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High Quality Broad Band Internet Service in High Speed Train Using Radiate

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Abstract: *In the last 25-30 years, wireless communications have become an essential part of people's lives all over the globe. People are relying highly on internet in their daily life due to the explosive growth of Internet-based applications and services. Internet services in moving vehicles are also very important nowadays. The major problem faced now is providing broadband connections in high speed trains moving at 500-600kmph with reduced handover problems. Hence providing high quality broadband internet services in high-speed trains also become more important. In this paper we propose the method of modified RADio- over- Fiber as AnTenna Extender (RADIATE) for providing high speed train communication for the users. This technique is and extender of cellular networks to avoid high capital expenditure in providing broadband Internet services. RADIATE employs on-roof antennas and operate these antennas by utilizing the cellular networks as backhauls. The modified RADIATE uses optical fiber which is 1550nm fiber optic that has the loss range of about 0.25 db/km. Hence the handover problems are solved to an extent and also provides constant channel to the requested users efficiently. Thus the cost effective and high quality of broadband internet services is provided in high-speed trains.*

Keywords: *High speed train communication, RADIATE, cost effective, high quality.*

1. Introduction

The rapid development of the technology and economy has made the abrupt growth of internet connections all over the world. This leads to the sudden changes in wireless communication technology. Initially the internet connections are provided in wired connections. Then based on the need of users wireless technology have been introduced. Initially the connections were provided to the users by the cellular network which is a radio based technology. Base stations (BS) are used to transmit and receive using the assigned spectrum. They also evolved as generations and currently often used is third generation (3G) which supports high speed cellular connections for voice as well as video based telephone systems.

Recently, trains have been the major location where people are expecting internet connections. 75% of passengers in the trains are the business travelers and they are highly interested in using WI-Fi access in trains and it has been realized. Several opportunities to provide broadband internet access on trains includes technology such as Wi-Fi, WiMax, satellite technologies and radio-over- fiber communication on broad trains are complicated because they face several difficulties like high penetration losses of signals which includes high vibration environment that require mechanical isolation of communication devices; thermally challenging environment where heat is the significant issues in train; electrical environment that is proximity to high voltages like electrical trains, high magnetic fields- in magnetic levitation. Other factors which affects train communication also includes limit visibility to wireless communications in tunnels; frequent handoffs in the cellular network which results in packet loss and packet reordering. Hence to enable high-quality broadband Internet services in high speed trains, many solutions have been proposed which are classified into four: Cellular network, radio-over-fiber (RoF), leaky-coaxial-cable and satellite communication based network access. Even though these are effective, still faces some difficulties and drawbacks.

For the purpose of cost-effective and high quality communication solution for high-speed trains a novel solution called RADio- over- Fiber as AnTenna Extender (RADIATE) has been introduced. This uses the cellular network based solutions and radio over fiber as an backhauls for Internet access in high-speed train communications along the rails. Even though

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there are ultimate improvements in cellular networks still there is a need to deliver and ultra high data rate for the passengers who request access to broadband internet. And also there is a challenge of solving rapid channel variations and overlay frequent handovers. All these problems are addressed by RADIATE which is RoF based communication used in high-speed trains.

2. Existing Solutions

2.1 Cellular based Network solutions: Cellular networks are most widely used by the mobile users and it's also useful to provide internet services for the requesting users. GSM-R is a currently used dominant wireless communication system for railway [2]. This system can provide only limited data rate of upto 200 kb/s to mobile users. But this system faces several problems such as frequent handover problems and also signaling congestion

2.2 Leaky-Coaxial cable: Here Leaky coaxial cable (LCX) is used as an antenna extender for data transmission and reception. Here the cable is used along the railway lines for radio communications on the trains [9]. But the data rate provided by this method is also limited up to 768 kb/s.

2.3 Satellite Communications: Satellites can also be used for provisioning Internet services since they have vast coverage area [1]. But this also have several drawbacks such as delay which is not suitable for real time internet applications. Change in weather conditions also interrupts the internet services by decreasing the capacity. It is also very difficult to cover the areas such as urban and hilly regions.

3. The RADIATE Architecture

The RADIATE architecture consist of in-cabin wireless access point, on-roof antenna system and the RADIATE control system (RCS) as given in Figure 3.1. The on-roof antenna system will be in contact through the fiber links indicated with blue lines in Figure. 3.1.

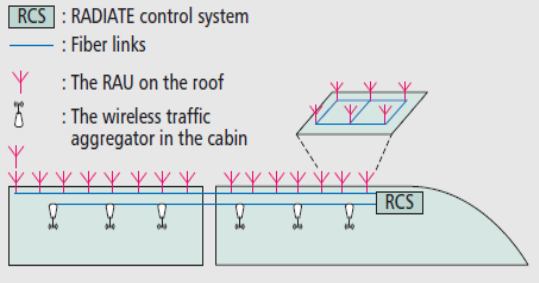

Figure 3.1. RADIATE architecture

The purpose of introducing this on-roof antenna system is to provide shield to the rapid channel variation and handover problems that occurs often. The RCS has main functions such as scheduling the traffic for the passengers requesting the internet services and also to optimize and control the antenna system to maximize the network capacity to its full extent. The RADIATE Control System (RCS) consists of the wavelength routing switch, electrical to optical converter (E/O) and optical to electrical converter (O/E) as given in Figure. 3.2. The signals received from the users are given as the electric signals to in-cabin access point and this is converted into optical signals using converter.

