

Advanced Train Tracking System Using Wi-Fi Technology

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In partial fulfillment of the Requirements for the Degree of Bachelor in Electrical and Electronics Engineering and Bachelor in Electronics and Communication Engineering

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August 2016

Declaration

This is to declare that this thesis named “Advanced Train Tracking System Using Wi-Fi” is submitted by the author listed below for the degree of Bachelor of Science in Electrical and Electronics to the department of Electrical and Electronics Engineering under the school of Engineering and Computer Science, BRAC University. We, therefore affirm that the thesis work and results are conducted solely by us and no other. Material of the study and work found by other researcher has been properly referred acknowledged. This thesis paper, neither in whole nor in part, has been previously submitted elsewhere for appraisal.

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Abstract

Java packets can send time and calculate time difference using client-server methods. By calculating the time difference, distance from a router or a fixed point can be determined. The packets can be manually made in Eclipse or any other java operated software. For tracking the trains we need to use Wi-Fi trackers which will communicate with the nearest router and the router will pass the information to the central server. The central server will process the information and store them in a server. The information then will be shown on a webpage or android app.

Acknowledgements

Most importantly, we are appreciative and communicating our thankfulness to Almighty who offers us His heavenly gifts, tolerance, mental and physical quality to complete this venture work.

We are profoundly obligated to our venture chief Iffat Anjum, Lecturer, Department of Computer Science and designing, BRAC University. Her insightful direction, essential proposals, perpetual persistence, steady supervision, significant feedback, and huge measure of work for going through our drafts and remedying them from the earliest starting point to the end of the research work has made the fruition of the task conceivable.

Last but not the least; we are very appreciative to our guardians and crew individuals for their backing and consistent consolation, which have dependably been a wellspring of awesome motivation for us. We are grateful to our peers. We also take this opportunity to thank every other individual who has supported, encouraged and lent us hand whenever it was required throughout our thesis.

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List of Abbreviation

BR	Bangladesh Railway
BRA	Bangladesh Railway Authority
RSSI	Received signal strength indication
GPS	Global Positioning System
GSM	Global System for Mobile communication
RFID	Radio Frequency Identification

Chapter 1

Introduction

1.1 Introduction

Railway systems are one of the important medium of transports of Bangladesh. It is the state-owned rail transport agency of our country which is totally controlled by Bangladesh Government. The Government operates and maintains the entire railway network of the country. Bangladesh Railway (BR) is controlled by the Directorate General of Bangladesh Railway under the Ministry of Railways along with Bangladesh Railway Authority (BRA) and which works for policy guidance of Bangladesh Railway [1]. Key features of BR are the coexistence of several gauges, Broad gauge, Meter gauge and Dual gauge, and the separation of the system by the Jamuna River (Brahmaputra) into a Western and Eastern Zone of operations with only one bridge, the 2003 Jamuna Bridge, connecting the two zones [2].

Bangladesh Railway covers a length of 2,855 route kilometers and employs 34,168 people. BR operates international, inter-city and suburban rail systems on its multi-gauge network [3]. It also owns coach production facilities. In 2014 it carried 65.00 million passengers and 2.52 million tons of freight making 8,135 million passenger-kilometers and 677 million ton kilometers.[2] Bangladesh Railway provides various types of services ranging from shuttle service for university students to freight and cargo service.

Under the Bangladesh Railway there are more than three hundreds trains, all these trains are being scheduled and maintained by the BR [1]. For the lack of proper maintenance, rules and regulations the railway system has failed to provide the destined services to the mass peoples. In most of the cases, trains do not come on its scheduled time in the station to pick up and drop the passengers. The passengers have to waste their valuable times in waiting for a delayed train, and this scenario is very common in Bangladesh. In Bangladesh, the trains are being delayed for

several reasons like, lack of seriousness and efficiency of the workers, lack of advanced mechanical system, lack of automation, old engines, large number of crossings etc. An effective train tracking system would have made our railway service more tolerable and useful.

A smart tracking system of the train with dynamic information distribution system will help the passengers to have more information about the trains. Urban public transit authorities are an increasingly common user of tracking systems, particularly in large cities. This particular system combines the use of Wi-Fi positioning system using socket programming and android application. Socket programming is used to measure the distance and location. The android application is used to show data like current position, available seats etc.

In our thesis work we designed an efficient and smart train tracking system where any anonymous user will be able know the location of the trains and act upon them. By setting train tracker in the rail line passengers will be informed that where the trains are and they can know it by using a simple application in there phone. The train tracker will play the role of tracking the train's whereabouts. There will be a main Wi-Fi system which will help to track the train. To track the trains there will be routers in the railways after a minimum distance to track the movement of the trains and installing an application in passengers phone, they will come to know where the actual location of their desired trains. The routers will be made Java enabled using third-party software. Also, the routers used will be able to cover at least 1200-1500 meters. Each train will have client code installed in a suitable java device or tracker. After the calculation done by the server, the data will be sent to the control center. The server will keep broadcasting in a given time limit. Control center will have mapping software, which will convert the distance from router into a location. The location will be sent to the central server. An android app will have the information, which is found from the server.

1.2 Basic Architecture of Wireless Tracking System

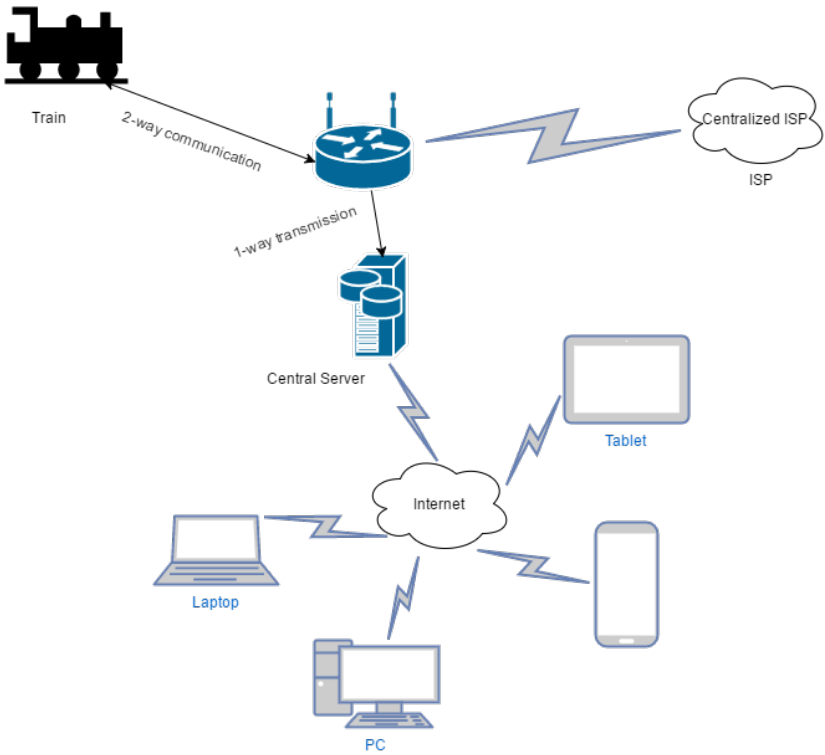


Figure 1.1: Basic Architecture of Wireless Tracking System

In our model, every router is connected with a centralized internet service provider (ISP). When a train comes close to a router, it connects with the router. After connecting, they exchange packets and some information. Those information are filtered and sent to the control station. Control station processes the information and sends the data to central server. By using internet, user can request and get information in any device.

1.3Types of Wireless Tracking System

There are two types of wireless tracking. They are Indoor tracking and Outdoor tracking. Both of them are described below.

- **Outdoor tracking:** There are numerous applications of outdoor tracking. Among all outdoor tracking scenarios, tracking in playground is the most popular one. By creating maps and using RFID tags, people use this tracking method to track the movements of their children playing outside. By using RFID tags, it is also possible to track slowly moving objects like cars in a parking lot. Though outdoor tracking using Wi-Fi is not so popular or widely used, it is gaining popularity slowly.
- **Indoor tracking:** Indoor tracking system using Wi-Fi is a widely accepted method of indoor tracking. It is considered to be the best method for indoor tracking as it does not suffer from multipath effect caused in a closed surface and also gives more accurate result. It can also penetrate through walls and suffer less from attenuation. These days, it is a common affair to track the staffs of an office by putting a RFID tag with their ID card and track them with these tags. This tracking method is applicable in every indoor environment regardless of the purpose [3].

