be solved by changing a better antenna on a AP or router device if it supports antenna upgrade. Higher the transmitting power higher will be the range of signals. Upgrading antenna of AP rather than that of tablet gives more scalability as upgrading antenna of tablet will only be useful for one tablet. While upgrading an antenna we should keep in mind that the AP and router should support required transmitting power of new antenna. So the AP device can be a limitation in antenna upgrade after a certain extent as its radio transmitting power of AP is limited. To deal with such situation we use other method of signal boosting by a repeater at some distance. This amplifies the signal at the range of AP before it degrades and further transmits it ahead to increase the range of the WiFi. This can be done by using the AP in the repeater mode. Wireless repeaters are physical layer devices which regenerates incoming wireless signals before the quality of signal is degraded.

6.3 Configuring Wireless router

The wireless router is configured initially by connecting it with LAN port (1,2,3,4) through ethernet cable with RJ45 connector to a laptop LAN port. Router power supply is switched ON. The router can be automatically set by running device CD and selecting various options. The manual setting can be done by login the router through web browser by typing IP address of router, default is http://192.168.0.1 for TP Link and http://192.168.1.1 for DLink. We can also find this IP address by command ipconfig in command prompt, in the result the address shown against default gateway is the IP address of the router for LAN configurations. Then it will ask for username and password for accessing the router configurations. Default username / password is admin / admin.[18]. On the TP Link router main page it gives some basic information about the device like:-

• MAC address (LAN and WAN)
• IP address (LAN and WAN), Wireless Channel (1 to 11,it also gives auto selection options)
• Maximum Transmission rate (300 Mbps)
• Name of SSID (TP-Link)
• Mode (b/g/n)
• Traffic sent / received.
• Egress and ingress bandwidth
• AP access security password
• DHCP settings

After configuration is done it is to be saved and then exit from the web browser. Now you can connect your computer and access intranet from ethernet cable. For wireless connectivity you can manually feed the security password of the AP to access intranet/internet via AP. If you dont want
to connect to AP through security password or if you think that it can be hacked then the router
gives you another option of secured connection via WPS. In the TPLink router connection logo
on desktop (TP Link logo comes after device CD is successfully run ) under WPS section. On
the router side it gives access by manual pressing of WPS button behind the router. Here the
router manager will press the button himself and allow access to the desired device, laptop or PC.
Similarly DLink router also has configurations settings options which can be manually set in the
similar fashion.

For connecting with internet router WAN port can be connected with IITB LAN port and internet
can be accessed through the laptop connected with LAN wire to the router or accessing internet
through the WiFi connection. Here the TP-Link TL WR 941ND device used in the Aakash lab is
only a router not a modem. So it cannot be connected directly with any ISP, it can only be connected
to IITB LAN port and then can act as a router/switch for setting up a LAN connection. The other
device is DLink 2750u is ADSL modem and router, so it can be connected with ISP telephone line
(It has a additional telephone port RJ11) and can be connected with internet directly from ISP like
MTNL(but this feature is not required in IITB for this IITB clicker project). Various ports and
connections of router are shown in the figure 6.1.

![Figure 6.1: TP-Link router ports and connections](image)

### 6.4 TP Link wireless router performance

The TP-Link TL WR 941 ND 300 Mbps wireless N router have some good features in that price
range of MRP Rs 5000. They have three antennas each of 3 dBi antenna gain (good antenna range is
upto 7 dBi but price increases with antenna gain) for better reception. They have one WAN port for
server side connection, four LAN ports and WiFi connectivity for clients side connectivity. Wireless
speed of maximum 300 Mbps theoretically for clients is claimed by the device. Practical throughput
seen during experiments by me with a single AP and client is 47 Mbps. Wireless transmit power
of 20 dBm. Other features are security encryption, Server, client, DHCP client list etc. The router
is connected to the server laptop from where the quiz is launched or it may be connected to the
LAN port for accessing IITB network from getting the quiz from website. This wireless router is
positioned in the centre front of the hall. This gives a decent coverage to nearby area upto three
or four rows on left and right side. So tablets which are on the nearby range to that AP will get
easily connected to it. Those who are at some distance may not get proper signal strength to get
connected.

