Collision Detection and Avoidance in Railways Using WiMAX

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Abstract— **As we have already seen that the railway has done a lot of efforts for collision avoidance and accidents prevention. Several techniques have been developed for avoiding such hazardous loss of life and property. In this paper we have proposed an approach using latest 4G technology WiMAX (Worldwide Interoperability for Microwave Access) i.e. IEEE802.16e standards for preventing train accidents. The approach helps the train to know the location of its own with the help of Fixed WiMAX base stations whose position is known. The approach doesn't require extra GPS service for the purpose calculating location like existing railway system uses. The WiMAX base station and the train (mobile stations) contribute in sending the information to the trains whenever a train comes in its vicinity and range. The trains will be equipped with WiMAX enabled laptops/Tablets for communicating with others. The speed location and distance of other trains will be known in advance to make safe from being part of some mishap. The technique will be more efficient and beneficial for avoiding situations like collision and catastrophe hazards. The simulation is done in Qualnet 5.0 network simulator.**

Keywords — **ACD (Anti Collision Device), GPS, Absolute Block System etc, CabSignalling, WiMAX.**

I. INTRODUCTION

As the railway network is considered to be the safest and easiest network. More than 10 billions of people and 1050 millions of freight travel by train annually. But nowadays, it is not that much safer as the lot of accidents occur due to improper communication among the network [1, 2], wrong signaling, worst weather condition, immediate route change. The train driver doesn't get proper information on time and before time so that the hazardous condition can occur and would lead to catastrophe [5]. This paper proposes an approach that will be efficient in all the way. The approach will make use of WIMAX base station for sending and receiving the information about trains to prevent collision. Train will also send information to calculate difference among them. WiMAX. A computer equipped with WiMAX would receive data from the WiMAX transmitting station, probably using encrypted data keys to prove unauthorized users access. The train will be WiMAX enabled and find its location with reference to fixed WiMAX base station placed parallel along the track, whose position is known. The fixed base station broadcast messages periodically and WiMAX enabled laptop/tablets fitted in the train use to communicate and can receive information about surrounding and the status of other trains. When the train comes in its vicinity or range the base station it sends its information about itself and takes information of other train's to know about the surrounding. This way all the trains can get updates about others and collision can be prevented and system will work smoothly.

The idea of WiMAX [8] is to provide high speed connections to users in rural areas as; it provides an alternative to wired connections (DSL or Cable) which are expensive. The WiMAX system is defined by a group of IEEE802.16 industry standards and its various revisions are used for particular forms of fixed and mobile broadband wireless access. WiMAX primarily used as WMAN. The IEEE802.16 system was designed location nomadic service in order to provide communication service to more than one location. It is a digital communication system. It is a part of 4G wireless technology. It can provide wireless access upto 50 km for fixed station and 15 km for mobile stations. WiMAX enabled handsets and laptops/tablets helps people connect to the fastest broadband internet from anywhere. It offers 72 megabits per second without any need cable infrastructure Developed for mobile device IEEE802.16e specification adds mobility management, extensible authentication protocol, handoff, and power saving sleep modes. It utilizes adaptive modulation and coding. So, users close to Base station get high speed connections and get lower speed when radio channel is not good. WiMAX [9] offers high data rates to home and business users and QoS (Quality of Service) in dense and

moderate speeds and QoS in rural areas. WiMAX provides a platform to deliver applications like voice, data, and video services. It completes the dream of millions of people accessing the internet cheaply and easily.

WiMAX consists of Base Stations on cell towers and CPE (or customer premises equipment or receivers). CPE is like DSL modems or cable modems. When a user sends data from one location to another wireless connection is transferred from one base station to another. When transmitting signal from user to the WiMAX base station or bus station to the user (WiMAX receiver), the wireless channel faces many attenuation like fractions, reflection, refraction, wall obstruction etc. All this attenuation may result of distorted, and split toward the multi path. WiMAX receiver's target is to rebuild the transmitted data perfectly to make possible reliable data transmission. The base station and user terminal transmit in different frequency bands. The MAC layer connection is oriented and uses TDM (Time Division Multiplexing) scheme for the downlink (DL) and a TDMA (Time Division Multiple Access) scheme for the uplink (UL). Each SS is periodically granted transmission opportunities by the BS. The BS accepts bandwidth requests from the SS and grants them time-slots on the uplink channel. These grants are made based on the service agreements, which are negotiated during connection setup. The BS may also provide certain time slots on the uplink that are available to all SS for contention. The SS may use these slots to transfer data or to request for dedicated transmission opportunities.