There different technologies and methodologies for wireless tracking system, we have summarized few of them below.

1.3.1 Wi-Fi Positioning

Wi-Fi positioning takes benefit of the speedy development in the early 21st century of wireless access points in urban areas. The most extensive localization technique used for positioning is based on measuring the intensity of a received signal and the method of "fingerprinting" [4]. Typical parameters convenient to geo-locate the Wi-Fi hotspot include the SSID and the MAC address of the access point. The accuracy depends on the number of positions that have been put into the database. The Wi-Fi hotspot database gets filled by comparing mobile device GPS location data with Wi-Fi hotspot MAC addresses. The possible signal variations that occurs can increase errors and inaccuracies in the path of the user. To minimize the instabilities in the received signal, there are certain methods that can be applied to filter the noise. Wi-Fi positioning system is used where GPS and GLONASS are insufficient due to various causes including multipath and signal blockage in indoors. In the case of low precision, some techniques

have been proposed to combine the Wi-Fi traces with other data sources such as geographical information and time restrictions [4].

- **RSSI and lateration based:**RSSI localization techniques are based on calculating signal strength from a client device to several different access points, and then merging this information with a transmission model to determine the distance between the client device and the access points. Trilateration techniques can be used to analyze the estimated client device position comparative to the known position of access points. Though it is one of the cheapest and easiest methods to implement, its disadvantage is that it does not provide accuracy, because the RSSI measurements have a habit of fluctuating according to changes in the atmosphere or multipath fading [5].
- **Fingerprinting based:** Traditional fingerprinting is also RSSI-based, but it depends on the recording of the signal strength from the access points in range and storing the information in a database along with the known coordinates of the client device in an offline phase. This information can either be deterministic or probabilistic. During the online tracking stage, the current RSSI vector at an unknown location is compared with the locations stored in the fingerprint and the closest match is returned as the estimated user location. This system may provide a median accuracy of 0.6m and tail accuracy of 1.3m.Its main disadvantage is that any change on the surrounding such as adding or removing furniture or buildings will change the map that corresponds to each location, requiring an update to the fingerprint database [5].

- **Angle of arrival based:**

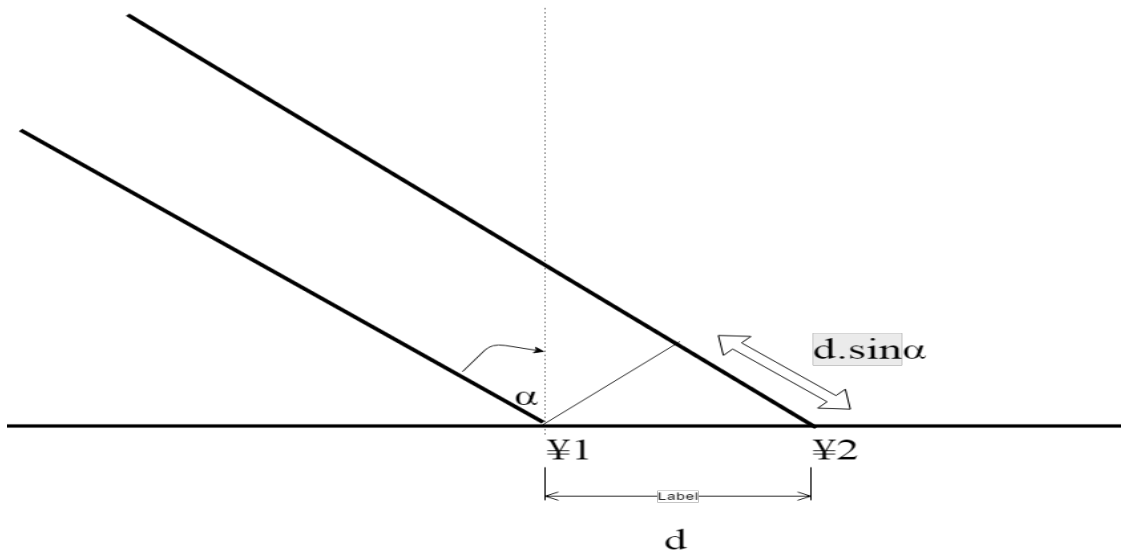


Figure 1.2: Angle of arrival based

With the creation of MIMO Wi-Fi interfaces using multiple antennas, it is possible to approximate the angle of arrival of the multipath signals received at the antenna arrays in the access points, and apply triangulation to analyze the location of client devices. SpotFi, Array Track and LTEye are proposed solutions which use this kind of technique. Typical calculation of the angle of arrival is done with the MUSIC algorithm [6].

1.3.2 Global Positioning System (GPS)

Global Positioning System (GPS) is an overall radio-route framework shaped from the group of stars of 24 satellites and their ground stations. The Global Positioning System is for the most part financed and controlled by the U.S Department of Defense (DOD) [7]. The framework was at first intended for the operation of U. S. military. However, today, there are likewise numerous

common clients of GPS over the entire world. The common clients are permitted to utilize the Standard Positioning Service with no sort of charge or limitations [7].

GPS vehicle trackers are precious devices for observing either an auto car or an entire fleet of vehicles. A constant auto GPS tracking device gives up-to-the-minute speed and location update, including content or email alarms in view of parameters set ahead of time. In case someone is thinking about whether driver has gone off kilter or if any teenager has been speeding, these vehicle GPS beacons give the answers anyone require. Point by point reports let us know precisely where a vehicle has been, the place it's going and how quick it's traveling.

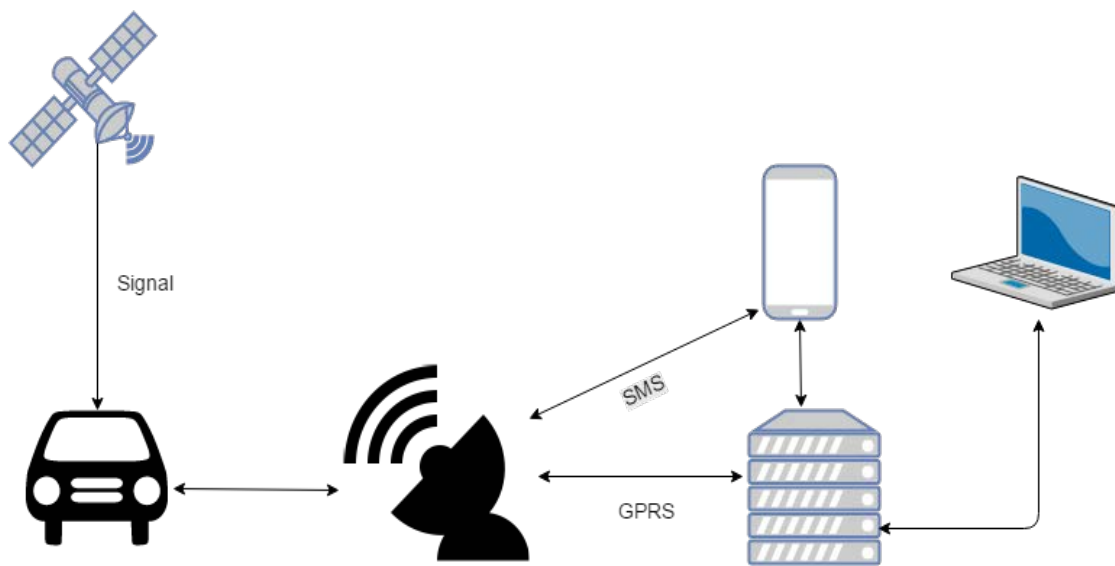


Figure 1.3: GPS-enabled Vehicle Tracking

Vehicle tracking solutions combine sophisticated GPS tracking technology with flexible, advanced mapping and reporting software. A GPS-enabled Vehicle Tracking Device is installed on each vehicle to collect and transmit tracking data via a cellular or satellite network, whichever works best for the operations. The device then delivers the data to the Track Truck hosted application, Net Track, which can access through the Web at any time. Receiver can receive real-time vehicle tracking updates, including location, direction, speed, idle time, start/stop and more, allow managing a tighter schedule and more efficient fleet [8].

