Automated Railway Track Switching System

A Smart Rail Station Control System

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APPROVAL

This thesis entitled "**Automated Railway Track Switching System**" has been submitted by **MD. Mohaiminul Islam Khan.** It has been accepted satisfactorily in partial fulfillment of the requirement for the degree of **Bachelor of Science in Electrical and Electronic Engineering,** for **Md. Mohaiminul Islam Khan** on August 2015.

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DECLARATION

This is to certify that this thesis is based on the results found by me. Materials of work found by other researchers are mentioned by reference. This thesis, neither in whole nor in part, has been previously submitted for any degree or diploma.

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Abstract

Railway system is one of the most popular and convenient system of transportation in Bangladesh. This whole sector is run by government of the people's republic of Bangladesh. It is one of the most popular because it's fast, traffic less and low cost. Though it is a popular system in Bangladesh, the whole railway system is still a little bit orthodox here. The government of Bangladesh faces a huge amount of losses every year because of the lack of efficient and educated manpower and different accidents. A smart automated railway system can solve all these problems. In this paper, a smart automated railway track switching system has been introduced and idea of a smart railway station has been introduced which will reduce the manpower problem and will save a huge amount of public property. This automated system is the combination and synchronization of different standalone subsystems. The introduced first subsystem here is the monitoring of the train via smart satellite navigation system (**GPS**); the second subsystem is in the control box of the rail track which consists of modern communication system (**GSM/GPRS**) and control unit for switching the track by filtering the data from the GPS Location. The third subsystem is a monitoring system designed for the control room of the railway station to monitor and control the whole system. The automation and control of the whole system has been done by microcontroller unit to reduce the cost and complexity of the system and for increasing the efficiency.

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Chapter 1: Introduction:

As the major part of the public transport system railway is serving millions of passengers and carrying tones of goods every day. Railways provide a better alternative to other modes of transport by being energy efficient since it can carry large number of people and goods at the same time. As a result, the railways had grown over the years and also the number of people using it. It contributes a lot in our economy. It is their responsibility to have a good management system for good customer services. Therefore, it is necessary for the management to make the train journey safe & reliable. But the recent train accidents especially head on collisions make the passengers to think otherwise. The old signalling and operating systems sometimes make wrong operation which causes severe train accident with a huge number of casualties as well as colossal financial losses. In my research, the soul idea was to design a system to avoid the head on collisions of trains due to either disoperation or maliciousness. In addition to this process, an automated rail line switching system has been introduced in this paper which will lead to a cost effective, safe and fast smart railway station for Bangladesh Railway.

A railroad switch, turnout or points is a mechanical installation enabling railway trains to be guided from one track to another, such as at a railway junction or where a spur or siding branches off. The switch consists of the pair of linked tapering rails, known as points (switch rails or point blades), lying between the diverging outer rails (the stock rails). These points can be moved laterally into one of two positions to direct a train coming from the point blades toward the straight path or the diverging path. A train moving from the narrow end toward the point blades (i.e. it will be directed to one of the two paths depending on the position of the points) is said to be executing a facing-point movement. [1]

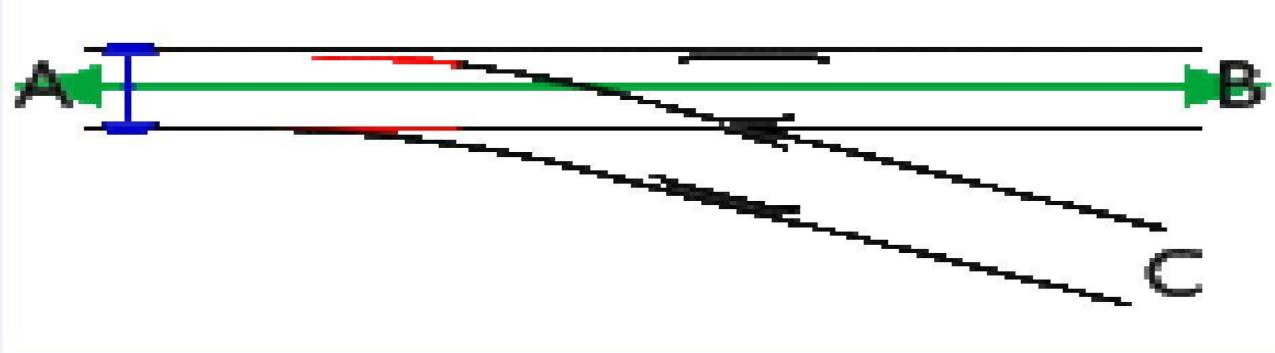


Fig 1.1: Diagram of a train track switching

1.1: Bangladesh Railway:

1.1.1: Structure of Bangladesh Railway:

Bangladesh Railway (reporting mark BR), is the state-owned rail transport agency of Bangladesh. It operates and maintains the entire railway network of the country. 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 BR. Key features of BR are the coexistence of several gauges, Broad gauge, Metre 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. Bangladesh Railway covers a length of 2,855 route kilometres and employs 34,168 people. BR operates international, inter-city and suburban rail systems on its multi-gauge network. It also owns coach production facilities.

After independence, the railway was first supervised by a Railway Board which was abolished in 1982. Thereafter, the BR came under the jurisdiction of the Railway Division of the Ministry of Communications with the Secretary of the Division working as the Director General of BR. In

1995, instead of being the part of the Ministry, BR came under control of a professional Director General supervised by the Bangladesh Railway Authority that is chaired by the Minister of Communications. BR is divided into two zones, East & West, each under control of a general manager who is accountable to the Director General of Bangladesh Railway. The two zones have their separate departments for operation, maintenance, and finances. Each zone is divided into two divisions that contain departments for Personnel, Transportation, Commercial,Finance Mechanical, Way and Works Signaling & Telecommunication, Electrical, Medical, etc. Each zone also has its Workshop Divisions, located at Pahartali and Saidpur respectively. A locomotive workshop is located at Parbatipur for broad and metre gauge locomotives. BR manages its own Railway Training Academy. A separate Directorate under the Ministry of Communications is charged to inspect different works of BR in relation to safety. [2]

1.1.2: Existing Railway Switching System:

In recent days, the Bangladesh Railway is using Electronic (Solid State) Interlocking and Relay based Interlocking Signalling System installed by **IRCON INTERNATIONAL LIMITED**(A turkey Infrastructure Company Limited). They have installed Relay Interlocking at 6 stations for Bangladesh Railways (1996-98) which has cost around US$ 2 million. Modern Signalling & Interlocking system at 12 stations situated on Akhaura – Sylhet section of East zone of Bangladesh Railways (2006-2008) cost around US$7.5 million. Solid State Interlocking at 4 stations & modification of existing Mechanical Signalling at 25 stations and modification of existing Relay Interlocking at 2 stations for Bangladesh Railways (2003-04) cost around US$ 3.82 million.[3]

This modern switching system has installed only in the major railway stations in Bangladesh. However, this system is not fully automated. In this system, the communication between the train and station is done by telecommunication. When a train confirms it's location, the people in the station control determines an empty platform for it, gives him the confirmation and turn on a switch for moving the track with that platform.

Fig 1.2: Moveable Rail Track

Fig 1.3: Mechanical Control box containing Electronic (Solid State) Interlocking and Relay based Interlocking

However, the other railway stations all over bangladesh's track switching systems are still manual which is controlled by a hand lever. When a train confirm it's incoming, a person or labour has to go there and pull the lever to switch the track.

Fig 1.4: Manual Hand Lever based track switching system

1.1.3: Railway Developments in Bangladesh:

Modernization of the communication system and infrastructure is one of the main prerequisites for the growth and economic development of a nation. Communication system is much more important for the business and other sectors. After consuming office for the consecutive time, the government has decided to convert railway sector into a developing one by implementing various projects. These include 50 short, medium and long term projects worth Tk 18,310 crore. For implementing these projects quickly, government has prepared a draft working plan and is strong minded to implement these working plans as soon as possible.

According to railway ministry, Government has 21 short term projects which will be implemented by June, 2015. 22 middle termed projects by 2016. Government has also decided to finish the work of 6 long term projects by 2018.

Director General of Bangladesh Railway Md. Tafazzal Hossain has said that these work plans have been taken to improve the passenger service of railway and thus making railway more

stronger medium of communication. He also said that these work plans will be finalized by the authority very soon. He hoped that it will develop the railway sector to a great extent. [4]

1.1.4: Flaws in present System:

Every year a lot of railway accidents are happening in our country and Bangladesh railway has to bear those those economical losses because of the accidents. The main reasons behing these accidents are lackings of eficient and trained manpower, geographical constraints, managerial problems and lack of moderrnization.