RSSI (Received Signal Strength Indicator) received at a tablet is an indicator for reachability
of wireless signal to that device. Generally from - 5 dBm or 100 percent to -50 dBm 50 percent is
considered good for reliable communication. From -51 dBm or 49 percent to -64 dBm or 32 percent is considered as fair RSSI for communication. The -66 dBm or 30 percent may be considered just sufficient RSSI to get connected and keep receiving/transmitting the data. RSSI beyond -70 dBm 25 percent, to -90 dbm 0 percent are bad for communication due to data losses.

6.5 DLink wireless router performance

DLink 2750u 300 Mbps wireless router was also considered with Multiple Input Multiple output (MIMO) technology antenna for checking the throughput. Various experiments were done with this router to measure throughput. It was found that its maximum throughput was 21 Mbps which is lesser than the TP Link wireless routers throughput. So TP Link TLWR941ND 300 Mbps router is better in terms of throughput and hence may be continued for Clicker testing of Aakash. Any other router better than current may also be considered for higher throughput.

6.6 WiFi Signal strength available in KReSIT lab

There are multiple AP available in the KRESIT building which can cause interference in communication. The reception of signal from each AP in the lab in KReSIT is shown in the figure 6.2.

<table>
<thead>
<tr>
<th>S. No.</th>
<th>SSID</th>
<th>RSSI dBm</th>
<th>Signal strength%</th>
<th>Channel</th>
<th>Rate (Mbps)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3it@itb</td>
<td>-85</td>
<td>6</td>
<td>5</td>
<td>54</td>
</tr>
<tr>
<td>2</td>
<td>Aakash</td>
<td>-80</td>
<td>11</td>
<td>11</td>
<td>54</td>
</tr>
<tr>
<td>3</td>
<td>Akash</td>
<td>-87</td>
<td>3</td>
<td>11</td>
<td>130</td>
</tr>
<tr>
<td>4</td>
<td>ATOMBERG</td>
<td>-86</td>
<td>5</td>
<td>1</td>
<td>54</td>
</tr>
<tr>
<td>5</td>
<td>Airmet-966464</td>
<td>-87</td>
<td>3</td>
<td>6</td>
<td>54</td>
</tr>
<tr>
<td>6</td>
<td>ABC</td>
<td>-88</td>
<td>2</td>
<td>11</td>
<td>54</td>
</tr>
<tr>
<td>7</td>
<td>adhoc</td>
<td>-92</td>
<td>0</td>
<td>1</td>
<td>54</td>
</tr>
<tr>
<td>8</td>
<td>AndroidAP</td>
<td>-91</td>
<td>1</td>
<td>11</td>
<td>54</td>
</tr>
<tr>
<td>9</td>
<td>BinTani++</td>
<td>-90</td>
<td>1</td>
<td>6</td>
<td>54</td>
</tr>
<tr>
<td>10</td>
<td>ClickerTest1</td>
<td>-84</td>
<td>7</td>
<td>1</td>
<td>54</td>
</tr>
<tr>
<td>11</td>
<td>dlink</td>
<td>-80</td>
<td>11</td>
<td>8</td>
<td>144</td>
</tr>
<tr>
<td>12</td>
<td>Lazy 8 Games</td>
<td>-85</td>
<td>6</td>
<td>4</td>
<td>54</td>
</tr>
<tr>
<td>13</td>
<td>IITB-Wireless</td>
<td>-71</td>
<td>21</td>
<td>11</td>
<td>54</td>
</tr>
<tr>
<td>14</td>
<td>IITB-Wireless</td>
<td>-76</td>
<td>17</td>
<td>11</td>
<td>54</td>
</tr>
<tr>
<td>15</td>
<td>IITB-Wireless</td>
<td>-72</td>
<td>20</td>
<td>11</td>
<td>54</td>
</tr>
<tr>
<td>16</td>
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<td>-80</td>
<td>11</td>
<td>11</td>
<td>54</td>
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<td>-81</td>
<td>10</td>
<td>7</td>
<td>54</td>
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<tr>
<td>18</td>
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<td>-80</td>
<td>11</td>
<td>8</td>
<td>54</td>
</tr>
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<td>6</td>
<td>7</td>
<td>54</td>
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<td>20</td>
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<td>-85</td>
<td>6</td>
<td>3</td>
<td>54</td>
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<td>6</td>
<td>4</td>
<td>54</td>
</tr>
<tr>
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<td>Researchlab</td>
<td>-90</td>
<td>1</td>
<td>1</td>
<td>54</td>
</tr>
<tr>
<td>23</td>
<td>Prabhu</td>
<td>-92</td>
<td>0</td>
<td>1</td>
<td>54</td>
</tr>
<tr>
<td>24</td>
<td>Tinkers R&amp;D</td>
<td>-77</td>
<td>16</td>
<td>1</td>
<td>150</td>
</tr>
<tr>
<td>25</td>
<td>Talk to a teacher</td>
<td>-87</td>
<td>3</td>
<td>6</td>
<td>54</td>
</tr>
<tr>
<td></td>
<td>TP-Link-Testing</td>
<td>-17</td>
<td>91</td>
<td>4</td>
<td>54</td>
</tr>
</tbody>
</table>