Mainly WiMAX consists of two parts:

1. **Base Station**: Base Station is similar to Base Station used in cell phone towers - A single WiMAX tower provides coverage to a very large area and can serve a large number of people.
2. **Receiver**: Receiver and antenna are small box or PCMCIA card, or they can be built into a laptop/tablet PC's like Wi-Fi.

A WiMAX Base Station can connect directly to the Internet with high bandwidth, wired connection. Base Stations can connect to another Base Station using a LOS microwave link which is also called backhaul.

II. RELATED WORK

A lot of methods like GPS based Cab Signaling, Block Signaling, Automatic Train Control (ATP), and Railway Collision Avoidance System (RCAS) and have been developed and used for avoiding collision and for getting proper communication, but not that much worth. Train Collision Avoidance System (TCAS) has also developed recently and Anti collision Device (ACD) is being developed and will be used till December 2013. Cab signaling is used for this purpose, so that the position of the train can be noticed by the driver in the cab only and correct decision can be taken before time. The circuit of all the tracks is provided at the station and gives the information where and on which track train is moving. The circuit contains maps of all tracks laid, provided with signal box indication and Leds to indicate the presence of a train. Optical fiber cable is running along the track with 5-7 volts of running in it, and the signal boxes are placed at the interlocking of track, so that the position of the train can be reflected in the track circuit which is situated in the station. On the basis of this the station master takes the decision and asks the driver to do accordingly. The train driver also takes decisions on the basis of the information displayed in the cab. The trains are equipped with GPS, so they can calculate their position and calculate how far the other train will be. But the system is not efficient as the timing is not accurate enough and the system could lead to catastrophe situation. Also the GPS receiver techniques require satellite communication, so it needs more battery power. So the techniques are not economical.

Other than this ACD (Anti Collision Device) [3] [4], this is microprocessor and GPS based and fitted in locomotive, guard van and at level crossing. So, that the train get to know its position and others to prevent from being collided. It can detect in the range of 3 Km, and then the train slow down its speed. The ACD broadcast message after every 3 sec, so that the other train can calculate its position and can prevent from being collided. Today railway system operates is known as double line section, i.e., Railway track parallel to each other carries trains in particular direction. The name of direction is UP and DOWN lines. In normal working this arrangement eliminates the potential for head on collisions. The additional constraints are provided in order to prevent rear end collision e. g., Train running back of another train will automatically skip due to Red signal. The Absolute Block System is a signaling system which prevents such accidents. The map of the entire track is with the ASM and Section Controller. The railway lines are provided tracking circuited sections. Block sections are called "Track Circuited Area" in which train runs automatically in the "Main Line". The Main Line is the line at which the train is passed with no obstruction or can say which is direct from one station to another, so that the train can be run through.

After the block section or before the block section train is manually controlled by the ASM (Assistant station master), who is being guided by the station controller.

There are three important persons deployed on this job.

1) **Train Driver**: job is to run the train with an observation aspect of the signal and operate the points.
2) **ASM (Assistant Station Manager)**: job is to decide all routes manually.
3) **Section Controller**: job is to operate all train movements.