The expansion of BR has been blocked since 1947. Only 80 kms rail line has been constructed for last 50 years. On the other hand, more than 1200 kms rail lines are under risk for operation due to lack of proper maintenance and attention which is mainly for insufficient fund allocation. As a result, derailment has become common. This has adverse impact on the efficiency and reliability of railway services. One of the major problems, presently faced by the Bangladesh Railways is a serious shortage of locomotives and route capacity. Far from having insufficient traffic on its trunk routes, the BR suffers an excess of traffic in relation to the capacity of these routes. Operating priority on these routes is given to passenger trains, and freight trains incur major delays and frequent cancellations as a result. Since the liberation of Bangladesh, instead of constructing new rail-routes, some of the branch line railway sections were declared redundant and subsequently closed and no proper attention to maintain the existing asset was being given. [5]

1.2: Aim and Scope of the thesis:

Since 1947, Railway development in Bangladesh has not been that much. Because of the lack of modernization and using smart technology, this government sector counts a huge amount of loss every year. In my research, I have design a smart auotmated railtrack switching system which will be cost effective, reduce the need of man power and will icrease the efficiency of overall system. In Bangladesh, we have 454 railway stations in total and Kamalapur railway station is the central railway station in Bangladesh.[2]

This automated system will be efficient and accurate and will reduce the risk of accidents. In this system, I have introduced a GPS tracking system for the train. The location of the train will be tracked simultaneously via GPS. When the location of the train will come to the predetermined location set by the engineers which will be safe enough distance from the station, the train will send it's gps loction using a GSM shield to the station or central command center. The train will also generated a signal whether it's a express train or local train. By comparing this two signal, the central command engineer will send a confirmation signal to the junction of the railway track to attach it with the desired rail platform's track. By using this system, we can replace the big mechanical lever based manual system for track switching and also replace the radio based communication system between train and command center. In this way, the whole railway system will be more effective, efficient and accurate and will be able to meet the customer satisfaction.

1.3: Previous work based on automated track switching system:

As railway system is one of the oldest mode of transportation around the whole world, a lot of scientific researches had been done for it's improvement and efficiency. However accidents and mishaps are unevitable, no research or system can give hundred percent safety gurantee on this issue but further development by research and implementation of new technology is possible. On November 2013, an indian paper has been published on ORIENTAL JOURNAL OF COMPUTER SCIENCE & TECHNOLOGY on Automated rail track control using microcontroller where they have proposed a design using sensor and microcontrollers. They used two platforms to make easy model which could make any number of platform. When train reached at certain distance from the railway track a set of sensors were placed to detect the train and two pairs of sensor were placed on other side of track to detect the train. When the train was at the first pair of sensors it sent a signal to microcontroller to know the availability of platform. Here after checking availability, microcontroller operated stepper motor to change the track. [6]

Another Paper has been published on 2014, which is also a sensor based design but with a better algorithm and software design. In their system, A low power dc motor is used as a track switching device. In the sensing unit photodiode is used for detecting IR radiation which ensures a reliable detection of trains' entrance. A communication line communicates between the track switching device and main monitoring room. Total system can be monitored and visualize by a software which shows train's position, operation mode and safety status. This system can work both automatically and manually and also can be controlled by the software from the main control room which gives the system more flexibility in operation. [7]

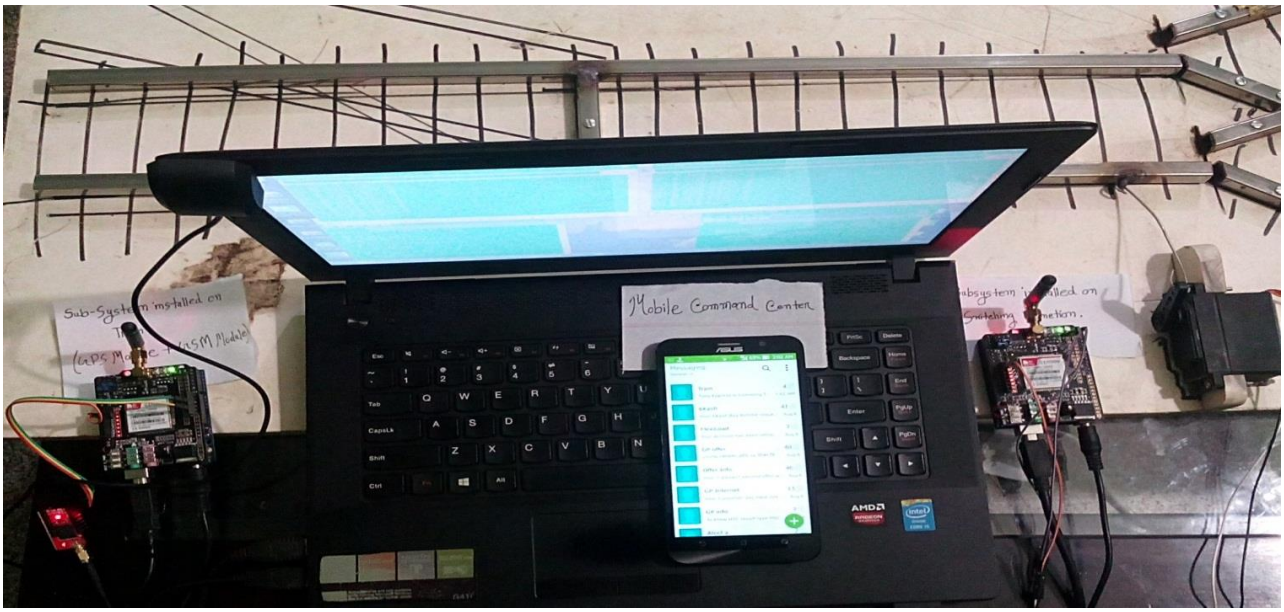
All of the above mentioned work is at ground zero for aiming the automated railway track switching system for fast, effective and smart railway station and reducing the number of railway mishaps in Bangladesh.

Chapter 2: System Architecture:

The architecture of this system employs a couple of micro-controllers and fuses them with a number of software which takes advantage of the micro-controller resources. A set of software is handled concurrently by a single micro-controller, allowing each of them to perform a variety of important functions side by side.

2.1: Overview:

The concept of this project is to build a fully automated smart railway station. To achieve that goal, I have to design different subsystems and make them work in a synchronized way. Every subsytem is controlled by microcontroller unit for accuracy and efficiency. The first subsystem is designed to be installed on train. It consists of a GPS shield for real time train tracking and a GSM/GPRS shield to send the GPS data and location to the central command center of the station.



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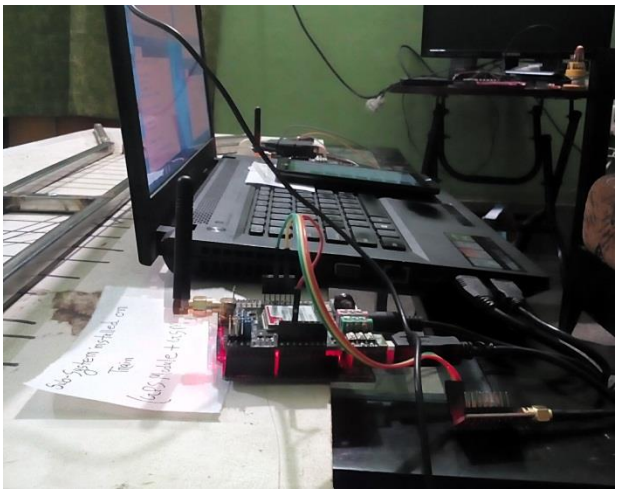

(2)

(3)

Fig 2.1: The Complete Automated System

The second subsystem is the central command center. I have used a GSM used mobile device as the receiver of the command center. The third subsystem is designed to be installed on the rail junction. It consists of another GSM shield to receive the command send from the central command center and a servo motor to switch the rail track in the desired platform. A feedback system has also be designed to ensure the switching of the track and safety of the whole system. The following block diagram explains the operation of the whole system at a glance:

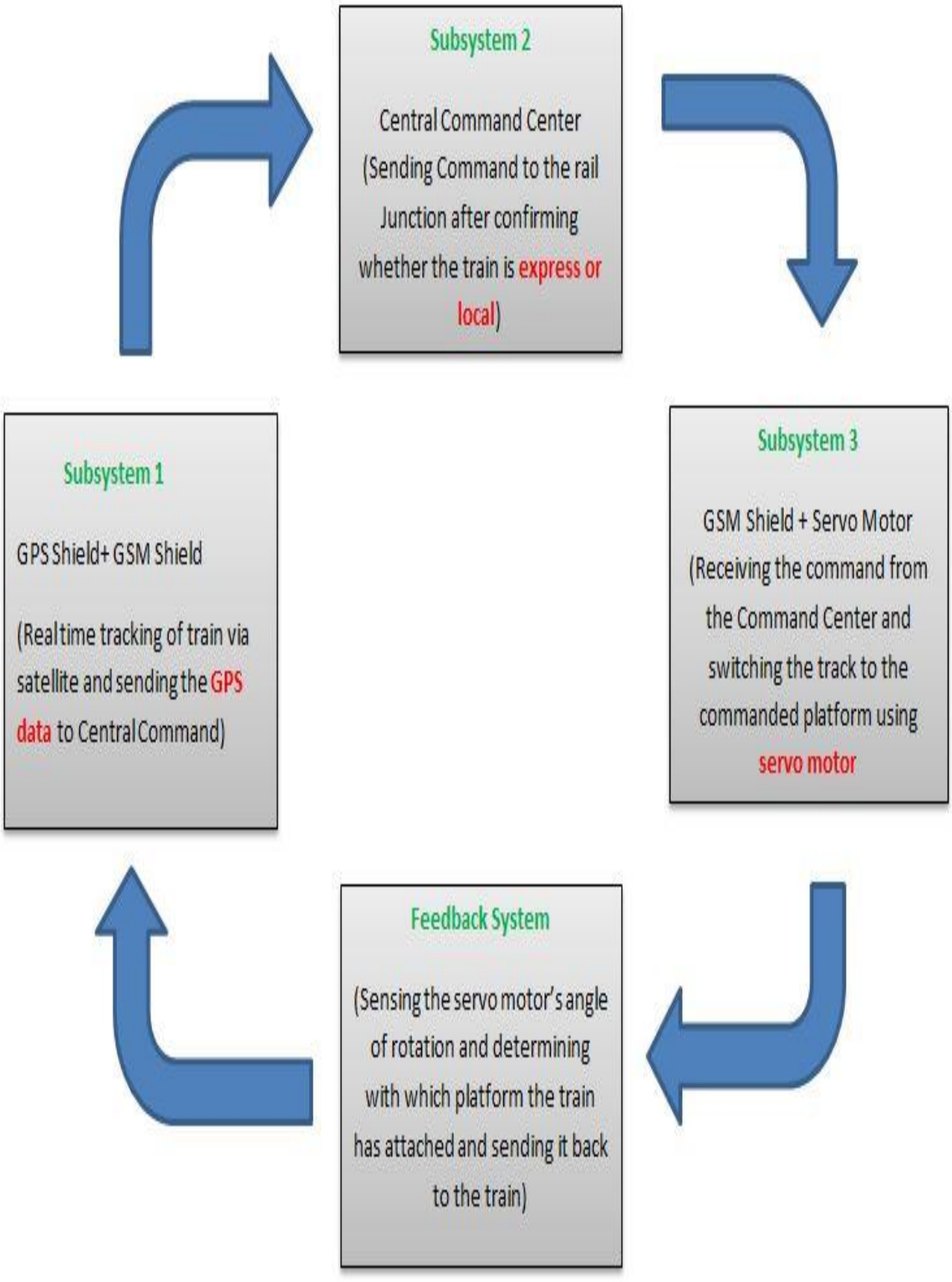

Fig 2.2: Block Diagram of the whole system

2.1.1: Real Time Train Tracking via GPS:

The first step of this project is to track the train via GPS. We have used venus GPS receiver controlled by microcontroller unit to track the train. The next step was to upload those GPS data on google map and establish a monitoring system. I have designed a web based Google map API on this purpose and upload that API in a TCP based web server to monitor the positioning of the train via internet.

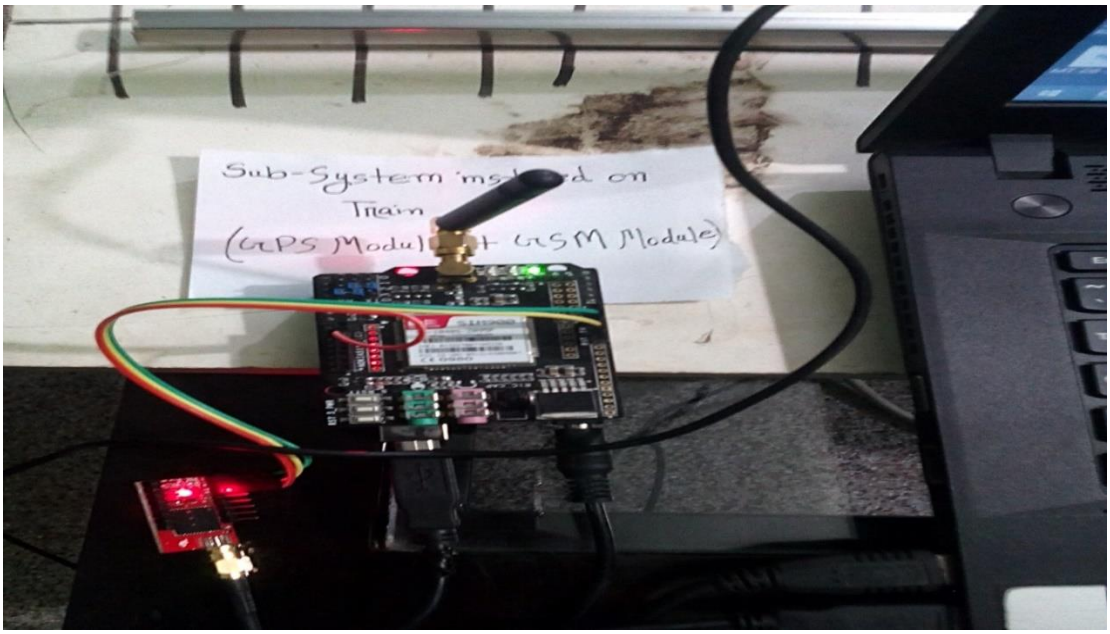

Fig 2.3: Subsystem designed for train

Here, at first the GPS receiver is getting the position of the train(longitude and latitude) from the satellite. The train's GPS location will be streaming in a website rapidly using a TCP server and Google map API. As the train will be moving at a very high speed, the server would have to be very fast and reliable to keep pace with the data. For uploading the data from the GPS to DNS Server, I use a GSM/GPRS shield. The GPS chip outputs the positioning information which is transferred over a GPRS link to the mobile operator's GGSN (Gateway GPRS Support Node)

and then to a remote server over a TCP connection. The TCP server stores the incoming positional data in a mySQL database. When a user clicks on the tracking page, Zope, which is an open source web application server, serves up an HTML page with an embedded javascript code. The javascript would run in the user's browser and has instructions to retrieve the positional information from the mySQL database every second. It then integrates this information into Google Maps through Google Maps API which displays the position on a map. Since the positional information is retrieved every second and the maps updated at the same frequency, a real time GPS tracking effect is achieved.

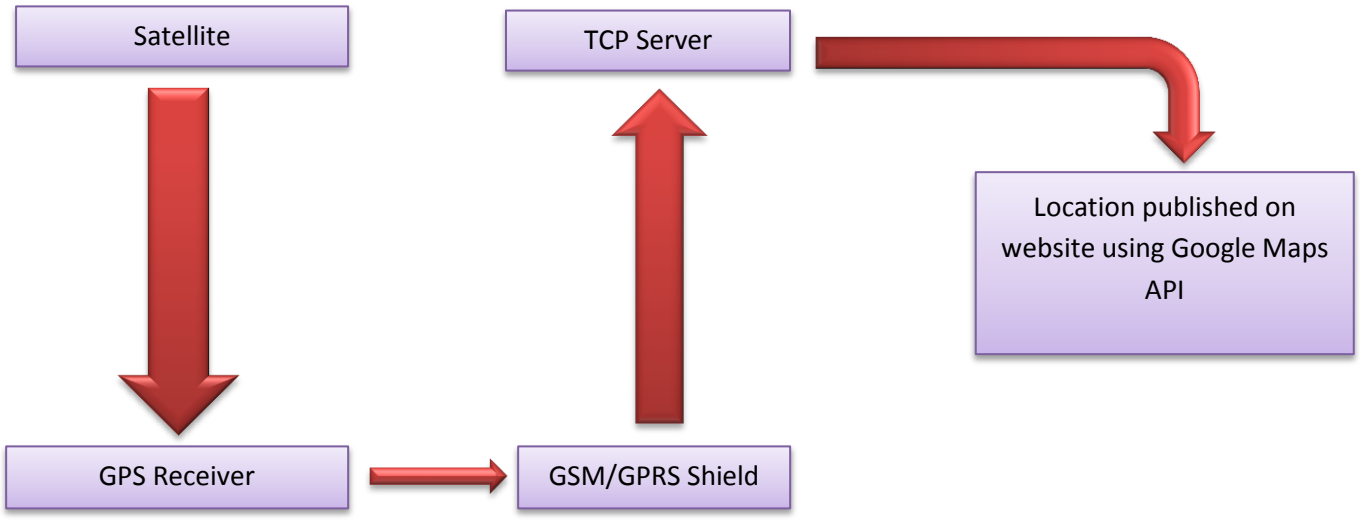

Fig 2.4: Block Diagram of real time train tracking

2.1.2: Mobile Command Center:

This subsystem unit will be installed in the control room of the station. Here we need a GSM based device to receive the GPS loaction of the train when it matches the predtermined location from the train. The GSM shield of the train will also generate a signal(SMS) assuring that whether the train is express train or local train. These two signal will be received in the form of

SMS in the GSM based mobile command center. In my project, I have used a smartphone on this purpose. After receiving the sms from the train, the engineer in the command center will be able to send the signal to the switching junction to connect with the desired platform. If the train is a express train, the train will be generate a sms using his name and type and send the sms in the cmobile command center and further command will be given from the engineer of the command center.