Figure 6.2: WiFi signal in the building
Chapter 7

Testing of Wireless router

The experiment was done with FTP file transfer over the network by sharing the folder from one laptop to the other laptop so that the TP-Link router can be tested individually for throughput as shown in figure 7.1. The data rate achieved in WiFi is 47 Mbps and with Ethernet wire is 70Mbps for TPLink. The data rate achieved in WiFi is 20.5 Mbps and with Ethernet wire is 70 Mbps for DLink. For determining data transfer rate open source software Wireshark was used from laptop connected to Router. It was observed when there were no interference from any other WiFi Access point, device or Bluetooth device in an isolated environment. Here the AP and the laptop was kept in close proximity so that RSSI is -18 dBm 90 percent good and the situation is most favourable.

![Experimental setup](image)

Figure 7.1: Experimental setup

7.1 With varying Range

Series of data transfer test over WiFi laptop and AP is done at various signal strength RSSI by increasing the distance of WiFi AP and laptop was done repeatedly and for random amount of time. The result observed in figure 7.2 is with increase in distance from AP the RSSI decreases and data transfer rate also decreases. So Transmitter-Receiver distance is inversely proportion to data rate and RSSI.
7.2 In presence of Bluetooth Interference

Data transfer test was done in the close proximity of WiFi laptop and AP with Bluetooth to Bluetooth transfer in mobile device as interferer. Although the available RSSI was -16 dBm the observed WiFi data transfer rate is 14.6 Mbps for D Link and 40.902 for TP Link router. The decrease in data transfer rate is well understood by the increase in distance of laptop and AP as displayed in figure 7.3.

- The interfering two Bluetooth device near each other is now kept at various distances from the AP like 0m, 0.5m, 1m, 1.5m and 2m with WiFi laptop near AP to observe the effect on data transfer rate between WiFi laptop and AP. With repeated experiments as shown in figure 7.4 I found that with increase in distance of two Bluetooth mobile interferer from AP, data transfer rate of WiFi devices increases.
• The previous set of experiments were done in which WiFi laptop was kept at distances of 3m, 7m from AP. Both Bluetooth transferring devices are kept near AP and then distance was varied 0m, 0.5m, 1m, 1.5m and 2m. The result observed is with increase in distance of bluetooth from AP the WiFi data transfer rate increases as shown in figure 7.5 and figure 7.6. As the bluetooth is taken away from the AP its interference reduces so the data rate increases.