1.4 Railway Wireless Tracking System

In GSM Module A train tracking system is established which is a collaborative project among Bangladesh Railway, Grameen Phone and Sun Corp. This model is based on GSM network and trackers. Each train contains a GSM tracker. Those trackers are always connected with GP's GSM network as it searches continuously for GP network and once connected; the connection is kept alive as GSM uses handoff process to keep a connection alive even though it goes out of the range of a BTS. The BTS stores the train's location by measuring the signal strength and velocity. Each train's current location is constantly updated in the central server of Bangladesh Railway as the information is passed by BTS. [9] Then the information is sent to users when they send a request to GP using SMS. Other mobile subscribers can also get this information. Those mobile companies send their requests to Grameen Phone for the information. Then Grameen Phone provides them the information.

1.5 Problem Definition and Solution Methodology

1.5.1 Problem Definition

We will create a smart tracking model which will ensure better accuracy and be less vulnerable to fading. Also we need to ensure that the tracking process is continuous or updating the information on a regular basis. So that if an user once start the process, he or she get to know the updates regularly. To overcome the errors of the previous model, we need to first address our main problems which are fading and multipath effect. We need to use a communication medium which is immune to fading and can provide better accuracy. Also we need to ensure that our tracking process and the extraction of information is simultaneous.

1.5.2 Solution Methodology

We know that Wi-Fi network is immune of multipath effect and provides more accuracy than GSM or GPS. This is why our model is based on Wi-Fi network. We are using it so that our system remains immune to these limitations Also the Wi-Fi routers which will be used to track the trains will have less public access to ensure that there is not too much traffic. To make it

more effective, we have built an Android app, which will help the passengers to know the exact position of the train all the time. These features will ensure that our model is effective and unique.

1.5.3 Contribution of this Work

Our main contribution in this work is that we are using a medium which is better in every aspect than GSM.

- We are using socket programming to communicate.
- Also we are providing an Android app, which is a very unique feature in this system. It will help the passengers to have updates on a regular basis and it will also feature ticketing facilities.
- Continuous update.
- Ticketing facilities included.

1.6 Report Outline

This thesis is organized as follows, the chapter 2, titled Motivation and Background, discusses about the existing works on the other tracking system. In chapter 3, we describe the system architecture and assumptions used in the development of the proposed tracking system. We discuss the proposed tracking system, its design components and Protocol operation elaborately in chapter 4. Chapter 5, shows the implementation results of our tracking system and compares the obtained results with a state-of-the-art work and other practical work. Finally we conclude the thesis in chapter 6 along with few directions of future research.

Chapter 2

Background and Motivation

2.1 Introduction

To implement our project we needed to study some works which had been done and approved by other authors and Universities. While studying these papers, we came to know about many algorithms, techniques, methods related to our work and also motivated us to believe in our work.

2.2 Indoor Smartphone Localization inactivity Aware Pedestrian Dead Reckoning with Selective Crowd sourced Wi-Fi Fingerprinting (HiMLoc):

2.2.1 Overview:

In this paper the authors proposed a unique solution called HiMLoc which uses Pedestrian Dead Reckoning (PDR) and Wi-Fi fingerprinting. PDR helps to enable continuous location tracking and finding errors. While experimenting, the authors used android phones to show the average location accuracy of less than 3 meters with the help of HimLoc. This method can identify the complex movements within an enclosed area. They tested this experiment in two ways, those are carrying a phone in hand and in pocket. A better result came for carrying mobile in hand. Wi-Fi and PDR elements helped to cover multiple floors within a building [10].

2.2.2 Advantages:

- **Multilayer tracking:** With this model, it is possible to track between floors of a multi-storied building. This carries a great significance as previous works were done for a single floor. By using this, tracking is possible for multiple floors.
- **Application:** This model ensures accuracy in inertial navigation systems and is used widely.

2.2.3 Limitations:

- **Cumulative process:** Pedestrian Dead Reckoning process is a cumulative process, which can be subject to significant errors as speed and direction must be always known to the observer. If once error occurs, it extends as this is a cumulative process.
- **Manual mapping:** As this model uses fingerprinting algorithm, manual mapping of whole area is required. In this model, the reference model although is fixed, but major change in the interior of a building will result in elimination of the previous map as the mapping process is not simultaneous.

2.3 An Improved Location Estimation Method for Wi-Fi Fingerprint based Indoor Localization

2.3.1 Overview:

In this paper the authors came up with two approaches for Wi-Fi indoor positioning: fingerprint-based approach and model-based approach. The fingerprint-based approach receives signal from reference point radio map the area at offline. On the other hand, the model-based method relies on indoor path-loss model to estimate user's location. The authors offered an algorithm called estimation algorithm where strong signals would get more priority than weak signals. Another thing is, by filtering the large differences and using the power co-efficient, can reduce the impact of differences in RSSI values [11].

2.3.2 Advantages:

There are certain advantages of using this model. They are stated below.

- **Drastic reduction of error:** This method reduced the error caused in Euclidean method by a significant margin. It helps to do indoor tracking with more precision now.
- **Recognizing signal strength:** This model also solved the signal strength related problem that Euclidean method had. Euclidean method cannot differentiate between weak and strong signals. Fingerprinting method solves this problem.
- **Unstable access points:** While mapping for Fingerprinting method, an access point can be in unstable state. That can cause serious error on approximation process. The proposed method can solve this problem, thus reducing the possibility of occurring an error.

2.3.2 Limitations:

This method has some limitations as well. They are stated below.

- **Manual mapping required:** As the proposed method uses Fingerprinting method, manual mapping is required. It also includes the fact that the model or the map will be vulnerable to changes in structure as the access points will be fixed.
- **Works only in a range:** The two discussed schemes have two different errors. Scheme-1 has problem to determine a fixed threshold to filter out differences in RSSI. Scheme-2, being responsive to even least amount of change in RSSI, can significantly affect the result. This small amount of change can also occur from fading, which can cause serious amount of error in the approximation. To reduce the error, there is a range fixed, which is a limitation.

2.4 Bluetooth Positioning using RSSI and Triangulation Methods

This paper is based on analyzing different indoor wireless positioning methods, particularly on the RSS based Bluetooth Positioning.

2.4.1 Overview:

In this research the authors used Bluetooth 2.1 (a new Bluetooth HCI interface) to cover major consumer electronics. The advantage of this HCI command is that the program could sense all Bluetooth devices surrounded by it with the RSSI values. In this research, they used three different algorithms to calculate the position [12].

- A. Least square estimation(LSE)
- B. Three-border positioning
- C. Centroid positioning

They did two types of experiments. One was positioning experiments and another one was effects of human body. According to this paper, there were two main approaches to minimize positioning error, the first is to choose a proper position algorithm and the second is to improve the RSSI reading accuracy they recommended to choose a filter to smooth the RSSI readings. In this experiment they used only the RSS and triangulation based methods for Bluetooth positioning. They also added that for the triangulation methods it is important to know the exact location of the reference nodes.

2.3.2 Advantages:

- The three algorithms are very useful and well described.
- Bluetooth is a very common device and affordable for everyone. So anyone can implement this method.

2.4.3 Limitations:

- Bluetooth is widely used for low cost communication, therefore, it cannot provide accurate time synchronization, and with the implementation of time base triangulation methods this problem can be overcome.
- Bluetooth is used in low footprint devices where directional or array antennas are missing. This makes the use of angle measurement methods difficult.

- RSSI reading does not go along side as per Bluetooth standard. The RSSI reading is mainly device dependent and is nor reliable.

2.5 Mobility Tracking using GPS, Wi-Fi and Cell ID

In this paper the authors discussed about the constructions of the mobility map and offline data processing.