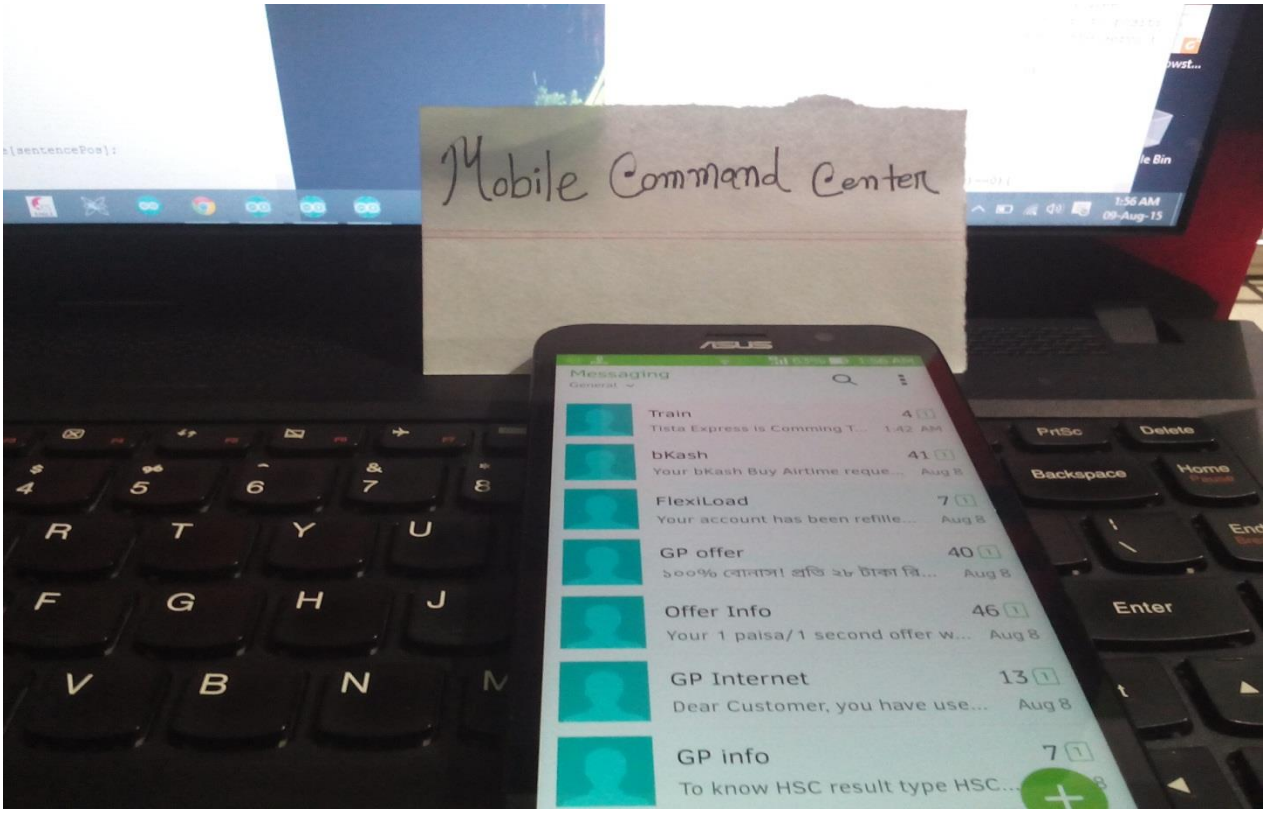

Fig 2.5: Mobile Command Center

2.3: Smart Signaling System for the switching of junction:

This subsystem is designed to receive the confirmation signal send from the mobile command center and operates the servo motor as commanded. The servo motor is connected with the rail track and it moves according to the command and connect with either of the platform. I have used servo motor because the servo can be controlled and measured by the angle of the rotaion. On the junction side subsystem, another gsm module will be installed which will be controlled by microcontroller unit and a servo motor which will be controlled by the microcontroller after getting proper command from the GSM shield.

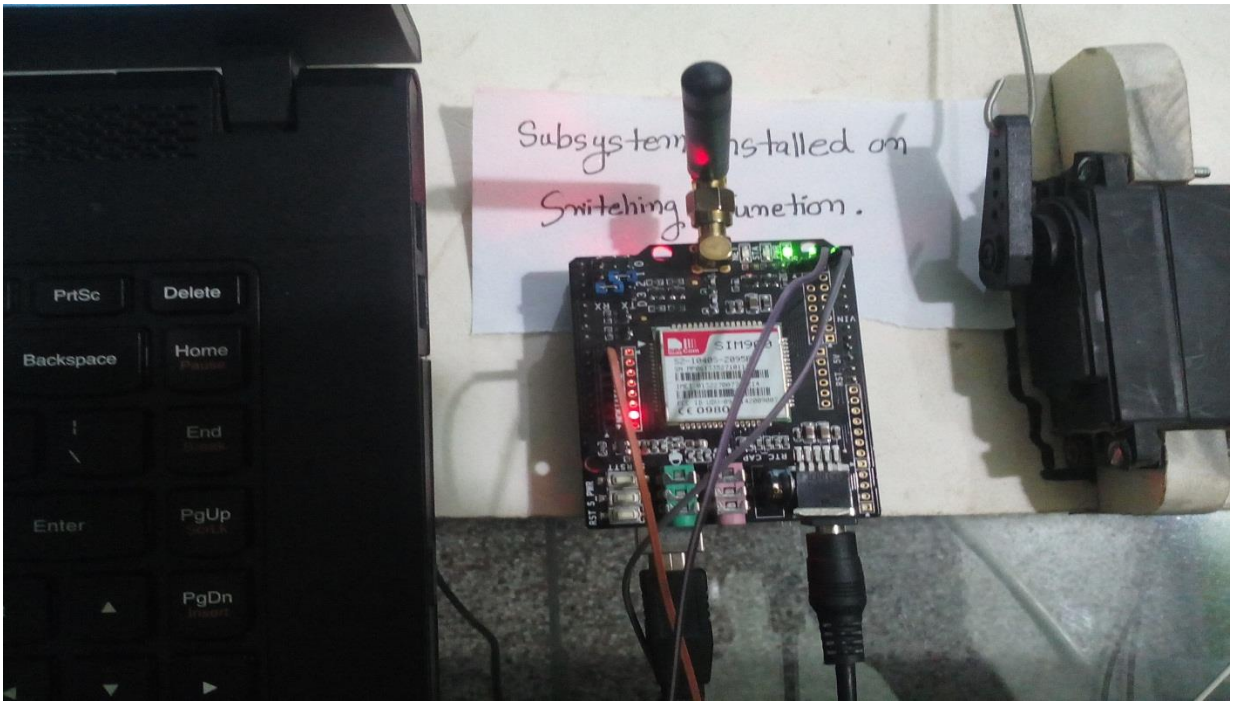

Fig 2.6: Subsystem Designed for switching junction

If the control engineer from the mobile command center gives confirmation to the junction by sending the signal(SMS) to be connected with platform 1, the gsm shield will receive the sms and will generate a message in the serial monitor that it is getting connected with platform 1.

When it gets connected with platform 1, the servo position becomes zero, and it gives a confirmation message in the train's serial moniotr that the rail track has connected to platform 1. When the command center generate sms for local train and send sms to connect with platform 2, the servo position becomes 67 degree and by measuring this angle, this subsystem sends a confirmation message to the train that the track has been connected to platform 2. If the command center gives a HOLD command, in case of unavailability of both of the junction, it will appear in the serial monitor of the train and the driver will be bound to stop the train.

2.2: Components:

This section lists the hardware and software components which have been used in the project.