When the train comes at the home signal, ASM will operate the signal manually to change the track, to change the track, to enter in loop line or to stop. Loop line is the line laid along the track. When a train comes near the station or the platform, it enters the home signal and the guided by ASM to follow the route. The ASM is being guided by controller and he/she operates the push button for signal to follow the route to stop at the station and leave the main line. The driver runs the train by seeing the signals. Signals are placed along the track. Signals are of two types:

1) Main Signal: The driver runs trains by seeing the Main Signal when run trains on the main line.
2) Arm Signal: The driver runs train or takes the train to "Loop Line" when near the platform or station by seeing the arm signal. Also performs crossover to change tracks when the route to a particular destination is through different track. Signals are shown by four colors Double yellow, Yellow, Red, Green.

When a train comes near station it gets the "Double Yellow Signal" (Double yellow to reduce the train speed a little), then the Yellow Signal (Yellow signal to reduce speed more) and then Red Signal (Red Signal to stop). Similarly vice-versa it gets Double Yellow Signal when starts to run at that time a train is at slow speed), then Yellow Signal to increase speed and finally if everything is clear and fine it gets Green Signal to runs train through till the line is clear. This is all about Double Line signal.

Now, when there is "Single Line" only one train can pass at a time. Now the condition occurs when the train is running on the track and same time another train coming on the same track. The ASM pushes the button to signal the driver to take the one train to the loop line and ask the second train to pass. And then the first train can get back to the main line and can pass by.

III. LOOP HOLES IN EXISTING SYSTEM

The driver doesn't know anything about what's going around. He doesn't have any information about other trains. His only job is do see a signal aspect and follow that. And the signal aspect depends upon the ASM, so if ASM gives wrong signal and gives wrong route accidents occur. Whole working is ASM dominant. The driver cannot take any decision.

In fog or worst weather condition driver can't able to see the signal and the situation would lead to accidents.

IV. PROPOSED METHOD

As IEEE 802.16e defines means for true mobility within an 802.16 wireless network. Determining an accurate location for 802.16e devices requires information on radio parameters. In the proposed method WiMAX base stations are placed along the track at equidistant. It is more like signal boxes placed at the interlocking to give the signal to the train coming on that track. Trains are considered to be equipped with WiMAX enabled Tablets/laptop's consisting directional antenna. The train can calculate their location with the help of WiMAX base station. As the base stations are fixed and located at fixed specified distances, so helps the train (mobile node) to localize it. Train query base station and collects its information about the base station, neighbors, distance and angle. By using this value as the train will be able to calculate the difference with respect to other train. Then train and base station broadcast its parameters to its vicinity, i.e. 5-15 km. Further precautions can be taken to avoid collision after getting the location of train and evaluating conditions. Information broadcast is done to avoid catastrophe situations. Base stations are used for locating trains where every train receives signals directly from the corresponding base station. All the base stations are connected to each other with microwave links or DSL cable. So the train at distant location will be able to visualize that trains far apart status and information. Here the distance between node and the base station is calculated on the basis of Angle of Arrival (AOA) and Received Signal Strength (RSS). WiMAX base station can be accessed by more than 60 users. It can also provide broadcasting services. The approach will prove itself as the secure and fastest way of collision avoidance, as the WIMAX is designed to handle high data rates. The simulation results show how WIMAX works for this.

A. Location Calculation Using BS when trains on the same track

The given scenario represents three fixed base stations and two subscribers (Train) node. The base stations are at every 10 km along the track and at fixed location. At the base station can cover upto 10 km radius, any wireless node within its coverage will be able to access. The two trains are moving on the same track don't know about each other.