Each request received from the user will have different wavelength and this is given into the wavelength routing switch. This helps the signals to travel to the long distance without loss in data. Then again the signals are converted to electrical signals in the receiver side. These converted signals are given into the Radio Frequency Controller. The purpose of this conversion is to make the signals essential for the long distance transmission.

These signals are given to the on-roof antenna which is situated over the top of the train. But this is also limited for the passengers in the train moving at the speed of 500 km/h.

Hence the introduced modified RADIATE system enables the broadband connections to the users moving at the speed above 600 km/h. This system uses the optical fiber of 1550nm which has the reduced loss range of about 0.25db/km than the existing methods. Here Graded Index Polymer Optic Fiber (GIPOF) is used for this purpose. And the number of antennas on the train is also reduced thereby reducing the cost. Since the entire user who requests for the services will be

satisfied without delay using the on-roof antenna system, the handover problems will be reduced. The voltage required for operating this antennas also low depending on their density. Thus handover problems will be reduced and cost effectiveness can be achieved

4. Results and Discussion

The simulation is done for the provision of broadband internet connections for the in high speed trains with reduced response time and also with high quality.

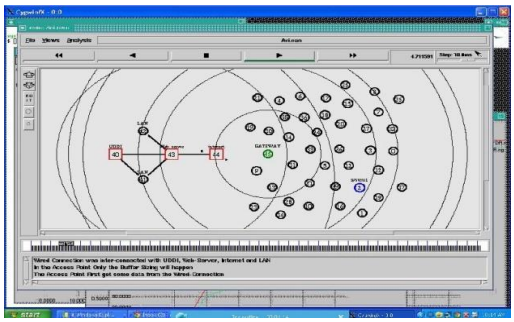

Figure.4.1. Providing requested service for users using RADIATE

Here the services requested can be uploaded or downloaded based on the user requirements (Figure 4.1). Then the analysis is done for packet delivery ratio, packet receiving ratio, delay and throughput for the existing and proposed system which are discussed below. In figure 4.2 the comparison is done between the Packet Delivery Ratios (PDR) of existing and proposed system to show the increased capacity.

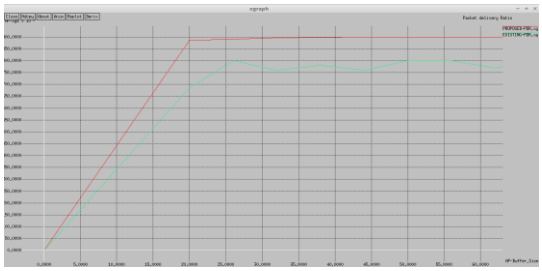

Figure 4.2. Comparison of PDR

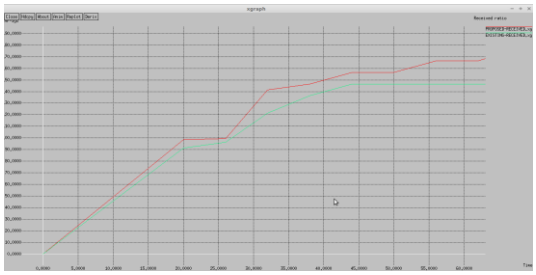

Figure 4.3 Comparison of PRR

In the Figure 4.3 the comparison between the existing and proposed packet received ratio is given which shows the increased delivery up to 85%.

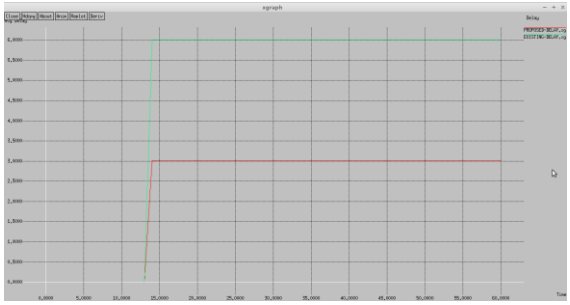

Figure 4.4 Comparisons of Delays

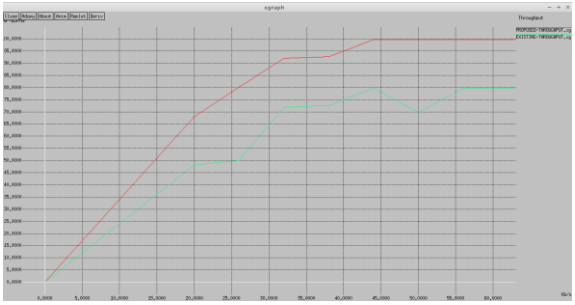

Figure.4.5. Comparison of Throughputs

In figure 4.4 the comparison of delays for the existing and proposed modified RADIATE system has been given and this shows that there is reduced delay up to 50% than existing system.

In figure 4.5 the comparisons of throughputs for the existing and modified system have been given. This clearly shows that high through put can be obtained from this method.

5. Conclusion

In this paper the novel solution called modified RADIATE system has been proposed for providing the broadband internet services in high speed trains. The analytical results for the existing broadband connections and proposed is also discussed briefly. It's also explained how the RADIATE structure addresses the frequent handover problems and also the cost effective solution for this proposed system. Finally, the throughput of the proposed modified RADIATE system is also analyzed.

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