2.2.1: Hardware:

This part describes the hardware components that were used to complete this project. Most of it contains electronics including micro-controllers, GPS Shield, GSM/GPRS Shield to implement logic.

2.2.1.1: GPS:

The Global Positioning System (GPS) is a satellite-based navigation system made up of a network of 24 satellites placed into orbit by the U.S. Department of Defense. GPS was originally intended for military applications, but in the 1980s, the government made the system available for civilian use. GPS works in any weather conditions, anywhere in the world, 24 hours a day. There are no subscription fees or setup charges to use GPS. GPS satellites circle the earth twice a day in a very precise orbit and transmit signal information to earth. GPS receivers take this information and use triangulation to calculate the user's exact location. Essentially, the GPS

receiver compares the time a signal was transmitted by a satellite with the time it was received. The time difference tells the GPS receiver how far away the satellite is. Now, with distance measurements from a few more satellites, the receiver can determine the user's position and display it on the unit's electronic map. A GPS receiver must be locked on to the signal of at least three satellites to calculate a 2D position (latitude and longitude) and track movement. With four or more satellites in view, the receiver can determine the user's 3D position (latitude, longitude and altitude). Once the user's position has been determined, the GPS unit can calculate other information, such as speed, bearing, track, trip distance, distance to destination, sunrise and sunset time and more. [8]

2.2.1.2: GPS Receiver:

As GPS tracking of the train is a major part in this project, I have used a GPS receiver made by SPARKFUN Electronics. The GPS receiver I use is known as SparkFun Venus GPS with SMA Connector. This is the latest version of Venus GPS board; the smallest, most powerful, and most versatile GPS receiver. It’s based on the Venus638FLPx, the successor to the Venus634LPx. The Venus638FLPx outputs standard NMEA-0183 or SkyTraq Binary sentences at a default rate of 9600bps (adjustable to 115200bps), with update rates up to 20Hz! The Venus638FLPx also allows for limited on-chip logging, as well as external logging using a SPI flash memory chip.

This board includes a SMA connector to attach an external antenna, headers for 3.3V serial data, NAV (lock) indication, Pulse-Per-Second output, and external Flash support. We’ve also provided solder jumpers to easily configure the power consumption, boot memory, and backup supply. This board requires a regulated 3.3V supply to operate; at full power the board uses up to 90mA, at reduced power it requires up to 60mA.

Fig 2.7: Venus GPS with SMA Connector and It's Antenna

Features:

- Up to 20Hz update rate
- -148dBm cold start sensitivity
- -165dBm tracking sensitivity
- 29 second cold start TTFF
- 3.5 second TTFF with AGPS
- 1 second hot start
- 2.5m accuracy
- Multipath detection and suppression
- Jamming detection and mitigation
- SBAS (WAAS / EGNOS) support
- 67mW full power navigation
- Works directly with active or passive antenna

- Internal flash for optional 75K point data logging
- Supports external SPI flash memory data logging
- Complete receiver in 10mm x 10mm x 1.3mm size
- Contains LNA, SAW Filter, TCXO, RTC Xtal, LDO
- Single 2.7-3.3V supply

It is easy to connect an external battery or super capacitor to the board, to support very fast restarts after power is removed. There are even pads on the bottom of the board for the 0.2F supercap (not included but you can find it in the related items below), which will keep the board hot-startable for up to 7 hours without power. [9]

2.2.1.3: GSM (Global System for mobile communication):

GSM (Global System for Mobile communication) is a digital mobile telephony system that is widely used in Europe and other parts of the world. GSM uses a variation of time division multiple access (TDMA) and is the most widely used of the three digital wireless telephony technologies (TDMA, GSM, and CDMA). GSM digitizes and compresses data, then sends it down a channel with two other streams of user data, each in its own time slot. It operates at either the 900 MHz or 1800 MHz frequency band. Mobile services based on GSM technology were first launched in Finland in 1991. Today, more than 690 mobile networks provide GSM services across 213 countries and GSM represents 82.4% of all global mobile connections. According to GSM World, there are now more than 2 billion GSM mobile phone users worldwide. GSM World references China as "the largest single GSM market, with more than 370 million users, followed by Russia with 145 million, India with 83 million and the USA with 78 million users." [10]

2.2.1.4: GPRS (General Packet Radio Service):

The first system to make an impact on the market was GPRS. The letters GPRS stand for General Packet Radio System, GPRS technology enabled much higher data rates to be conveyed over a cellular network when compared to GSM that was voice centric. GPRS technology became the first stepping-stone on the path between the second-generation GSM cellular technology and the 3G W-CDMA / UMTS system. With GPRS technology offering data services with data rates up to a maximum of 172 kbps, facilities such as web browsing and other services requiring data transfer became possible. Although some data could be transferred using GSM, the rate was too slow for real data applications. The key element of GPRS technology is that it uses packet switched data rather than circuit switched data, and this technique makes much more efficient use of the available capacity. This is because most data transfer occurs in what is often termed a "bursty" fashion. The transfer occurs in short peaks, followed by breaks when there is little or no activity. Using a traditional approach a circuit is switched permanently to a particular user. This is known as a circuit switched mode. In view of the "bursty" nature of data transfer it means that there are periods when it will not be carrying data.

To improve the situation the overall capacity can be shared between several users. To achieve this, the data is split into packets and tags inserted into the packet to provide the destination address. Packets from several sources can then be transmitted over the link. As it is unlikely that the data burst for different users will occur all at the same time, by sharing the overall resource in this fashion, the channel, or combined channels can be used far more efficiently. This approach is known as packet switching, and it is at the core of many cellular data systems, and in this case GPRS.

GPRS technology offered a significant improvement in the data transfer capacity over existing cellular systems. It enabled many of the first email and web browsing phones such as PDAs, Blackberrys, etc to be launched. Accordingly GPRS technology heralded the beginning of a new era in cellular communications where the mobile phone capabilities allowed significantly more than voice calls and simple texts. GPRS enabled real data applications to be used and the new phones to become mobile computers on the move allowing businessmen to be always in touch with the office and domestic users to be able to use many more data applications. [11]

2.2.1.5: GSM/GPRS Module:

After the succesful tracking of train, the major part of this project is to sending the GPS location to the mobile command center and from mobile command center to the switching junction of the train to do the switching operation via a servo motor. For this purpose, a gsm based communication is recommended. Another important part of the project is to show the GPS location in the google map. For this purpose, GPS location is needed to be uploaded in a Google maps API in a online server and GPRS communication is essential for this purpose.

To build a successful and reliable GSM/GPRS communication, I have used the GSM/GPRS shield from EFCOM, model- EF02020. GPRS Shield - EFCom is an ultra compact and reliable wireless module. This GPRS Shield is compatible with all boards which have the same form factor (and pinout) as a standard Arduino Board. EFCom is base on SIM900 GPRS module, which delivers GSM/GPRS 850/900/1800/1900MHz performance for voice, SMS, Data, and Fax in a small form factor and with low power consumption. SIM900 is a complete Quad-band GSM/GPRS module in a SMT type and designed with a very powerful single-chip processor integrating AMR926EJ-S core, allowing you to benefit from small dimensions and cost-effective

solutions. The GPRS Shield is configured and controlled via its UART using simple Command Manual_V1.03.pdf AT commands. Just plug this shield on the Arduino/ Freaduino board, you could easy to use AT command control EFCom Shild. You can use the 2 jumper block to connect the SIM900 URAT post to any pins within D0-D3(for Hardware/Software serial port). There is a switch on board , you can use it to select the connection of the UART port or Debug port , even be set on on Arduino, but by the switch and jumper block, the SIM900 can be connect to PC via FT233RL. The shield allows you to achieve this via any of the three methods:

- Short Message Service
- Audio
- GPRS

Features:

The main features of this module are following:

- Fully compatible with Arduino / Freaduino and Mega.
- Free serial port connecting, you can select Hardware Serial port(D0/D1) control or Software Serial port(D2/D3) control it.
- SIM900 all pins breakout. Not just the UART port and debug port be layout, but also all pins on SIM900 be layout to the 2.54 standard pitch.
- Super capacitor power supply for the RTC.
- EFCom not only can use the button for power on , but also can use the digital pin of Arduino to power on and reset the SIM900 module.
- Quad-Band 850/ 900/ 1800/ 1900 MHz
- GPRS multi-slot class 10/8

- GPRS mobile station class B
- Compliant to GSM phase 2/2+
- Control via AT commands (GSM 07.07 ,07.05 and EFCOM enhanced AT Commands)
- SIM application toolkit
- Supply voltage range : 3.1 … 4.8V
- Low power consumption: 1.5mA(sleep mode)
- Operation temperature: -40°C to +85 °C
- Dimension:68.33x53.09mm(Same dimension of Arduino main board) [12]