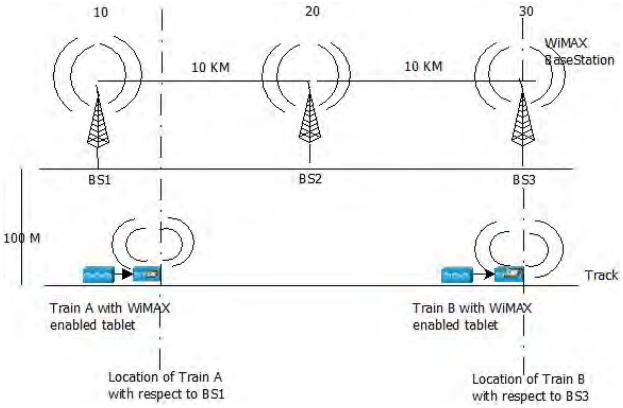

Figure 1. Representation of train's running on same track and in same direction

Trains calculate their location with the help of BS and broadcast in its proximity to BS's and trains. Base station further broadcast to other base station and train in its vicinity. As the base stations are connected to each other as microwave links. Using this information the trains will be able to take possible precautions to avoid collision. Similar information between the trains will be exchanged to prevent from being collided. The information contains location, BS_id, train number, track_ID, speed, time and security message. Base station keeps track of databases to hold subscriber information equipment cofig, location, BS_id, train number, track_ID etc for security.

1) The train will send SLOWDOWN message when running on the same track in the same direction.

2) STOP message when two trains on different direction and then INTERLOCK to perform crossover to change its track.

B. Location Calculation Using BS when trains running on different track

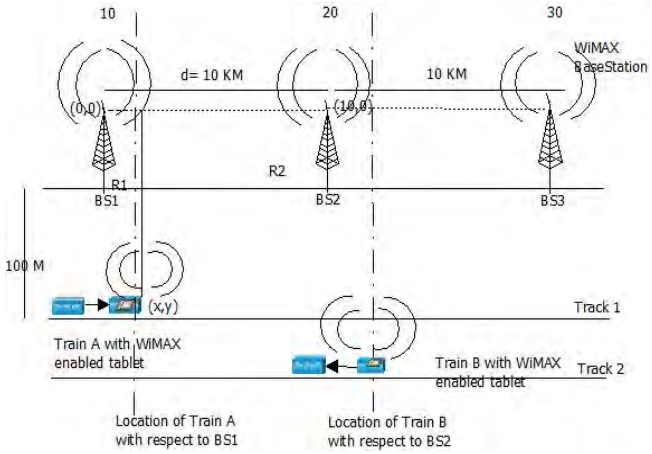

Figure 2. Representation of train's running on same track and in opposite direction

V. SIMULATION

The simulation is done using QualNet. It's a network simulator. QualNet is a commercial spin-off from the GloMoSim simulator, which was developed at the University of California, Los Angeles, UCLA, and is distributed by Scalable Network Technologies. During simulation runtime, it allows the user to observe the signals being transmitted and received at each node, which aids in the understanding of what is physically happening. The three main programs used in QualNet are the simulator, the analyzer and the packet tracer. The simulator runs the given simulation, the analyzer displays the results and the packet tracer allows us to follow the path of a packet through the network. And the protocol is developed from C++ coding.

For location calculation of WiMAX subscriber, we have used the MAC802.16 model of QualNet 5.0, which has implemented features defined in both IEEE 802.16 and IEEE 802.16e. WiMAX is implemented as part of the Advanced Wireless QualNet 5.0 Model Library. WiMAX was not available in the used version of QualNet; therefore we used the Research Version of Qualnet 5.0. The location or coordinates further used as input to the software and the information will be used to avoid collision and preventing accidents. The coordinates also helps to calculate speed of trains. So, that the distance between trains can be calculated and precautionary

decisions can be taken. The message will contain track_id, BS_id, train_no, time coordinates, speed, and warning messages.