2.5.1 Overview:

The main target of this experiment is to make the system (which they designed) had to work with three types of location measurements. Those are defined as type A, B, C. Type A had no GPS and Wi-Fi. All types of measurements were clustered in a specific LP with the same cell-ID. Type B had a cell ID and a latitude-longitude reading from GPS. Finally, type C had a cell ID and a latitude-longitude reading by Wi-Fi. The mobility pattern system was implemented on a HTC Desire 510e running android 2.3.3. To evaluate the performance of the system, a person carried that android phone around a university campus for 5 days and collected the cell ID and location measurements from AGPS and Wi-Fi. They covered a large area on campus by roof where AGPS signal was not available but the use of Wi-Fi allowed the system to have more accurate location points and identifications of the PCLs [13].

For online tracking, they used a five-state transition diagram to build the mobility of a person. It could reduce the number of AGPS fixes and could predict and reconstruct the real path successfully.

2.5.2 Advantages:

- Three types of location measurement- GSM, Wi-Fi and Cell ID.
- Offline data processing is made possible with the use of GSM and Cell ID.

2.5.3 Limitations:

- GPS cannot vary more than 15 meters of a fixed location.

- This is a lengthy process.

2.6 Real Time Location based Tracking using WI-FI Signals

In this paper, the authors discussed about different types of techniques that specified for location based tracking and also discussed on the different types of uses of wireless WI-FI signals for location tracing.

2.6.1 Overview:

WI-FI signals can be used to track the user's location. While tracking the users it is easier to track them who are close to the Wi-Fi comparing to the users who are at a far distance. In this paper the numerous algorithms are described to track the users' location by using wireless WI-FI signals. The algorithms are: Bayesian Algorithm, History- based Algorithm, Nearest Neighbor Algorithm, HMM model etc. All of these algorithms have their own criteria to track the user and also helpful for tracking the locations in an easy way. These algorithms can be used for finding places and location tracking of the users for their safety with the usage of wireless Wi-Fi signals. For tracking devices in indoor places the system called WITS (Wireless Indoor Tracking System) is used [14].

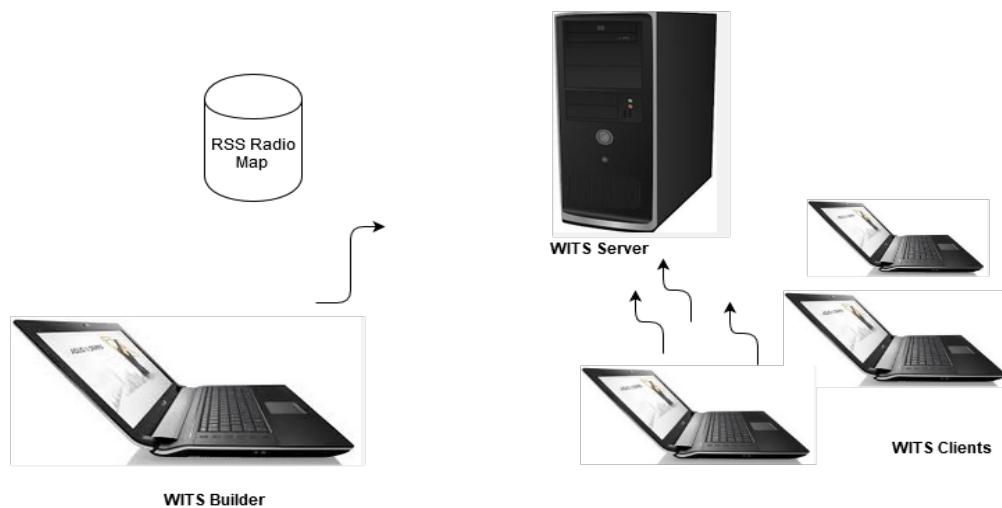


Figure 2.1: Architecture of WITS

2.6.2 Advantages:

- Usually 75-150 ft. is the range of Wi-Fi network. As now-a-days, many mobile devices are well equipped with Wi-Fi to enable them for connecting the internet very easily.
- The nearest neighbor algorithm uses a Map to keep the track of the users in a specific location.
- History based algorithm is more beneficial for the users who travel long distance. In this process WITS uses a series of consecutive signal strength to locate the place.
- RSSI performs healthier in indoor walled environments, e.g. Hospitals, while TDoA has advantages in unobstructed, outdoor environments.

2.6.3 Limitations:

- Wi-Fi network is mainly depends on Wi-Fi signal types and Wi-Fi signal reporting. The things which can affect the quality of Wi-Fi are-Opened or closed area, building with walls and equipment, external antenna, etc. Wi-Fi is a low frequency radio signal which cannot go through metal, water and other materials easily.
- The nearest neighbor algorithm and Bayesian algorithm these two algorithms are only useful for the current received signal strength to estimate the unknown location.
- Hidden Markov model (HMM) is not suitable for the users who are moving constantly in different places. So this model is beneficial only for the user who is in still position.

2.7 Tracking Unmodified Smartphones Using Wi-Fi Monitors

In this paper, the authors demonstrated that unmodified smartphones tracking is both practical, economical and accurate by using Wi-Fi monitors.

2.7.1 Overview:

Here the authors described a system for passively tracking unmodified smartphones, based on Wi-Fi detections. The system they built had only common, off-the-shelf access point hardware to both collect and deliver detections. Based on measurements from several real-world deployments, we find that many smartphones are tractable using the techniques described in the paper. The accuracy of passive Wi-Fi tracking depends mainly on the density and geometry of deployment. Though by using monitors spaced over 400 meters apart, they achieved a mean error under 70 meters as compared to GPS ground truth. Given the low equipment cost, good accuracy and high coverage of their proposed system they believed that it might be suitable for large-scale deployment in urban areas. [15]

2.7.2 Advantages:

- This technic could bring a large-scale deployment in urban areas as it can track unmodified smartphones using Wi-Fi.
- A characterization of Wi-Fi scanning and power saving behaviors of a number of popular smartphone models.

2.7.3 Limitations:

- Authors made the technology with the assumption that phones travel along a spatial network of roads or paths.
- A transmission might be recognized by two monitors simultaneously, if a pair of monitors are spaced more closely than 600 meters.

2.8Table:

Paper name	HIMLoc	Wi-Fi indoor positioning system	Bluetooth positioning	Mobility Tracking	Real time location based tracking
Feature					
Multilayer tracking	Yes	No	No	No	No
Simultaneous update of mapping	No	No	No	No	No
Differentiating between signal strengths	No	Yes	No	No	No
Low cost	No	No	Yes	No	Yes
Easy implementation	No	No	Yes	Yes	No
Accuracy	Very accurate	Very accurate	Not very accurate	Not very accurate, within 15 meters	Accurate within 25-50 meters.
Usage of RSSI	Yes	Yes	No	No	Yes
Error reduction procedure	No	Yes	No	No	Yes

Table 1: Summary of Related Works

Chapter 3

Proposed Mythology

3.1 Basic concept and components

The first condition for our method is that a centralized Wi-Fi network is spread throughout the country. As the method requires a constant availability of Wi-Fi network, it is mandatory to have a complete coverage of network provided by the same service provider. Communication between two different providers will require additional time. So it is required that we use a method which is fast and also provides accuracy.

The required components and their specifications are given below.

3.1.1 Routers

To create a meshed Wi-Fi network, it is needed to use routers with larger coverage area and have more user capacity. There are different routers available which offer a range of 200 to 300 feet. As till now, no long range routers are made for commercial purpose. But in near future they will be made available for marketing. We can use IEEE 802.11n routers and amplify its signal by using "Amped Wireless N600mW extender" to increase the range. There is another router which is "TL-WA5210G" made by TP-Link for outdoor business purpose. This offers a range of 2 kilometers using internal antenna and is extendable up to 15 km using high gain directional antenna.



Figure 3.1: TP-link TL-WA5210G outdoor router



Figure 3.2: Amped Wireless N600mW extender

3.1.2 Trackers

To initiate the tracking process from the trains or the client side, trackers are needed with Wi-Fi compatibility. Currently available Wi-Fi trackers do not support java. So for now we can use any device that uses Wi-Fi and is java enabled like modules used in cell phones.