<table>
<thead>
<tr>
<th>Distance AP - Bluetooth (m)</th>
<th>Distance Bluetooth-Laptop (m)</th>
<th>Distance AP-Laptop (m)</th>
<th>RSSI (dbm)</th>
<th>Signal Strength %</th>
<th>D Link Rate (Mbps)</th>
<th>TP Link Rate (Mbps)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>3</td>
<td>3</td>
<td>-36</td>
<td>67</td>
<td>13.247</td>
<td>35.042</td>
</tr>
<tr>
<td>0.5</td>
<td>3</td>
<td>3</td>
<td>-40</td>
<td>62</td>
<td>14.927</td>
<td>37.59</td>
</tr>
<tr>
<td>1</td>
<td>3</td>
<td>3</td>
<td>-35</td>
<td>68</td>
<td>16.53</td>
<td>37.855</td>
</tr>
<tr>
<td>1.5</td>
<td>3</td>
<td>3</td>
<td>-38</td>
<td>65</td>
<td>17.213</td>
<td>39.661</td>
</tr>
<tr>
<td>2</td>
<td>3</td>
<td>3</td>
<td>-38</td>
<td>65</td>
<td>17.87</td>
<td>45.282</td>
</tr>
</tbody>
</table>

Figure 7.5: Throughput with varying bluetooth and laptop at 3m from AP

<table>
<thead>
<tr>
<th>Distance AP - Bluetooth (m)</th>
<th>Distance Bluetooth-Laptop (m)</th>
<th>Distance AP-Laptop (m)</th>
<th>RSSI (dbm)</th>
<th>Signal Strength %</th>
<th>D Link Rate (Mbps)</th>
<th>TP Link Rate (Mbps)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>7</td>
<td>7</td>
<td>-66</td>
<td>30</td>
<td>12.7</td>
<td>31.449</td>
</tr>
<tr>
<td>0.5</td>
<td>7</td>
<td>7</td>
<td>-66</td>
<td>30</td>
<td>13.93</td>
<td>35.108</td>
</tr>
<tr>
<td>1</td>
<td>7</td>
<td>7</td>
<td>-64</td>
<td>32</td>
<td>14.464</td>
<td>37.503</td>
</tr>
<tr>
<td>1.5</td>
<td>7</td>
<td>7</td>
<td>-65</td>
<td>31</td>
<td>15.911</td>
<td>38.6</td>
</tr>
<tr>
<td>2</td>
<td>7</td>
<td>7</td>
<td>-63</td>
<td>33</td>
<td>17.16</td>
<td>42.144</td>
</tr>
</tbody>
</table>

Figure 7.6: Throughput with varying bluetooth and laptop at 7m from AP

All the experiments mentioned above was recorded by using wireshark data capture software using in promiscuous mode. Wireshark logs are also kept for future reference and further analysis of data. The Clicker application was also used in next set of experiments instead of file transfer operation. In this case also results were similar. The only difference is the data rate was lower in all cases as the clicker application does not pump data constantly to the client at the same speed over a period of time. Also the data pumping rate is much lower. The same set of test is conducted for Aakash tablet and data transfer rate for clicker application specifically is measured. Then Clicker application was run to see the effect of interferer on the throughput, delay retransmissions and jitter. These experiments are conducted with one tablet only. Similar experiments were done for measuring data transfer rate in the presence of another AP in the vicinity. Series of runs were done to confirm the results of the experiments.
7.3 In presence of WiFi Interference

The experiments were conducted by setting wireless router in AUTO for channel selection mode. If there is any AP available in particular channel then the wireless router will automatically switch to other free channel to avoid interference.

7.4 Capturing wireless data in monitor mode of NIC

In monitor mode of NIC we get the radio communication beacon frame of length 223 bytes which are periodically broadcasted by wireless access points with its SSID name. Broadcasting of beacon frame generally occurs at 0.1 sec time interval. In this mode we can actually capture the CTS of 40 bytes and RTS of 46 bytes request being exchanged between the source and the destination. The raditap header consists of certain AP related informations which are as follows:-

- Signal strength in dBm
- Channel number on which communication is happening
- Channel frequency corresponding to Channel number
- Transmission data rate
- Source and Destination MAC address
- Supported data rates
Chapter 8

Testing of Clicker application

8.1 Network setup

One Access point is connected with ethernet to local server. Tablet communicates with AP in wireless medium. Tablet IP address is 192.168.0.100, local server IP address is 192.168.0.101 and IP address of AP is 192.168.0.1.