Screen Shots

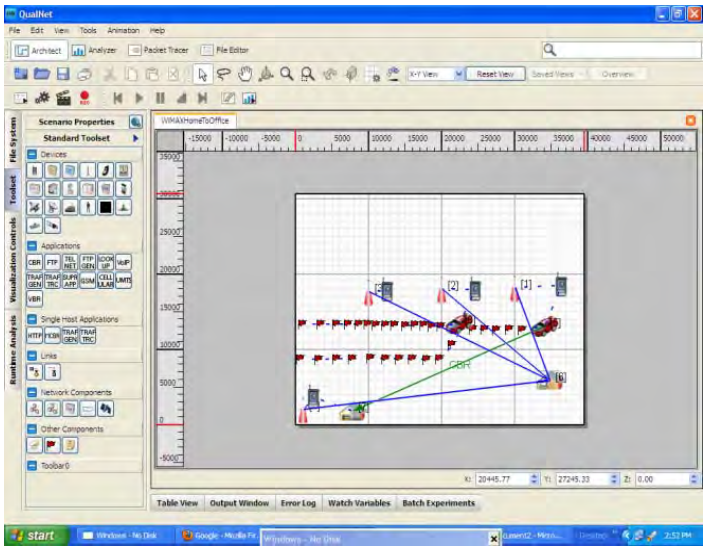

Figure 3. Train A calculates its location form BS1 and Train B from BS2

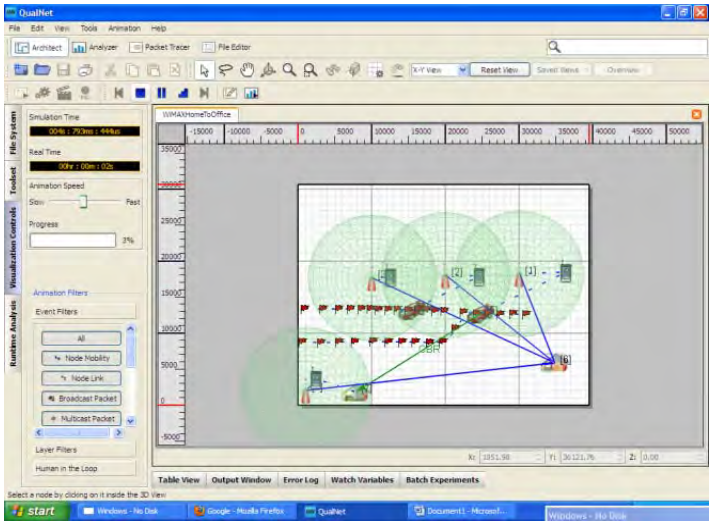

Figure 4. Train A calculates its position and distance from Train B sends Slow-Down Message and change its track

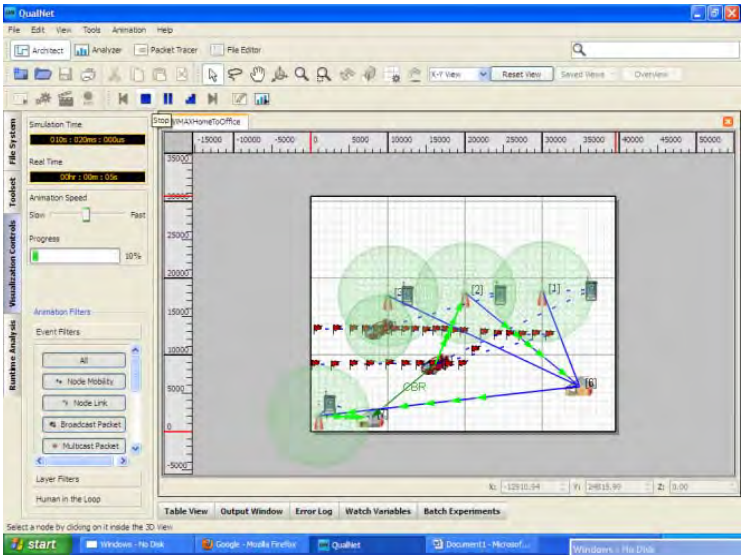

Figure 5. Train B slows down its speed when comes in the vicinity of Train A and Train B let Train A pass to avoid collision

VI. SIMULATION RESULTS

Simulation results show that every time when a train comes in proximity of Base Station it calculates its location and print base station number BS_id from train is calculating train_ID, time, location coordinates, speed and track_ID etc.

- If two trains come under the range of 10 km means in proximity of each other or in range of same base station accessible to each other, train will send track_id speed and location to other train. So, that the appropriate decision can be taken and collision can be avoided.
- If Train's will be on same track SlowDown or Track change message will be send.
- If trains come under same base station and running on same track under 2 km will send stop message train_no, track_id, train location, and etc to avoid Rear End collision.
- If trains running on different track do not send any message unless they are on single line.