3.1.3 Server

A central server is needed to store all the information regarding tracking like current location of all the trains. This information is later transferred to an android app and a web page to display. The server needs to store information of all the trains operating in the country.

3.1.4 Android app

An android app is developed for consumers to have the benefit of this tracking system. This app will show all the information stored in the central server like location of train, available tickets etc. By using this app, customers will get proper information about their desired train.

3.2 Details of the process

When a train starts to enter an area with routers, it is predicted that it will connect with the router with the maximum signal strength. So the tracker will connect with the network by exchanging the IP address. In this manner, client will know the IP address of server. Then server will initiate the connection process and the client will bind the IP address with the created socket to complete the creation of socket. Then the required protocols will be exchanged to get the desired information.

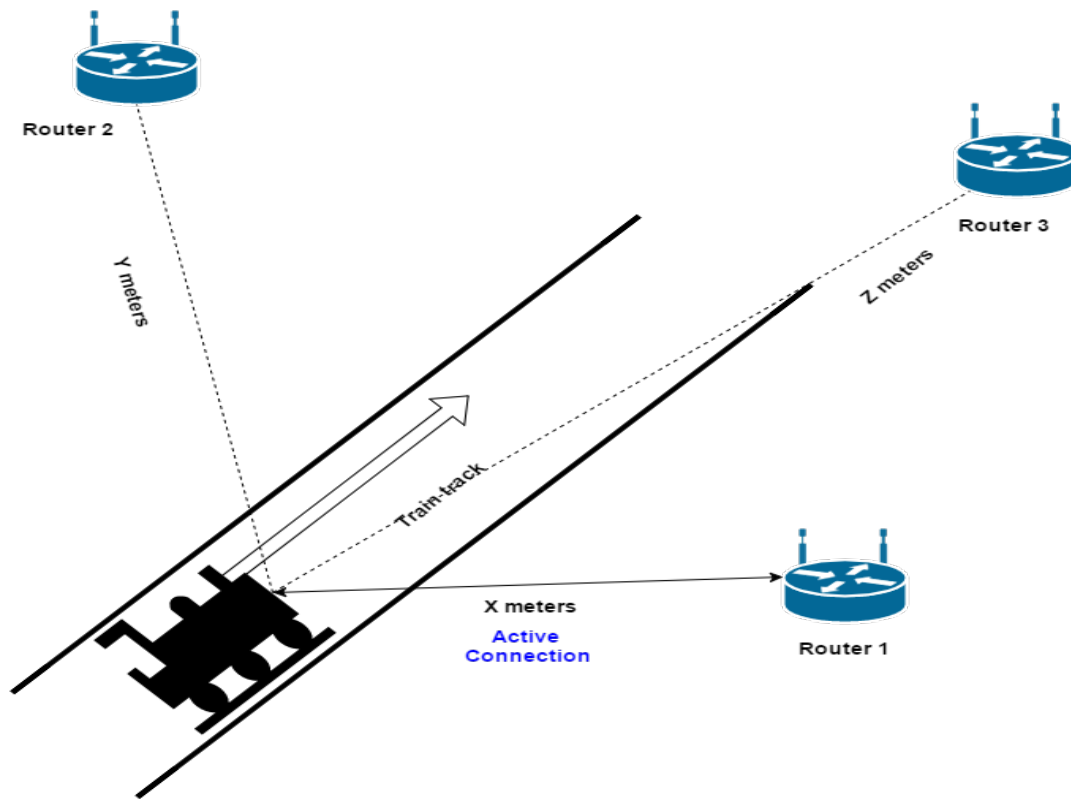


Figure 3.3: Meshed network

3.2.1 Server (Router) part

When a router is turned on, it will initially keep sending broadcast packets at a regular time interval. For our model, we have selected the time interval to be 50 seconds. After successfully creating connection and creating socket, router will run the code. It will receive the time from the tracker and will find the time difference from its own connection establishment time. Then this time difference will be multiplied with the speed of a packet travelling per second, which is calculated by using a simulation in MATLAB. The multiplied product is the distance between the tracker and the active router. The router then will create another socket and using the pre-defined IP address of the central server, will send the data to the control center. Control center will convert the source IP address to a location using “Fingerprinting” algorithm and find out the actual position. Then the Information will be saved in a server.

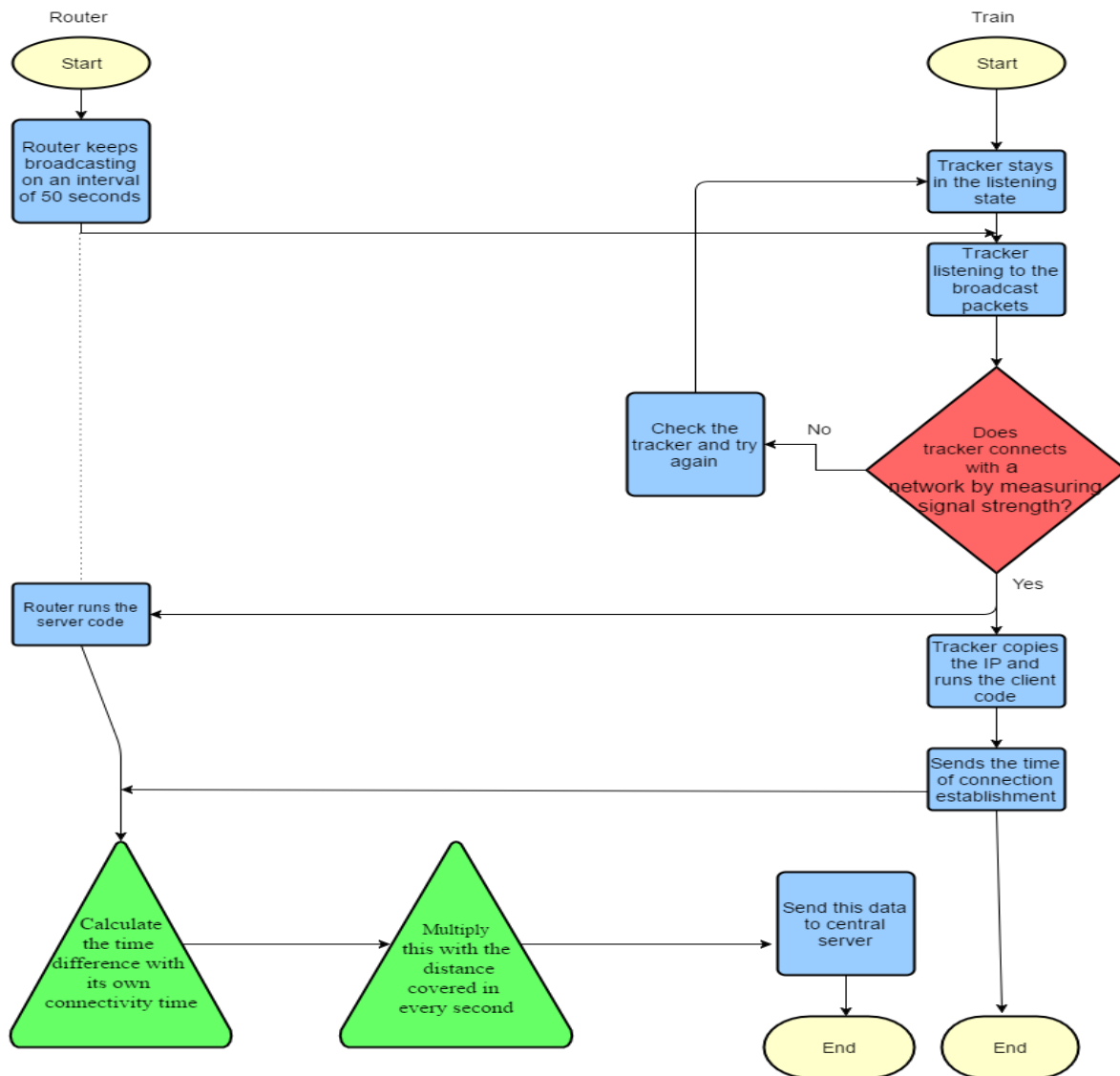


Figure 3.4: Communication and data transfer between router and Train

3.2.2 Client (train) part

When a train comes near a router, the Wi-Fi tracker starts to measure the signal strengths from other routers. Initially the tracker stays at idle or listening mode. Which means that the tracker won't do anything but keep waiting to receive broadcast packets sent from the routers. By measuring the signal strength, the tracker will fix the router to connect with, which will be the closest router. Then when the connection is made, the router will copy the IP address provided by

the network and run the client code. In the code, it is instructed that the client must send the connection establishment time to the server. After sending the time, the client code will end and no further process is done on the tracker.