8.2 Data transfer during the quiz

Data transmission takes place when quiz.jsp is accessed by the tablet and when quizend.jsp is accessed by the tablet for submitting the answers and when quizresults.jsp is accessed by the tablet to get the result of the quiz. Number of bytes of TCP packets transferred in displaying the quiz page, submitting answers and getting results as per the number of questions in the quiz are displayed in figure 8.1

<table>
<thead>
<tr>
<th>No. of Ques.</th>
<th>No of bytes in quiz.jsp</th>
<th>No. of bytes in quizend.jsp</th>
<th>No. of bytes in Quizresults.jsp</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>6x1514=9084</td>
<td>78</td>
<td>1514x2=3028</td>
</tr>
<tr>
<td>5</td>
<td>6x1514=9084</td>
<td>90</td>
<td>1514x2=3028</td>
</tr>
<tr>
<td>10</td>
<td>7x1514=10598</td>
<td>105</td>
<td>1514x3=4542</td>
</tr>
<tr>
<td>15</td>
<td>7x1514=10598</td>
<td>120</td>
<td>1514x3=4542</td>
</tr>
<tr>
<td>20</td>
<td>7x1514=10598</td>
<td>135</td>
<td>1514x3=4542</td>
</tr>
<tr>
<td>25</td>
<td>7x1514=10598</td>
<td>141</td>
<td>1514x4=6056</td>
</tr>
</tbody>
</table>

Figure 8.1: Data transfer during quiz
8.3 Throughput results during the quiz

Clicker quiz was conducted from local server through AP to one tablet. Various number of questions 1, 2, 5, 7, 10, 15, 20 and 25 were launched in separate quizzes to determine the throughput in each one of them. The duration of quiz was set to 20 seconds. This experiment was conducted without any interference in the region. Thereafter same experiment was conducted with bluetooth interference. Bluetooth interference was introduced by two mobile phones with file transfer operation with each other and then throughput was calculated. Both the Bluetooth mobiles were near each other. Bluetooth distance from WiFi AP was 0 m. The throughput during 20 sec quiz with and without bluetooth interference is shown in the figure 8.2 below.

<table>
<thead>
<tr>
<th>No. of Ques.</th>
<th>Duration of quiz (secs)</th>
<th>Throughput (Mbps)</th>
<th>Throughput With Bluetooth (Mbps)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>20</td>
<td>0.018</td>
<td>0.016</td>
</tr>
<tr>
<td>2</td>
<td>20</td>
<td>0.018</td>
<td>0.016</td>
</tr>
<tr>
<td>5</td>
<td>20</td>
<td>0.018</td>
<td>0.017</td>
</tr>
<tr>
<td>7</td>
<td>20</td>
<td>0.019</td>
<td>0.017</td>
</tr>
<tr>
<td>10</td>
<td>20</td>
<td>0.019</td>
<td>0.017</td>
</tr>
<tr>
<td>15</td>
<td>20</td>
<td>0.019</td>
<td>0.017</td>
</tr>
<tr>
<td>20</td>
<td>20</td>
<td>0.020</td>
<td>0.018</td>
</tr>
<tr>
<td>25</td>
<td>20</td>
<td>0.020</td>
<td>0.019</td>
</tr>
</tbody>
</table>

Figure 8.2: Throughput for quiz of duration 20 sec

The same experiment was conducted with reduced Clicker quiz duration of 5 sec to achieve higher throughput by conducting the same quiz in lesser duration. The throughput during 5 sec quiz with and without bluetooth interference is shown in the figure 8.2 below.

