A SURVEY ON HIGH QUALITY BROADBAND INTERNET SERVICES IN HIGH SPEED TRAINS

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Abstract - *In recent years, there is the rapid development of High speed railways (HSR) all over the world and is deployed widely everywhere. Transmission rate highly depend on the distance between the Base Station (BS) and the train. Hence the transmission of data and services varies over time and distance with different data rates. Most of the passengers travelling over the high speed trains face the fading channel and handover problems. Hence Improved Distributed Antenna System for HSR has been proposed by replacing the overlap region of two adjacent Logical cells by a complete cell called Fixed Handover cell. Another mechanism introduced to improve the handover performance of Long Term Evolution (LTE) is coordinated multiple point transmission technology. This method obtains the diversity gain by receiving signals from the adjacent BSs and thereby increases the quality of receiving signal. This paper deals with the various methods and solutions that are being implemented in high speed train communication and also the advantage of using the RADIATE method for obtaining improved quality of data services.*

Key Words: **LTE, HSR, RADIATE, High speed train communications, handover.**

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.

2. Improved Distributed Antenna System

Continuous linear coverage can be provided for the high speed vehicle along the highways using Distributed Antenna System (DAS). Radio over fiber network using DAS was initially proposed for the road vehicle communication. Due to its coverage efficiency when compared with conventional network, it is employed in HSR communication. This scheme improves the handover reliability by transforming the hard handover into macro diversity soft-handover in the traditional cellular network.

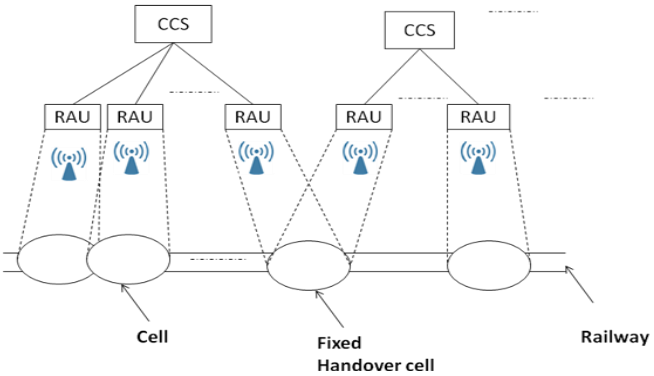

Fig 1. Improved Distributed Antenna System

Even though there is a smaller overlap, there is no enough time for handover when train quickly moves through that region. Hence this Improved DAS has been introduced to increase the reliability [1]. In this method, the overlap region between two adjacent cell can be replaced by the complete cell namely Fixed Handover cell.

The fixed handover cell is covered by two Remote Antenna Unit (RAU) and is connected by two adjacent Central Control Stations (CCSs) respectively in different Logical cells. The RF channel in the particular Logical cell need not be the same as the adjacent one to avoid co-channel interference. Thus there will be sufficient time to complete the handover which avoids ping-pong effect. It has advantages such as seamless handover, simple handover, and cost-effective deployment that support high mobility.

3. Broadband internet in trains

This paper [2] introduces the broadband access to the fast moving passengers while maintaining sufficient quality of service. To realize such a connection, we need a wireless network which provides lot of the services to fast moving users and also high data rates.

This network also has Central Control Station, Remote Antenna Units which are connected via optical fiber using Radio-over fiber technology.

This scheme also depends on a capacity reallocation mechanism for reconfiguring the extended cell. Hence in this method the end user is always surrounded by the group of cells which is always transmitting concurrently the user-specific data and also the same user-specific data is transmitted over the radio frequency and this enables the seamless communication conditions for truly random mobility and velocity patterns. This also presents the physical layer network architecture which realizes 2.5 Gb/s downlink connection over a single 60GHZ radio frequency.

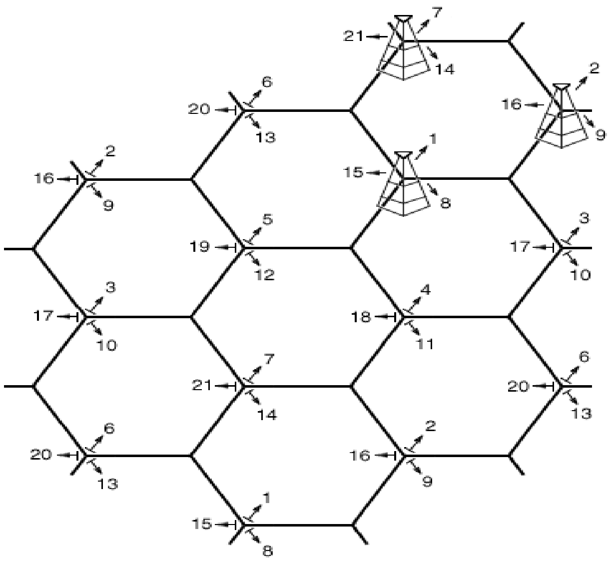

Fig 2. Moving Extended cell

Challenges of this high speed train communication are as follows: Mechanical isolation is required for communication devices at "high vibration environment"; heat may be the significant issue in parts of train and hence it is "thermally challenging"; the changes in railway companies must be automatically discovered by the communication network; visibility to wireless communication will be limited by the tunnels; Due to frequent handoffs there may result the packet loss and packet reordering. Hence currently Wi-Fi is integrated on laptops, and WiMax is also available.