3.2.3 Control station and server

After receiving the information from the router, the central server uses “Fingerprinting” algorithm to convert the IP address and the distance to a location. Then it forwards the data to the central server, which will store the information.

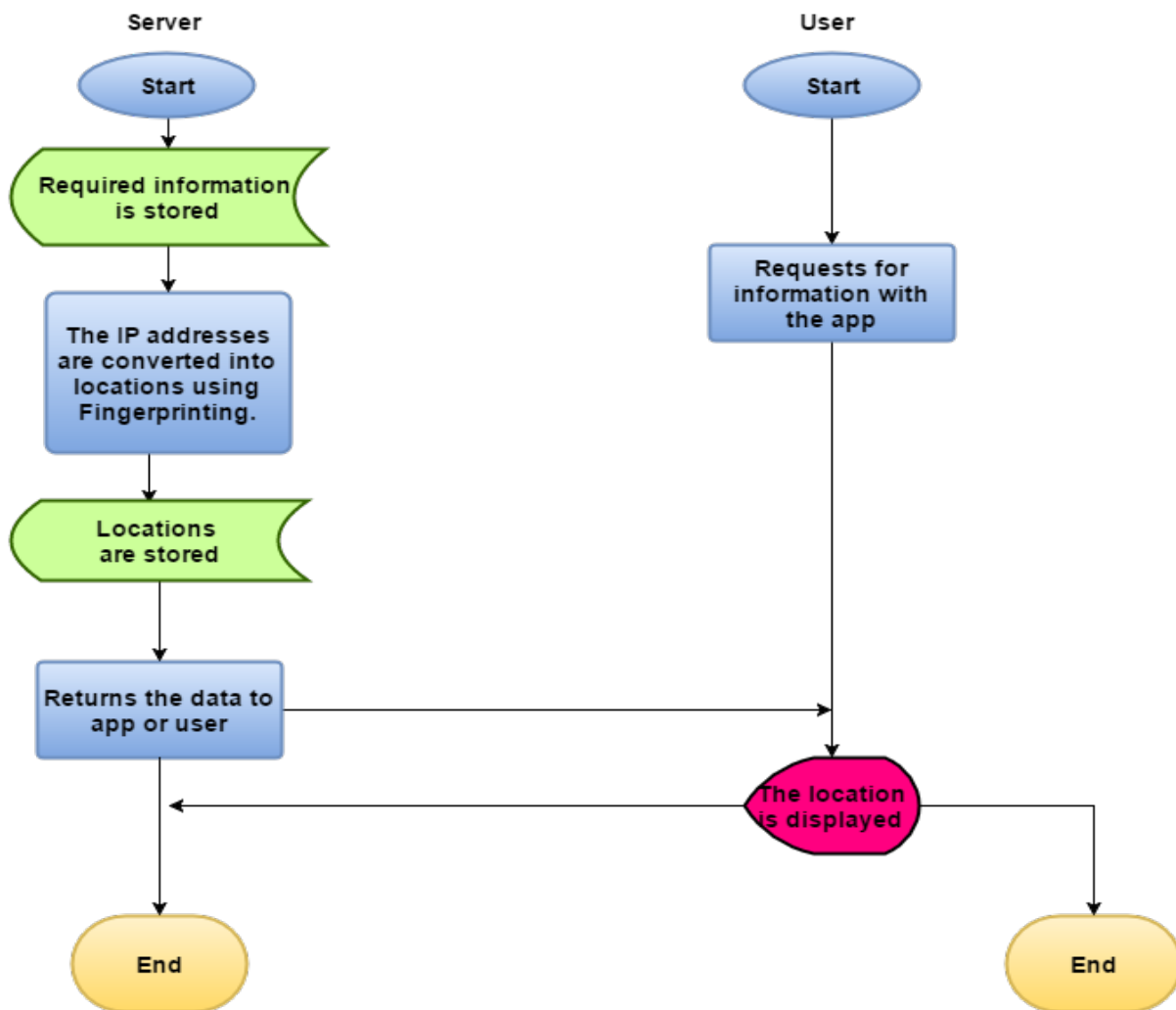


Figure 3.5: Flowchart of processes between user and central server

3.2.4 Android app

After the desired information reached the central server, it will be shown on an Android app for the customers. The data will be fetched from the server using HTTP. The app will refresh each minute to provide the most accurate information.

Implementation of "Advanced Train Tracking System Using Wi-Fi"

4.1 Introduction

For our model, we needed to work with a communication method in which two Wi-Fi enabled devices can communicate properly without any obstacle and within minimum time required. After studying we decided to work with socket programming. The reasons behind choosing socket programming are that socket programming offers communication within a very short time as the process is very simple and the whole method does not support any complexity.

4.2 Implementation in Java

Sockets use TCP to provide the communication method between two computers. A client program creates a socket on its end and tries to connect that socket to a server. When the connection is made, the server builds a socket object on its end. The client and server can then communicate by writing to and reading from the created socket. A socket is a theoretical representation for the local endpoint of a network communication path.

Berkeley socket is an application programming interface (API) for Internet sockets and UNIX domain sockets, which is used for inter-process communication (IPC). It is usually executed as a library of linkable segments. It was devised with the 4.2BSD UNIX and released in 1983. Berkeley sockets evolved with little adjustment from a *de facto* standard into an element of the POSIX specification. Therefore, the term POSIX socket is basically identical with *Berkeley sockets*. They are also known as *BSD sockets*, which acknowledge the first accomplishment in the Distribution. Berkeley sockets originated with the 4.2BSD UNIX operating as a programming interface. Only in 1989, UC Berkeley could release versions of its OS and

networking library free from the licensing issues of AT&T Corporation's copyrighted UNIX [16].

All modern operating systems apply a version of the Berkeley or POSIX socket interface. It became the regular interface for connecting to the Internet. Even the Winsock implementation for MS Windows, which is developed by informal developers, very much follows the standard. The BSD sockets API uses C programming language. Other programming languages provide similar interfaces, typically written as a wrapper library based on the C API.

4.2.1 Socket Programming

Sockets is the basic method to communicate between two PCs utilizing TCP. A client program makes a socket on its end of the communication and attempts to associate that socket to a server.

At the point when the connection is made, the server makes a socket object on its end of the communication. The client and server can now communicate by composing to and perusing from the socket. The java.net Socket class represents a socket, and the java.net. ServerSocket class gives an instrument to the server system to listen for clients and build up connections with them.

The following steps occur while establishing a TCP connection between two computers using sockets:

- The server declares a Server Socket object, mentioning the port number the communication is to occur on.
- The server uses accept () method of the Server Socket class. This method waits till a client connects with the server on the declared port.
- When the server is waiting, a client instantly represents a Socket object, mentioning the server name and the port number to connect to.
- The constructor of the Socket class tries to connect the client to the mentioned server and port number. If connection is created, the client now has a Socket object capable to communicate with the server.

- On the server side, accept method returns a direction to a new socket on the server that is connected to the client's socket.

When the connections are established, communication can take place using Input/Output streams. Every socket contains both an Output Stream and an Input Stream. Client's Output Stream is connected to the server's Input Stream, and vice versa.

TCP is a two-way communication protocol, so data can be transferred across both streams at the same time.