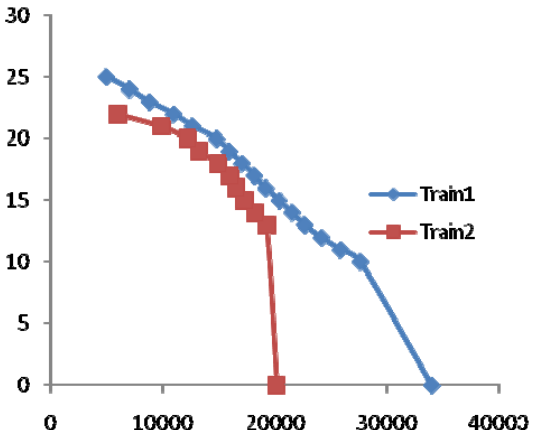

Figure 6. Graph

From the above graph it is shown that two trains started at some distance with different speed. When trains got to know each other coordinate and location. Train1 send Slowdown message to train2 and train2 reduces its speed and allow train1 to pass. This way collision can be detected and avoided.

VII. CONCLUSION

In this paper we have shown that WiMAX technology will be beneficial for locating trains, detecting and preventing collisions. As the IEEE802.16e has the capability of providing the features needed for the purpose and the paper has proved that WiMAX will be more efficient technique. The method will be more beneficial than the technique presently used for collision avoidance, prevention and positioning of trains. Fixed WiMAX

base stations will help to locate trains. The simulation results show that the technique will be feasible. The results show that WiMAX will be able to calculate the coordinates of trains and they will further use for collision avoidance and prevention.

REFERENCES

[1] A concept for reducing railway accidents. H Ben Brown, Jr. Gregg Podnar, Mel Siegel, February, 2005.

[2] Railway crossing collision avoidance system. Shirley et al. - September, 2001.

[3] S.Gautam, S.Nemade, T.Sakla "Simulation of an anti- collision system on same track for railways", in International Journal of Engineering and Technology, Vol. 2(9), 2010, pp.4832-4837.

[4] Cost effective system for Railway level crossing protection Konkan Railway.

[5] G.Xie, A.Asano "Study on Formal Specification of Automatic Train Protection and Block System for Local Line", in 2011 Fifth International Conference on Secure Software Integration and Reliability Improvement.

[6] M.Hammoshi "WiMAX Simulation Model to Investigate Performance Factors", in Journal of Convergence Information Technology, Vol 6(1). Jan 2011.

[7] Mika Husso, "Performance Analysis of a WiMAX System under Jamming", M.Sc. thesis, Helsinki University of Technology, Department of Electrical and Communications Engineering.

[8] WiMAX Forum. www.wimax.com/home -2008.

[9] WiMAX Essentials. http:www.scribd.com/doc/30562544/WiMAX-Essentials.

[10] U.Tariq, U. Jilan and T.Siddiqui "Analysis of Fixed and Mobile WiMAX", MS in Electrical Engineering majors in Telecommunications", Blekinge Institute of Technology, 2007.

[11] WiMAX FORUM, "Fixed, nomadic, portable and mobile applications for 802.16-2004 and 802.16e WiMAX networks", Nov. 2005.

[12] GPS/GSM based train tracking system. http://mgovworld.org/libra/mgovernance/papers/gps-sm-based-train-tracking-system.

[13] B. Stadlmann, S. Mairhofer, G. Hanis "Field Experience with GPS based Train Control System", in University of Applied Sciences Upper Austria, Wels School of Engineering and Environmental Sciences.

[14] Train Collision Avoidance System (TCAS), government of india ministry of railways.

[15] P.Goel "Indian Railway Block Signalling", vol.1.

[16] "Comparison of Collision Avoidance Systems and Applicability to Rail Transport", in Institute of Navigation.

[17] "The North American Joint Positive Train Control (NAJPTC) Project" , in apr 2009.

[18] "http://ecee.colorado.edu/~liue/teaching/comm_standards/2011F_WiMax/4G%20WiMax.htm#intro".

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