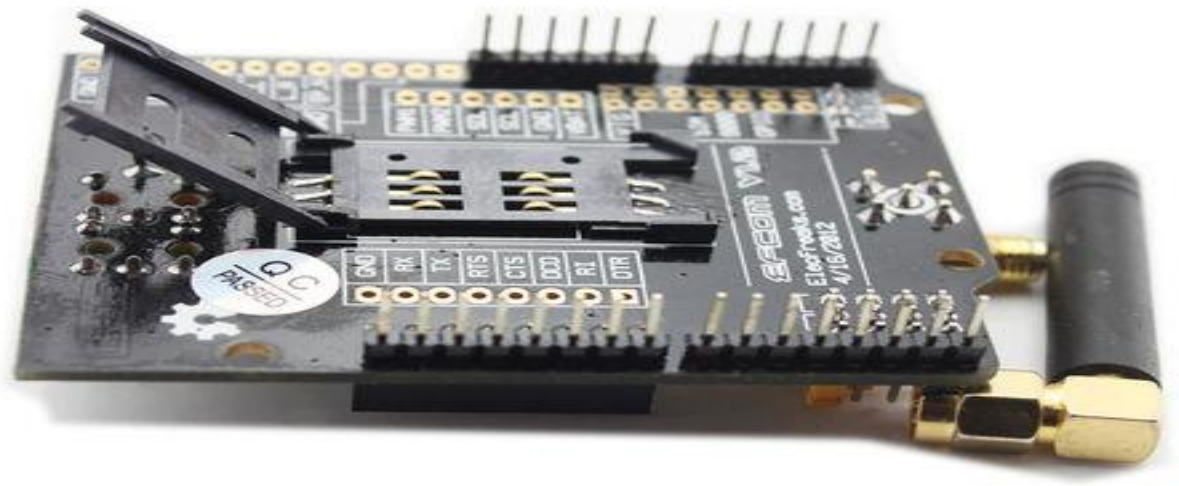

Fig 2.8: Bottom view of EFCOM GSM/GPRS Shield

2.2.1.6: Microcontroller Unit:

For the controlling, operation and accuracy of the whole system, I have used a few microcontroller unit. In this project, arduino uno has been used as the microcontroller unit for the purpose of controlling and operation.

Arduino Uno is a microcontroller board based on the ATmega328P. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz quartz crystal, a USB connection, a power jack, an ICSP header and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started. The Arduino/Genuino Uno board can be powered via the USB connection or with an external power supply. The power source is selected automatically. External (non-USB) power can come either from an AC-to-DC adapter (wall-wart) or battery [13]. The adapter can be connected by plugging a 2.1mm center-positive plug into the board's power jack. Leads from a battery can be inserted in the GND and Vin pin headers of the POWER connector. The board can operate on an external supply from 6 to 20 volts. If supplied with less than 7V, however, the 5V pin may supply less than five volts and the board may become unstable. If using more than 12V, the voltage regulator may overheat and damage the board. The recommended range is 7 to 12 volts. The ATmega328 has 32 KB (with 0.5 KB occupied by the bootloader). It also has 2 KB of SRAM and 1 KB of EEPROM (which can be read and written with the EEPROM library). [13]

Each of the 14 digital pins on the Uno can be used as an input or output, using pinMode(), digitalWrite(), and digitalRead() functions. They operate at 5 volts. Each pin can provide or receive 20 mA as recommended operating condition and has an internal pull-up resistor

(disconnected by default) of 20-50k ohm. A maximum of 40mA is the value that must not be exceeded on any I/O pin to avoid permanent damage to the microcontroller. [13]

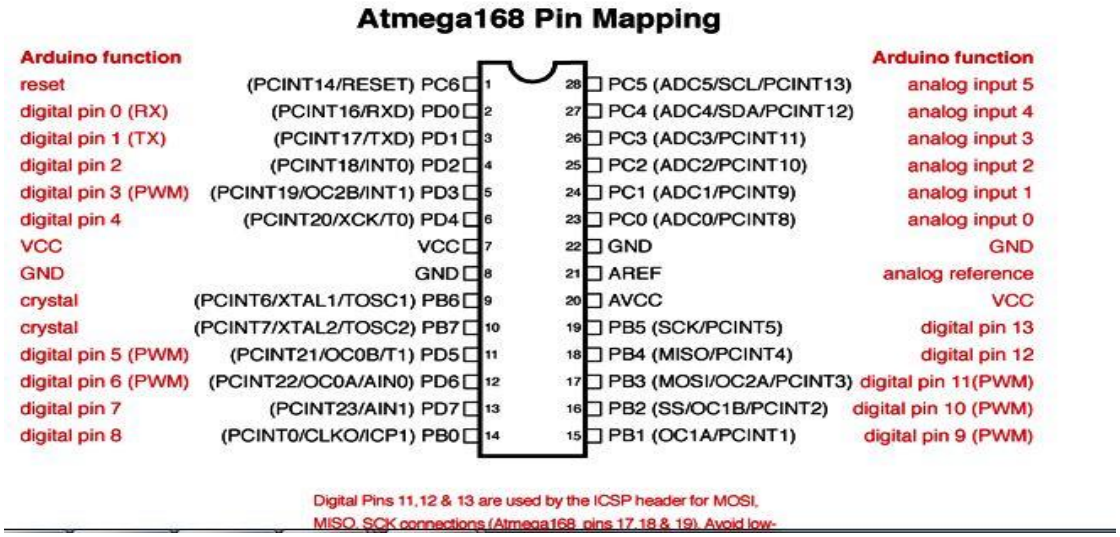

Fig 2.9- Atmega168 Pin Mapping

Arduino/Genuino Uno has a number of facilities for communicating with a computer, another Arduino/Genuino board, or other microcontrollers. The ATmega328 provides UART TTL (5V) serial communication, which is available on digital pins 0 (RX) and 1 (TX). An ATmega16U2 on the board channels this serial communication over USB and appears as a virtual com port to software on the computer. The 16U2 firmware uses the standard USB COM drivers, and no external driver is needed. However, on Windows, a .inf file is required. The Arduino Software (IDE) includes a serial monitor which allows simple textual data to be sent to and from the board. The RX and TX LEDs on the board will flash when data is being transmitted via the USB-to-serial chip and USB connection to the computer (but not for serial communication on pins 0 and 1). [13]

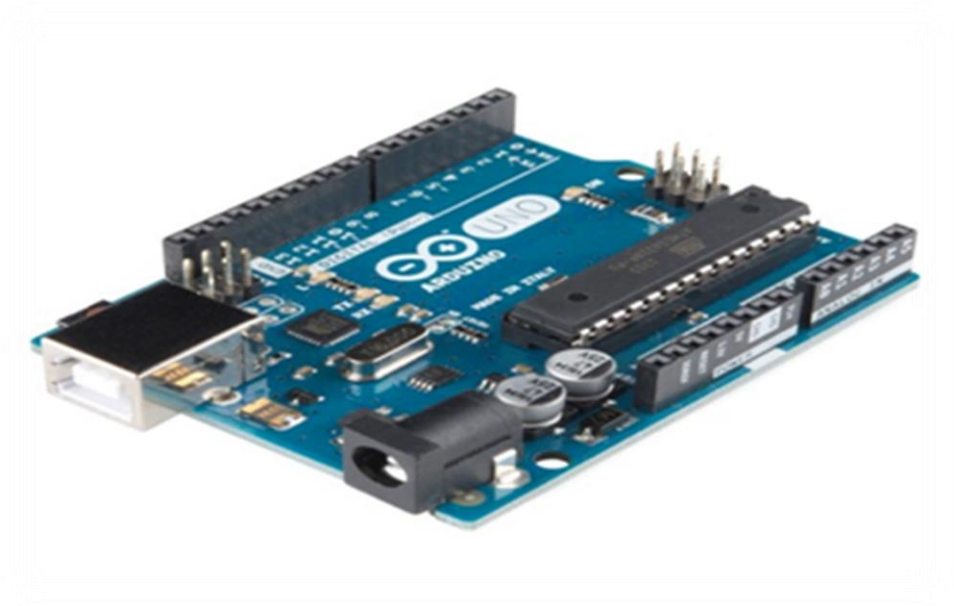

Fig 2.10: Arduino UNO board

A SoftwareSerial library allows serial communication on any of the Uno's digital pins. The ATmega328 also supports I2C (TWI) and SPI communication. The Arduino Software (IDE) includes a Wire library to simplify use of the I2C bus; see the documentation for details. For SPI communication, use the SPI library. [13]

2.2.1.7: Servo Motor:

For moving the rail track in our desired direction of the required platform, I have used servo motor. The main purpose behind using servo motor is it gives us to control it by it's angular rotation which gives us more accuracy and control over a system. In this project, using the servo motor's angular system controlled by the microcontroller unit, I have been able to move the rail track in a precise angle, and using the servo's rotor angle, a feedback message system has been programmed in this system to give the confirmation to the train that he is clear to enter into the station.