4.3 Application in our Thesis

Socket programming is one of the widely used methods to communicate between two nodes or points. In our thesis, we have used socket programming to communicate among the components (as routers, trackers and servers). We have used java as the language and NetBeans IDE as the constructor. Our code has two segments; one for client purpose and another for server purpose. We are using long-range routers which can cover up to 1500 meters in range as servers in the Client-Server model. These servers can accept java language if we install third party software. For client, we can use tracker that supports java or any java supported device. For the central server, we can use a CISCO server to store the information.

To start the connection, we first have to announce the necessary imports that we are using for both codes. Then, we have to work on two different codes. The processes are stated below.

4.3.1 Server code

At first, a socket is needed to be created to establish the connection. We announce a random port number in the server code to begin the creation of a socket. To calculate the time difference, we need to get the connection establishment time in milliseconds. So we use calendar function and convert it into “long” as string. We need to print the time to show the exact time in milliseconds that is required to establish the connection on server. We need to create a “DataOutputStream” variable to send any message or data to client. Then we use “InputStreamReader” to listen if anything is sent from the client and use “BufferedReader” to save it as string. We can also print the

message sent by client.

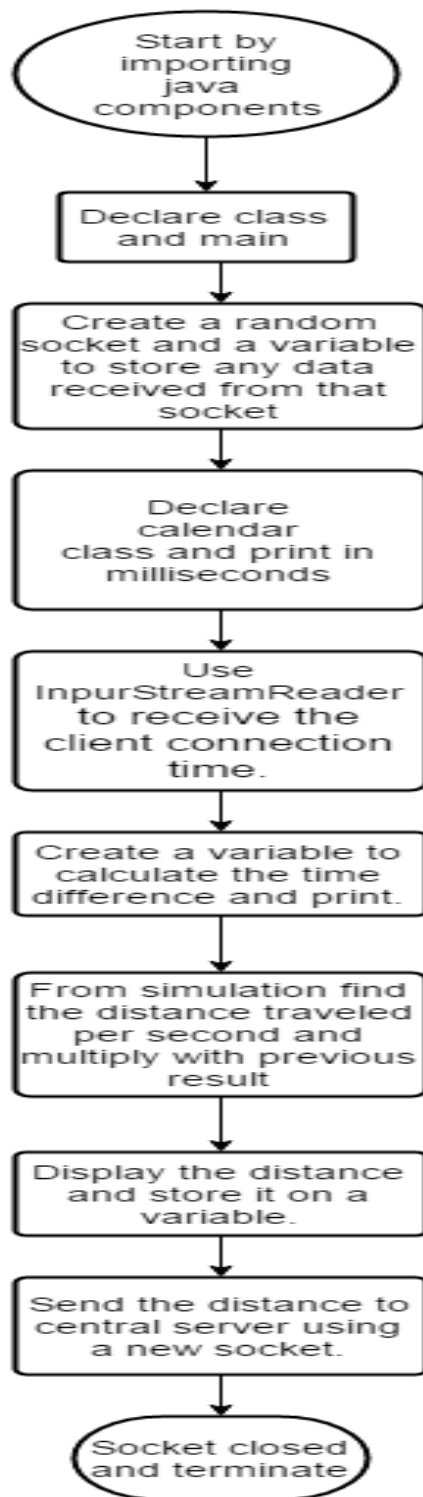


Figure 4.1: Flowchart of Server Code

4.3.2 Client code

At the server code, we declared a random port number. In the client code, we need to bind the port number with the precise IP of the router working as the server in this model. Then we use “InputStreamReader” to listen if anything is sent from the server and use “BufferedReader” to save it as string. We also need to extract the connection establishment time of the client. This time will be shown in the server output of the code.

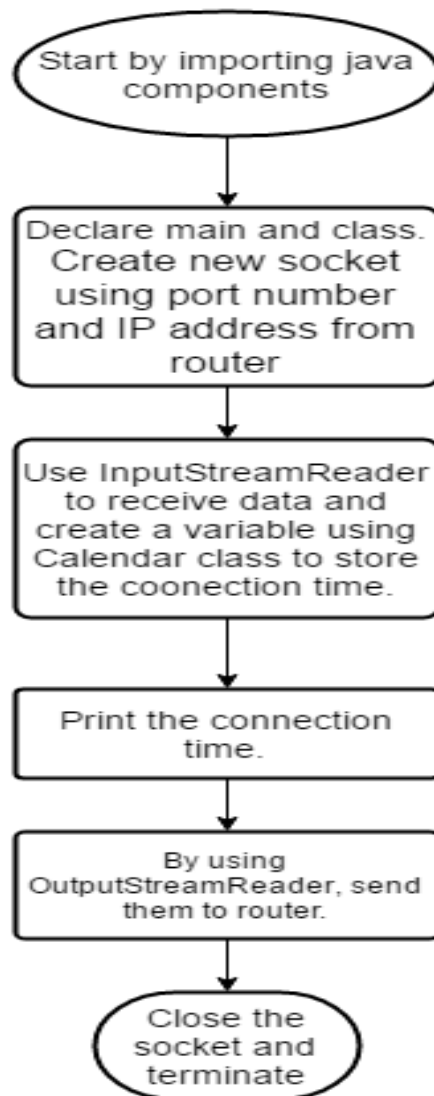


Figure 4.2: Flowchart of Client Code

Now we know both the time in milliseconds format. A drawback in this method is that the time in milliseconds which is shown started from 1970; as this is a calendar. But we used this because we do not need time synchronization. What we need is the time difference while connecting. We can find the distance by multiplying bandwidth and the required time to send 1 MB of data. This assumption can be derived from creating a simulation using MATLAB.

The factor to note here is that, Wi-Fi speed will not be always same. But we can assume that by using routers with high gain and amplification mechanism, this problem can be averted.

After calculating the distance in server code, we can send it to the central server simply by creating another socket and the IP address of the central server.

4.4 Android Application

We have developed an interactive user interface using Android Studio, named METRO-LINK, to make our train tracking service more reachable to common people and to make it more users friendly. Now we will discuss about the Android Studio and the development phases of our application.

4.4.1 Android Studio

Android Studio [18] is an official Integrated Development Environment (IDE) for developing Android application, which is based on IntelliJIDEA. Though IntelliJ has powerful code editor and developer tools, Android Studio also offers even more features that enhance the productivity of building Android application, for instance:

- It has flexible Griddle-based build system.
- It has a fast and feature-rich emulator.
- C++ and NDK are supported by android studio.
- Here developers do not need to build a new APK running application while changing from run to push.
- Extensive testing tools and frameworks are available.

- Lint tools are available to catch performance, usability, version compatibility, and other problems.
- Built-in support for Google Cloud Platform is accessible and it makes easy to integrate Google Cloud Messaging and App Engine.
- Code templates and GitHub integration are there to help the developers to build common app features and import sample codes.

4.4.2 METRO-LINK

METRO-LINK is a very simple and user friendly software. User can get all necessary information regarding train's arrival and departure time, current position and also for user convenience they can buy tickets by this vary software. As user need to open an account to use this software this feature ensure security while buying ticket from internet. Most importantly, by using this software anyone can get excess from anywhere and can see real-time stimulation of a particular train.

We choose android platform over windows or IOS, as because, android phones are widely available and used by majority of mobile users comparing windows and IOS operating system (OS).

After downloading and installing METRO-LINK in their smart devices for the first time users are asked to fill up a simple sign up form which required Email Address and Password. For users who has already signed up need to write down their user name and password to log in. After successfully log in, now user sees two options on display. She/he can chose between "stations" or "ticket booking & purchase". By clicking "ticket booking & purchase" user will be directed to Bangladesh Railway's official website. From there they can book and purchase tickets.

If user chose "stations", on the next page all the station names will come out. Selecting of any specific station will take him/her to the next page, here he/she can look for arrival and departure times of trains at that particular stations. For example, if the user click on departure button he/she will see all the trains name with their departure time. The third option "current location" will

connect him/her to the main server. On request from the user the server will provide necessary information and user will see desired train's location.