<table>
<thead>
<tr>
<th>No. of Ques.</th>
<th>Duration of quiz (secs)</th>
<th>Throughput (Mbps)</th>
<th>Throughput With Bluetooth (Mbps)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>5</td>
<td>0.03</td>
<td>0.029</td>
</tr>
<tr>
<td>2</td>
<td>5</td>
<td>0.030</td>
<td>0.029</td>
</tr>
<tr>
<td>5</td>
<td>5</td>
<td>0.032</td>
<td>0.03</td>
</tr>
<tr>
<td>7</td>
<td>5</td>
<td>0.034</td>
<td>0.03</td>
</tr>
<tr>
<td>10</td>
<td>5</td>
<td>0.034</td>
<td>0.031</td>
</tr>
<tr>
<td>15</td>
<td>5</td>
<td>0.034</td>
<td>0.032</td>
</tr>
<tr>
<td>20</td>
<td>5</td>
<td>0.037</td>
<td>0.032</td>
</tr>
<tr>
<td>25</td>
<td>5</td>
<td>0.037</td>
<td>0.032</td>
</tr>
</tbody>
</table>

Figure 8.3: Throughput for quiz of duration 5 sec
Chapter 9

Testing Clicker application in Lecture Hall

9.1 Testing with one Aakash tablet and one AP

One Aakash tablet was connected with wireless router and a server laptop was connected with LAN port of wireless router. The quiz was transmitted to the tablet. It was successfully received and all the responses were recorded correctly.

9.2 Testing with one AP

Testing of Wi Fi network in KReSIT auditorium for quiz was conducted using Clicker. For this activity Test setup used is shown in figure 9.1.

Figure 9.1: Clicker Test setup with one AP
- One Wi Fi Access Point of TP Link TR WR 941ND 300Mbps Wireless N Router.
- Server Laptop from which the quiz was conducted.
- All tablets initially connects to server laptop through WiFi medium and a connection is setup.
- Questions were multicasted to each tablet from the laptop in the quiz form and was received by tablets and after completion of quiz all the responses were submitted to server via Access point.

Experiments and Result achieved are shown in the figure 9.2

- Initially 10 tablets were connected and quiz was launched to check the response submission delay. All responses by the tablets were recorded correctly.
- Then the test was carried out with 20 tablets in that also all the responses were recorded correctly.
- Then test was carried out with 30 tablets at some distance with each other when the response submission was noticed with a delay of 3 sec in some tablets. It is inferred that the delay was due to congestion at the receiving end at AP.
- The same tests were done with 40 tablets, the delay was more prominent up to 5 sec in this case.
- Tests with 50 tablets was also done and found delay of 5 secs in some tablets during submission of response and delay in receiving of quiz also.
- With 50 tablets the connection of some tablets also lost in between, the reason for this may be poor signal strength available to that tablet.

<table>
<thead>
<tr>
<th>Total Tablets for quiz</th>
<th>Quiz displayed properly on tablets</th>
<th>Results of quiz displayed properly</th>
<th>Delay in displaying result of quiz in some tablets</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>One Ques. quiz</td>
<td>Multiple Ques. quiz</td>
<td>One Ques. quiz</td>
</tr>
<tr>
<td>10</td>
<td>10</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>20</td>
<td>20</td>
<td>-</td>
<td>20</td>
</tr>
<tr>
<td>30</td>
<td>30</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>40</td>
<td>40</td>
<td>40</td>
<td>37</td>
</tr>
<tr>
<td>50</td>
<td>48</td>
<td>-</td>
<td>48</td>
</tr>
</tbody>
</table>

Figure 9.2: Clicker results with two AP
9.3 Testing with two APs

Experiment with two Access point as shown in figure 9.3 was carried out. Then the test was carried out with 10, 15, 20, 25, 30, 40, 50 tablets in that also all the responses were recorded correctly. The reason of no connection loss and no delay was due to better network availability due to two AP at different ends which can act as standby to each other.

![Figure 9.3: Clicker Test setup with two AP](image)

9.4 Testing with three APs

I have done testing of Wi Fi network in KReSIT auditorium for quiz conducted using Clicker. For this activity Test setup used is shown in figure 9.4 below.