In this project, a 12v high torque servo motor has been used as the tracks are very heavy. A servo motor is basically a DC motor(in some special cases it is AC motor) along with some other special purpose components that make a DC motor a servo. In a servo unit, you will find a small DC motor, a potentiometer, gear arrangement and an intelligent circuitry. The intelligent circuitry along with the potentiometer makes the servo to rotate according to our wishes.

Fig 2.11: Servo Motor

At initial position of servo motor shaft, the position of the potentiometer knob is such that there is no electrical signal generated at the output port of the potentiometer [14]. This output port of the potentiometer is connected with one of the input terminals of the error detector amplifier. Now an electrical signal is given to another input terminal of the error detector amplifier. Now difference between these two signals, one comes from potentiometer and another comes from external source, will be amplified in the error detector amplifier and feeds the DC motor. This amplified error signal acts as the input power of the dc motor and the motor starts rotating in desired direction. As the motor shaft progresses the potentiometer knob also rotates as it is

coupled with motor shaft with help of gear arrangement. As the position of the potentiometer knob changes there will be an electrical signal produced at the potentiometer port[14]. As the angular position of the potentiometer knob progresses the output or feedback signal increases. After desired angular position of motor shaft the potentiometer knob is reaches at such position the electrical signal generated in the potentiometer becomes same as of external electrical signal given to amplifier. At this condition, there will be no output signal from the amplifier to the motor input as there is no difference between external applied signal and the signal generated at potentiometer . As the input signal to the motor is nil at that position, the motor stops rotating. [14]

2.2.2: Software:

2.2.2.1: Arduino IDE:

The Arduino integrated development environment (IDE) is a cross-platform application written in Java, and derives from the IDE for the Processing programming language and the Wiring projects. It is designed to introduce programming to artists and other newcomers unfamiliar with software development [15]. It includes a code editor with features such as syntax highlighting, brace matching, and automatic indentation, and is also capable of compiling and uploading programs to the board with a single click. A program or code written for Arduino is called a "sketch". Arduino programs are written in C or C++. The Arduino IDE comes with a software library called "Wiring" from the original Wiring project, which makes many common input/output operations much easier. [15]

2.2.2.2: GSM Library:

The GSM Shield library contains the source and header records for the fundamental functions needed to trade writings through GSM and transferring it to a site where the developments of the trains can be followed. Consequently, this should be imported into the Arduino library. An Arduino Uno board can have code of to 32bytes blazed into it. Counting the libraries helps us compose a minimized code which generally would have been extremely gigantic and disordered, given the enormous number of functions included. The library contains the majority of the elements of the SIM900 module we have utilized as a part of the "SIM900" source document.

2.2.2.3: AT Commands:

The GSM Shield library contains the source and header records for the fundamental functions needed to trade writings through GSM and transferring it to a site where the developments of the trains can be followed. Consequently, this should be imported into the Arduino library. An Arduino Uno board can have code of to 32bytes blazed into it. Counting the libraries helps us compose a minimized code which generally would have been extremely gigantic and disordered, given the enormous number of functions included. The library contains the majority of the elements of the SIM900 module we have utilized as a part of the "SIM900" source document.

There are two types of AT commands: basic commands and extended commands. Basic commands are AT commands that do not start with "+". For example, D (Dial), A (Answer), H (Hook control) and O (Return to online data state) are basic commands. Extended commands are AT commands that start with "+". All GSM AT commands are extended commands. For example, +CMGS (Send SMS message), +CMSS (Send SMS message from storage), +CMGL (List SMS messages) and +CMGR (Read SMS messages) are extended commands.

2.2.2.4: Google Map API:

For the continuous monitoring of the train's GPS loaction, A google map API has been designed for this project. The Google Maps APIs give developers several ways of embedding Google Maps into web pages, and allows for either simple use or extensive customization. For my purpose, I have designed a google map javascript web based API which will show the continuos positioning of the train in a dedicated web server. For the web based service, I have to made the API in html 5 and javascript. An application programming interface (API) is a set of routines, protocols, and tools for building software applications. An API expresses a software component in terms of its operations, inputs, outputs, and underlying types. Google Maps API belongs to a set of APIs developed by Google which allow communication with Google Services and their integration to other services[17]. Google Maps is chosen instead of Bing or Apple Maps as on the web all of them have more or less the same features with Google and Bing being much more polished. On the phone however, Google Maps edges both of them out as it has more features. Given that the number of users of smart phones and tablets are increasing more day by day and the vast majority of them are Android users, using Google Maps was necessary. [17]

2.2.2.5: NMEA (National Marine Electronics Association) Data for GPS:

GPS receiver communication is defined within this specification. Most computer programs that provide real time position information understand and expect data to be in NMEA format. This data includes the complete PVT (position, velocity, time) solution computed by the GPS receiver. The idea of NMEA is to send a line of data called a sentence that is totally self contained and independent from other sentences. There are standard sentences for each device category and there is also the ability to define proprietary sentences for use by the individual

company. All of the standard sentences have a two letter prefix that defines the device that uses that sentence type. (For gps receivers the prefix is GP.) which is followed by a three letter sequence that defines the sentence contents. In addition NMEA permits hardware manufactures to define their own proprietary sentences for whatever purpose they see fit. All proprietary sentences begin with the letter P and are followed with 3 letters that identifies the manufacturer controlling that sentence. For example a Garmin sentence would start with PGRM and Magellan would begin with PMGN. [18]

Each sentence begins with a '$' and ends with a carriage return/line feed sequence and can be no longer than 80 characters of visible text (plus the line terminators). The data is contained within this single line with data items separated by commas. The data itself is just ascii text and may extend over multiple sentences in certain specialized instances but is normally fully contained in one variable length sentence. The data may vary in the amount of precision contained in the message. For example time might be indicated to decimal parts of a second or location may be show with 3 or even 4 digits after the decimal point. Programs that read the data should only use the commas to determine the field boundaries and not depend on column positions. There is a provision for a checksum at the end of each sentence which may or may not be checked by the unit that reads the data. The checksum field consists of a '*' and two hex digits representing an 8 bit exclusive OR of all characters between, but not including, the '$' and '*'. A checksum is required on some sentences. [18]

NMEA consists of sentences, the first word of which, called a data type, defines the interpretation of the rest of the sentence. Each Data type would have its own unique interpretation and is defined in the NMEA standard. The GGA sentence shows an example that provides essential fix data. Other sentences may repeat some of the same information but will

also supply new data. Whatever device or program that reads the data can watch for the data sentence that it is interested in and simply ignore other sentences that is doesn't care about. In the NMEA standard there are no commands to indicate that the gps should do something different. Instead each receiver just sends all of the data and expects much of it to be ignored. Some receivers have commands inside the unit that can select a subset of all the sentences or, in some cases, even the individual sentences to send. There is no way to indicate anything back to the unit as to whether the sentence is being read correctly or to request a re-send of some data you didn't get. Instead the receiving unit just checks the checksum and ignores the data if the checksum is bad figuring the data will be sent again sometime later. [18]

Chapter 3: Result Analysis:

3.1: Output and Statistics:

In this chapter, an analysis of the whole system will be described. The success rate of the whole system performing synchronizingly is promising though many other variables need to be constant at that time such as GPS tracking of the train, strength of GSM network etc. This whole system is a combination of three different subsystem performing altogether. In a total, the whole system has been run 70 times and out of 70 times, all the system has perfectly worked together 58 times which gives us a success rate of 73%.