The whole system is summarized in the following figure,

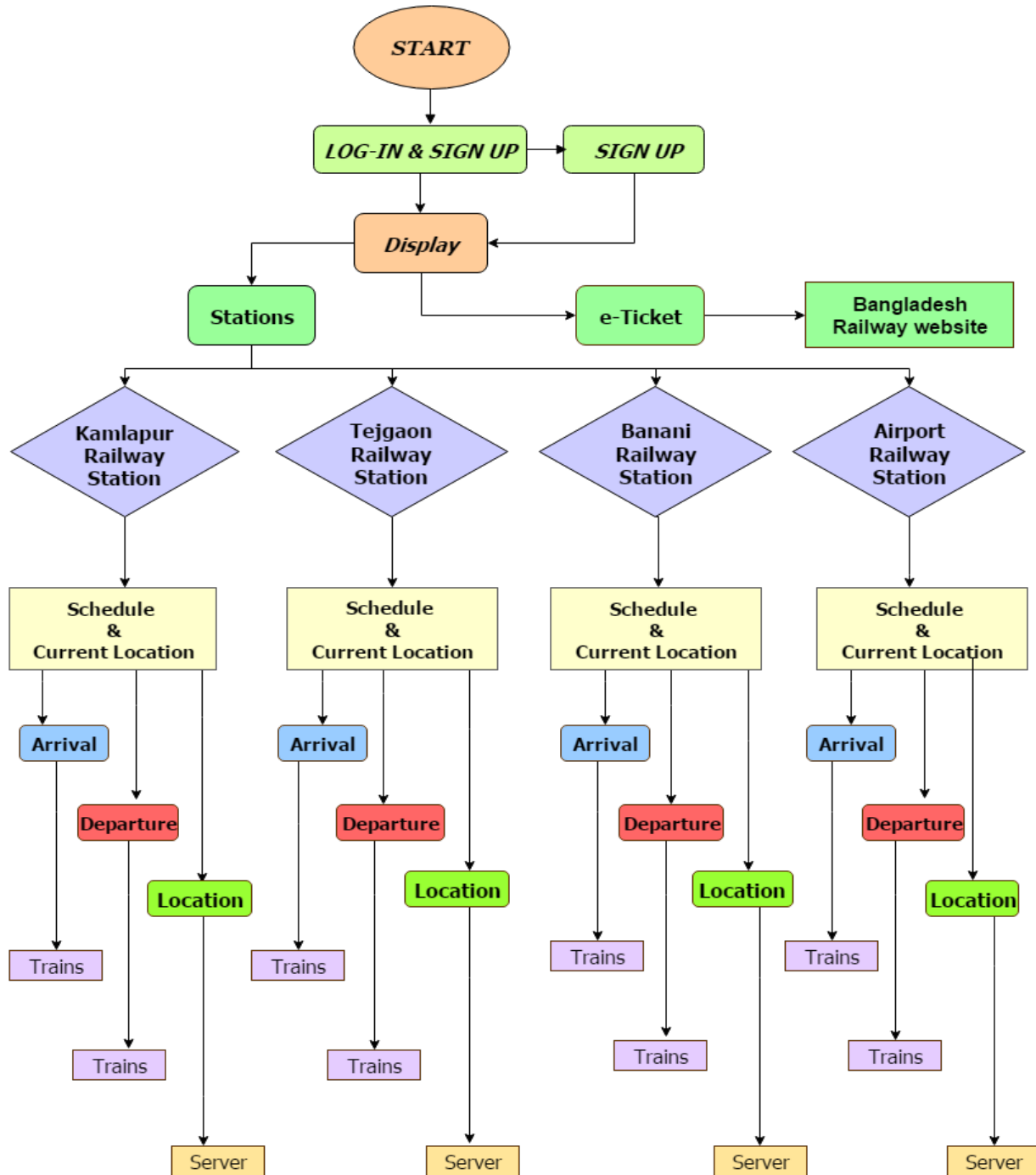


Figure 4.3: Operating Principle of METRO-LINK

4.4.3 Development of METRO-LINK

Android studio 2.1.1 version was used to develop the software. We designed our software in API 15: android 4.0.3(IceCreamSandwich), the reason was, by targeting API 15, application will run on approximately 97.4% of the devices that are active on Google play store.

We assigned our main-activity as the launcher and all other activities as layout. Different types of text Views, buttons and backgrounds were implemented in the application to make it more interesting for the users. In LOG-IN and SIGN UP section different types of text fields were implemented such as Name, Username, Password and Email Address. Database works as a collector of information that is organized so that it can easily be accessed, managed, and updated. In one view, databases can be classified according to types of content: bibliographic, full-text, numeric, and images. So we created a database chart to maintain the records of signed up users. To update the trains arrival and departure time of each of the station, another database chart was created.

For booking tickets and purchasing, we called the website of BD rail E-Ticket. With the help of this facility, a user can get the website without any hassle. Last but not in the list, to see the current position of a particular train we called the central server for the information.



Figure 4.4:User interface of METRO-LINK

4.4.4 Benefits

While developing METRO-LINK software our main intention was to make such a software which is very simple and easy to use. It has the facilities for the users to get all the information about the trains and user can buy tickets from online as well. This application is secure for buying tickets because user have to open an account. Moreover, user can use it anytime from anywhere.

4.4.5 Limitations

METRO-LINK has some limitations such as this app will take information from server then it will deliver the information to the user. So users have to have internet excess to use this application. Another thing is GSM is not applicable for this application. At present, this application is designed only for metro trains. So this app is not capable of giving information which are coming from or going outside of Dhaka. IOS and windows users cannot use this application as it is only applicable for androids.

4.4.6 Future Work

We are still trying to improvise this application by minimizing the limitations we have right now. At present our main priority is to develop a web view, so that, user can visualize the trains and it will be more realistic. Also we are trying to develop this app for IOS and windows users.

Chapter 5

Conclusion

5.1 Summary of the Thesis

Those days are gone when people had to wait for hours in railway stations. Our Train Tracker allows people to communicate with the train itself to know the exact timing of its arrival and departure. Traveling by rail is cheaper and also more comfortable than traveling by road. But, trains have lost their popularity to an extent and the biggest reason is delay. These days, people don't have hours to waste sitting idle in the stations. Though our tracker cannot solve this problem it can save people's time by letting them have the exact information about the arrival and departure of their train. Anyone with a smart phone and internet can easily track the train while sitting at home. This will definitely help to reduce unnecessary harassments and irritations. If this tracker becomes popular among the masses, trains will become more popular to them too. This can cause a drastic reduction of the unbearable traffic jam we face every day because many people, who travel by bus or car, will travel by train for this benefit. So, if we see the bigger picture we can create a very useful tracking method which will serve the people of our country. All we have to do is make this method accessible to the masses and let them know about its worth.

Our tracking system is better due to the fact that we are using Wi-Fi, which provides us better connectivity and fewer limitations. In a Wi-Fi network, there are very negligible chances of data drop or failure in connectivity. It will provide us with better accuracy and immunity from multipath effect and fading. Our tracking mechanism and our method of providing data is what makes our model unique from other models. The major benefit from our model is that more accurate information is provided and they are shown in an app, which is something not done before.

5.2 Limitations

As this is the first paper in train tracking system, it has some major limitations. They are discussed below:

Socket programming: Socket programming is an old API made for communication purpose between two users. It contains very limited number of function. Measuring a distance directly is not possible using socket programming. We have done a simulation in MATLAB to get more realistic theoretical results.

Mapping procedure: To know the exact position of the routers acting as servers, we need to map the precise locations of them. But creating a map using Fingerprinting is a matter of a lot of time. Though, when the service provider will spread their service all over the country, we can assume that they will create a map to keep track of their equipment.

Central center and server: To converge the raw distance found from the routers to actual location and to store them requires a central server and a control center. Control center will maintain the routers and follow an algorithm to convert discrete locations to actual locations. Central server will store all the information. We do not have that algorithm or the server. It requires a lot of time and skill to build that. As those resources were not available, we could not build them.

5.3 Future Works

Our future plan is to enhance some of the features and add the missing components. The additional features will be

- Compartment tracking of a train using UV Wi-Fi signal.
- Platform tracking.
- A virtual map containing the desired train's location and the track it is on.

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