- Three Wi Fi Access Point of TP Link TR WR 941ND 300Mbps Wireless N Router
- Server Laptop from which the quiz was conducted.
- All tablets initially connects to server laptop through Access point in WiFi medium and a connection is setup.
- Questions were multicasted from the laptop in the quiz form and were received by tablets and after completion of quiz all the responses were submitted to server via Access point.
Then the test was carried out with 10, 15, 20, 25, 30, 40, 50, 60 and 70 tablets in that also all the responses were recorded correctly. The reason of no connection loss and no delay was due to better network availability due to three AP at different ends which can act as standby to each other. In this environment one central AP is connected to two other APs which are also sharing the load and TxRx the WiFi signals for distribution and submission of quiz responses. If there are more then it connects to AP based on Received Signal Strength Indicator (RSSI). The AP on Channel 1 is also preferred by tablets for connection even if it is far.

9.5 Testing with three APs on different Channel with tablets tagged to each AP

In this experiment all the three APs were given different IP addresses and a group of tablets were designated with each AP as per their geographical location for conduct of quiz. Here a group of tablets have to connect to a particular IP only by setting the IP address in it. So these tablets are tagged to the particular AP and the will communicate to this AP only during the clicker quiz as shown in figure 9.5. They will not communicate to other APs.
Wireshark laptop was connected with all the three APs with WiFi and the Wireshark packets logs were recorded twice for each AP during the clicker quiz for analysis. Server IP address was 172.16.201.122. IP address given to various AP are as follows:-

- IP Address of AP configured in Channel 3 was 172.16.1.5
- IP Address of AP configured in Channel 7 was 172.16.1.6
- IP Address of AP configured in Channel 11 was 172.16.1.7

Tablets beyond 141 had connection problems. In some cases total number of successful connection was upto 154. It can be inferred that each AP can hold approximately 50 connections. Result of the experiment are displayed in figure 9.6. All the tablets got connected to their designated Access points. This helps in balancing the load on AP and prohibiting a particular AP getting overloaded. For recording Wireshark logs it needs to switch the laptop to the monitor mode from managed mode. In this mode only all the TCP and required logs will be recorded. The laptop needs to be booted in Ubuntu or Linux which gives the facility to monitor all the data going and coming from NIC (Network interface Card) to the network. In widows it prohibits the display of such data. It only gives very limited access to such data even in promiscuous mode. Data from all the three APs
can be recorded in parallel by connecting wireless USB receiver (TL-WN721 N 150 Mbps by TP link) to USB port.

<table>
<thead>
<tr>
<th>Quiz No.</th>
<th>No. of Ques. In quiz</th>
<th>Tablets in quiz</th>
<th>Results displayed</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>97</td>
<td>97</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>113</td>
<td>113</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>3</td>
<td>114</td>
<td>114</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>4</td>
<td>118</td>
<td>118</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>1</td>
<td>174</td>
<td>154</td>
<td>Connection problem</td>
</tr>
<tr>
<td>6</td>
<td>1</td>
<td>148</td>
<td>144</td>
<td>Connection problem</td>
</tr>
<tr>
<td>7</td>
<td>1</td>
<td>151</td>
<td>141</td>
<td>Connection problem</td>
</tr>
</tbody>
</table>

Figure 9.6: Result of testing with three AP
Chapter 10

CONCLUSION

Clicker is extremely useful application for providing questionnaire in classroom. It facilitates the professor and students by allowing conduct of quiz to students for knowing grasping of individual students. This provide immediate result of quiz to processor who can know the understanding level of class and alter his teaching methodology. There are some networking limitations in Wireless medium which limits its utility to a few tablets. These problems can be solved by having better network availability and can be achieved by using more than one Access Points in a large room for providing reliable connectivity to the tablets for quiz duration. This will solve the problem of connecting multiple tablets through Wi-Fi simultaneously as proven with the help of experiments.

One AP can handle load of approximately 50 tablets in proximity. So number of AP may be multiplied per 50 student class size. One extra AP can be used to have a better reliability. In multiple AP scenario assigning different non overlapping Channel number and tagging group of tablet also solve interference issues.
Bibliography


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