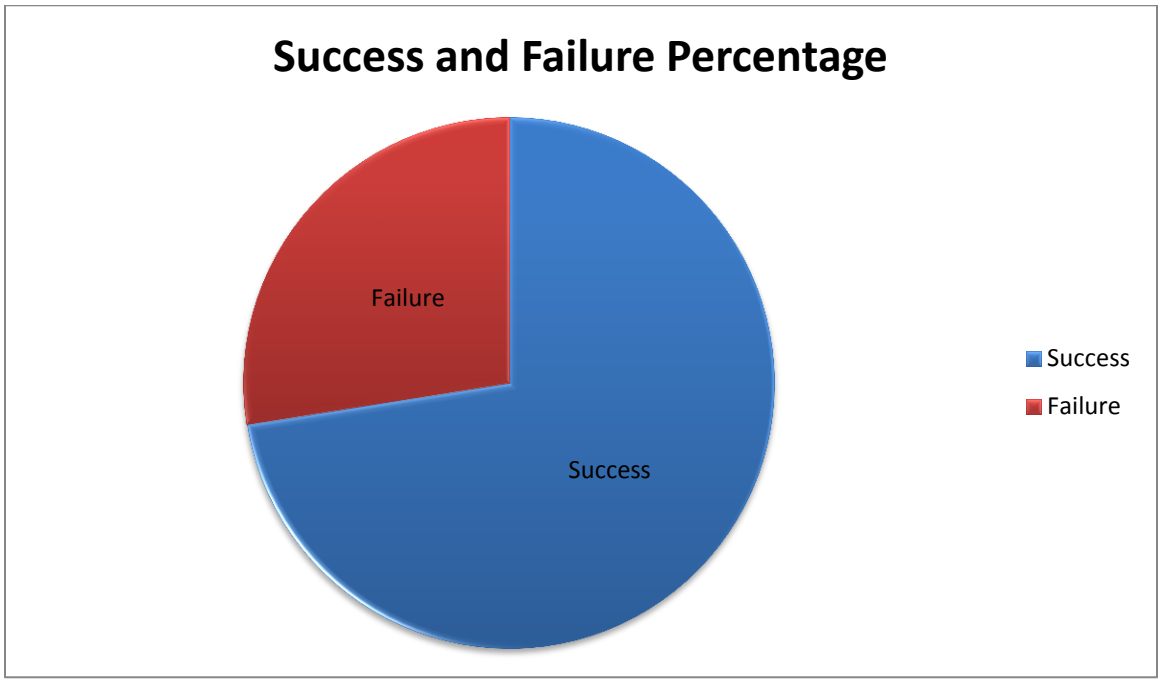

Fig 3.1- Pie Chart of System's result analysis

When the whole system runs, the output of the systems are GPS tracking of the train and publish it in a web server using Google Maps API, sending those data in the mobile command center of the station and after analyzing the data, control signal will be send to the switching juction of the

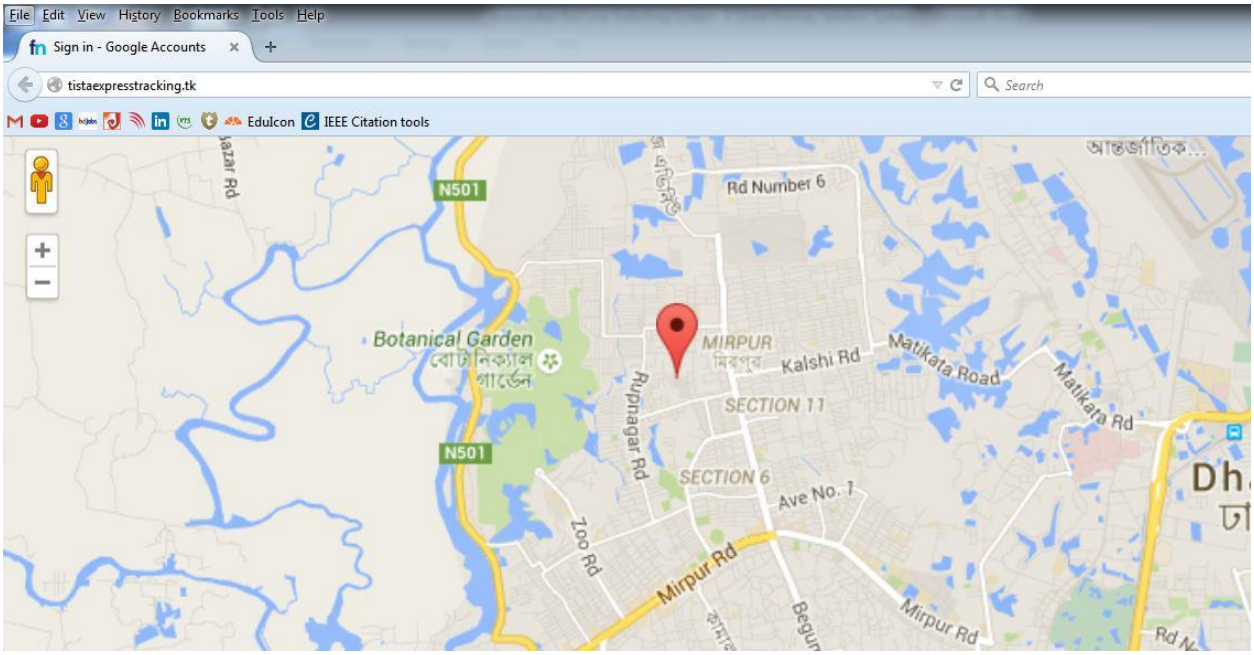

Fig 3.2: Tracking of train visible in Google Map

track and after successful switching of track, a confirmation signal will be sent to train in sms form.

3.2:Limitation:

During the research, it has been observed that under a few circumstances, the system fails to deliver hundred percent accuracy. The first drawback is the tracking of train via gps when the weather is cloudy. Due to device limitations, the continuous tracking process has been disturbed sometimes. The second drawback has been faced while trying to sending the GPS data in the command center and also uploading it into the webserver. Due to device limitations, using the same shield for both GSM and GPRS communication, sometimes creates disturbances which results in the failure of the system.

3.3: Comparison:

The existing rail station system in Bangladesh uses radio communication for the confirmation of incoming train, use color light signals to give different command to the train and recently they have installed relay based interlocking system for the switching of junction only in some major railway stations . When the operator of the control gives a switch a high ammount of current charges the relay and it switches the track to the desired platform. However, the confirmation and tracking of the train is done over orthodox radio communication from train to control. Comparison to that, this prposed automated system will be much more cost effective, smart and fast. Here the whole tracking of the train is done by GPS and the position of it is visible from a web server simultaneously. The whole signaling and commanding system has been replaced by GSM communication system for ensuring reliabilty and effectiveness. A feedback system is also introduced for the safety purpose. In total, this proposed system is much more efficient, self sustaining and smart than the existing one in Bangladesh.

Chapter 4: Conclusion and future scope:

This paper aims to a smart railway control for all the rail stations in Bangladesh which will result in the modernization of one of the major government sector of Bangladesh. This automated system will be the result of simulataneous performance of three different subsystem. Firstly, the tracking of train via gps and monitoring the position in google map will replace the radio communication between control and driver and will establish a more reliable, fast and powerful smart tracking and communication system. The train itself will generate a signal about it's status which will be forwarded into the central command and central command will be able to send the right signal into junction instantly via GSM communication. It will make the signaling and switching of railway track more promising, fast and effective. In any kind of unwanted circumstances, the feedback system designed by the software will send a signal to the driver of the train to hold to avoid any unwanted mishaps which will ensure the safety of the system and the people. In a nutshell, this proposed design of an automated smart railtrack switching system and idea of a smart railway station can change the geography of the railway industry and can establish a hundred percent safe rail communication system for the people of Bangladesh.

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Appendix-A

List of AT Commands:

For GPS:

Command	Description
AT+CMGF=	Specifies the input and output format of the short messages. 0 for PDU mode and 1 for text mode.
AT+CMGS	Sends a message.
AT+CMGR=*	Reads a message. * is the number of the message.

For GPRS:

Command	Description
AT+SAPBR	Configures GPRS profile
AT+HTTPINIT	Initializes HTTP service
AT+HTTPPARA	Configures HTTP parameters
AT+HTTPACTION=0	Sets HTTP Method Action, GET in this chase.
AT+HTTPREAD	Reads HTTP data
AT+HTTPTERM	Closes the opened HTTP session.

Appendix-B

List of NMEA Sentences:

- AAM - Waypoint Arrival Alarm
- ALM - Almanac data
- APA - Auto Pilot A sentence
- APB - Auto Pilot B sentence
- BOD - Bearing Origin to Destination
- BWC - Bearing using Great Circle route
- DTM - Datum being used.
- GGA - Fix information
- GLL - Lat/Lon data
- GRS - GPS Range Residuals
- GSA - Overall Satellite data
- GST - GPS Pseudo range Noise Statistics
- GSV - Detailed Satellite data
- MSK - send control for a beacon receiver
- MSS - Beacon receiver status information.
- RMA - recommended Loran data
- RMB - recommended navigation data for gps
- RMC - recommended minimum data for gps
- RTE - route message
- TRF - Transit Fix Data

- STN - Multiple Data ID
- VBW - dual Ground / Water Spped
- VTG - Vector track an Speed over the Ground
- WCV - Waypoint closure velocity (Velocity Made Good)
- WPL - Waypoint Location information
- XTC - cross track error
- XTE - measured cross track error
- ZTG - Zulu (UTC) time and time to go (to destination)
- ZDA - Date and Time