Moving Extended Cell concept is also introduced to ensure connectivity for all possible directions when the user leaves his/her cell. As a result, end user can continuously transmit the same data content which is surrounded by the cells.

4. Radio-over-Fiber based solution

Combining high bandwidth connections in the range of 5 Mb/s/user and fast moving users travelling in trains moving at the speed of 300km/h and also maintaining sufficient level of QoS has become a greatest deal nowadays. Hence dedicated cellular wireless network along the rail tracks has been proposed. Most of the cellular communication with fast moving users travelling in the train faces the frequent handovers when they are hopping from one BS to another. Hence there is a chance of numerous packet losses reducing the bandwidth. So and attractive solution of replacing the network using Radio-over-Fiber to feed the base stations installed along the rail tracks, in combination with the moving cell concept has been introduced [3].

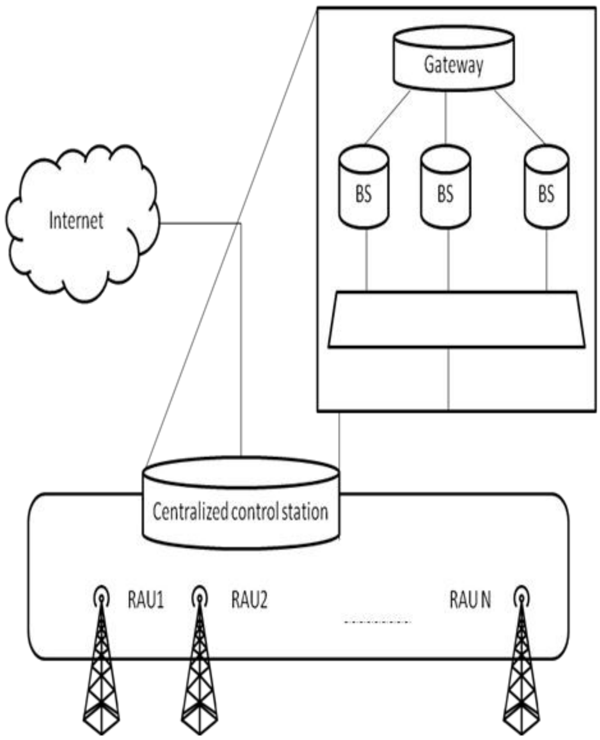

Fig 3 - Radio over fiber network providing internet on the train, including centralized control station containing different base stations.

Recent high speed trains and intercity trains can carry more than 1000 people and in double-deck trains there are more than 1500 seats. When the seating capacity is completely occupied, assume that 10 percent of passengers need the broadband access. If so, almost 750 Mb/s is needed for the double deck trains. Hence to offer this connection we must need at least 5 Gb/s for the train. So this can be provided by the optical access network.

There will be several RAUs located along the rail tracks which are interconnected by the optical ring network. All the RAUs within the single ring will be under the supervision of CCS and processing will be performed. In downstream traffic, the data will be modulated as a radio frequency in control station and transmitted to antennas near the trains. In upstream RAU will transmit the captured frequency band to control station and filters the desired frequency and processed further.

We also consider the cell pattern that moves together with the train instead of the train moving along the cell pattern, and so the handovers can be avoided. In this idea the BS before and after the handover remains unchanged and only the used RAU will be changed. This provides real broadband access to train passengers.

5. CONCLUSION

Thus broadband internet connection provided to high speed trains in various scenarios is analyzed and following results are presented

Table -1: Comparative Analysis

Title	Method used	Speed of train	Advantages
Broadband internet in Trains	Movable cell concept	200km/h	Dynamic bandwidth allocation. Data rate is upto 2 Mb/s/user
Radio-over-Fiber- based solution to provide Broadband Internet Access	Cellular trackside solution; radio over fiber network with moving cells	300 km/h	Increased quality of services for broadband connection. Data rate will be 5 Mb/s/users
An Improved Distributed Antenna System for High-Speed Railway	Distributed Antenna System; Fixed Handover cell	350 km/h	Avoid the occurrence of Ping-pong effect, seamless handover, simple handover and cost effective
Reliable broadband wireless communication for high speed train using baseband cloud	New virtualized single cell design that mitigates the impact of handover failures	400 km/h	Full frequent frequency reuse. Data rate more than 100 Mb/s
Wireless cellular network for high speed vehicles	High speed train communication using baseband cloud (C-HSTC)	500 km/h	Improved capacity.

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