Indian Journal of Natural Sciences *www.tnsroindia.org.in ©IJONS*

Vol.14 / Issue 77 /April / 2023 International Bimonthly (Print) – Open Access ISSN: 0976 – 0997

RESEARCH ARTICLE

A Sensor-Based Seamless Handover Solution for Express Train Access Networks (ETANS)

Saranya C*, S. Sivagami and Kalpana R

Assistant Professor, St. Francis de Sales Degree College, Bengaluru, Karnataka, India.

Received: 10 Jan 2023 Revised: 22 Feb 2023 Accepted: 29 Mar 2023

***Address for Correspondence**
Saranya C
Assistant Professor,
St. Francis de Sales Degree College,
Bengaluru, Karnataka, India.
E. Mail : saranyac@sfscollege.in

ABSTRACT

In India, express train transit is increasingly important for carrying about a million people every day. The biggest obstacle to delivering broadband information services to railway commuters is finding a seamless handover solution to ensure wireless service continuity. This inspires us to build an Express Train Access Network (ETAN), where the deployed sensor network captures the train movement state and can reveal the wireless signal strength, using Radio over Fiber architecture and sensor technology. It is possible to create an intelligent handover decision system because the train travels along a fixed track in a fixed direction. In this system, a critical movement state can precisely cause an optical switch unit in the central station to carry out the handover procedure. The suggested architecture can perform handover in 22 ms at a train speed of 350 km/h, providing wireless services for users without interruption, even for a cell radius as small as 100 m, according to theory analyses and simulation results. The study of the aforementioned greatest challenge for ETAN is the primary focus of this essay. Since the majority of Indian railways have fiber communication networks and benefit from RoF, this paper uses the fundamental RoF architecture for ETAN. In contrast to current approaches, we integrate sensor technology into ETAN, resulting in the creation of a specific handover choice system with the ideal fusion of sensors (such as pressure or light sensors) and optical switch technologies. Simulation findings show that our proposal can effectively address the handover issue and offer express train passengers seamless wireless service.

Keywords: Radio over Fiber(RoF), Access network, Light sensors, Mobile cellular networks.

INTRODUCTION

In Wireless Mobile Networks, Handover

Handover is the process by which an active link between a mobile host (MH) and a corresponding terminal or host is moved from one point of access to another network to another in conventional mobile cellular networks and wireless LANs. The signal strength deteriorates as an MH moves away from a BS, forcing it to transfer to a different BS for communication. Any cellular-based wireless network must keep an ongoing connection during handover, so it is crucial. Such places of attachment are referred to as BSs in wireless LANs and access points in cellular voice and mobile data networks. (APs). Such a place of attachment serves a coverage purpose in either scenario. A voice conversation is transferred from one BS to another during handover in cellular telephony. It entails moving the link from one AP to another in the context of WLANs. In hybrid networks, this will entail the transfer of a link between two BSs, an AP, a BS and an AP, or vice versa.

Each time a handover occurs, speech users experience an audible click that ends their communication. Data users may also experience packet loss and unneeded congestion control measures as a result of handover. However, since signal level degradation is a random process, basic decision-making processes, such as those that rely on signal strength measurements, lead to the ping pong effect. Both the network load and the user's impression of quality are severely hampered by this. We go over general handover-related concerns as well as sample conventional wireless networks' handover processes. The average speed of Express Train Access Networks (ETAN), a high-speed train service with a top speed of 150 mph (240 km/h), is less than half that amount. Business and railway travellers now frequently use ETAN.

The ETAN Handover Decision System

It is obvious that an express train moves at a high speed and follows a set path in addition to having a fixed direction. This finding can be used to combine sensor networks and optical switch technologies to create a handover decision system specifically for ETAN. The Standard Propagation Model (SPM) is used in our theoretical model to calculate path loss; however, the channel model differs slightly from the field test findings in terms of the large-scale fading impact in the Beijing-Shanghai high-speed railway. Therefore, it is appropriate to mention it here for a fundamental theoretical explanation):

Figure 1 explains about working principle of the handover decision system. People now anticipate much more to be able to access the Internet regardless of location due to the Internet's explosive growth over the past 20 years. Trains and airplanes have traditionally been two places where passengers have not always been able to access high-speed Internet. In the specific instance of trains, giving passengers access to the Internet while they are traveling makes sound business sense: while increasing traveler numbers, Internet access for passengers can generate revenue for the train company. For instance, a 2004 study conducted in the United Kingdom discovered that 72% of business travelers preferred trains to automobiles or aircraft when Wi-Fi was accessible on trains. 78% of these business travelers, according to this survey, said they would use Wi-Fi if it were made accessible on trains. When it comes to freight trains, having Internet connectivity enables real-time or nearly real-time tracking of freight-related events on board, which could reduce the freight carrier's insurance costs. Broadband Internet connectivity also offers the following advantages: This paper's primary contribution is a survey of studies and initiatives aimed at making Internet access available on trains. Highlighted are the elements of a rail setting that make communications from trains challenging. We distinguish between the work produced in Japan, Europe, and North America due to the unique characteristics, for reasons that will become clearer later. The remainder of this essay is organised as follows: The problems preventing high-speed railway communications are outlined in Section II. In addition to providing some background on handoff and addressing train-related problems, Section III presents the reference architecture for Internet access on trains. Discusses the early ideas that served as the foundation for the implementation of broadband Internet access on trains. We offer a taxonomy of the online train connectivity tools. Results from test beds that looked at how to install fast Internet on trains are discussed.

The efforts made—or those in progress—to implement high-speed communications from trains are further broken down into an examination of execution efforts taking place in North America and Europe. outlines business plans created to evaluate the feasibility of offering broadband Internet.

RESULT AND DISCUSSION

So far, we've looked at the reference design, the basic ideas supporting the deployment of broadband Internet on trains, and the taxonomy of access network technologies. This part reviews the outcomes of tried-and-true Internet access on trains. Starting with prototypes, we move from the more theoretical to the actual implementation. In 2004, Sivchenko et al. presented simulation findings demonstrating the expected decline in Internet traffic performance on high-speed trains as the number of users rises. Investigated in is how well various radio technologies perform in terms of data rates encountered by fast-moving trains. In 2005, Gaspard and Zimmermann assessed the correlation of throughputs with Doppler shift (speed). This study was done in two stages: in the first, a mobile transmitter was moved along the track while a channel sounder was used to measure the channel for various mobile receiver placements. The next step involved comparing various access network radio technologies using a hardware simulation of the channel properties. The tests assessed how a channel's throughput would change between a receiver on a train and a trackside transmitter.

Performance Analysis

We present a first optical physical layer network architecture that allows the realisation of the MEC approach after performing a performance analysis of the MEC (Moving Extended Cell) concept in terms of call dropping probability and packet loss values. We focus on providing full MEC configurability directly in the optical domain as we show an optical switching architecture for implementing MEC in the CO. The suggested network architecture makes use of WDM technology to assign each Remote Antenna Unit (RAU) a specific wavelength, which requires the use of a minimum number of wavelength channels equal to the number of RAUs used in the network. Every cell is thus provided with a particular wavelength, making it possible for the MU to transmit data to a new cell by simply switching to the wavelength providing the new cell.

Single 60 GHz RF -Over-X Network

Every MU uses a wireless link at 60 GHz thanks to this network's use of a single 60 GHz RF carrier frequency that is modulated on every optical wavelength and capable of carrying data at up to 2.5 Gb/s data rates. Figure shows the physical layer setup for a network that uses M wavelengths and can support up to N mobile users overall. Each MU's data will be transmitted using a 60 GHz RF carrier when a 7-cell Extended Cell structure is taken into account. This RF carrier will then be superimposed on the 7 wavelengths that correlate to the 7 cells making up the MU's current EC. Only one user can be found in each group of seven cells in order to prevent wavelength collision and RF interference effects, suggesting that the network can sustain a total of $N = M/7$ users.The figure 2 (a) explains about architecture of WiMax System and figure 2(b) explains about WiMax-ROF system in details.

WiMAX-RoF

Multiple BS are used in the WiMAX access network along the railway. For Internet connectivity, each BS is linked to an access service network (ASN) gateway. Four handoffs are necessary for the train to proceed from one BS's cell coverage to the next, for instance, if five BSs are needed to cover the track, as shown in. Although handoffs occur frequently in all wireless systems, they are particularly difficult in extremely mobile connections due to the terrain and speeds of up to 300 km/hr. When the BSs are placed along the railway, as depicted in Figure, the RF cell coverage in each WiMAX BS is roughly 0.5 to 5 km. However, deploying network coverage over mobile areas frequently poses particular and pressing difficulties. These corridors typically pass through thinly populated regions as well as difficult terrain like tunnels, mountains, bridges, and various man-made obstructions. The deployment of wireless coverage throughout the entire corridor comes at a high expense and, in many instances, results in marginal to poor reception throughout the corridor.

It has been determined through characterising and analysing WiMAX-RoF performance that RoF transmission occurs during TDD framing over a WiMAX link. The WiMAX-RoF link states that a single BS over HSR could be used to increase the RF range. Additionally, the throughput and packet loss characteristics at various fibre connection lengths have been examined and analysed. Therefore, it may be anticipated that using WiMAX-RoF will stop handovers. In the Song Shan tunnel in the THSR, a WiMAX-RoF field experiment using a straightforward architecture of two RAUs in RoF link was set up and carried out. The performance of the WiMAX-RoF connection will be further examined and characterised through additional static and quick trials.The figure 3 explains about the principles of handover decision system as Follows.

1. Each railway is given a unique ID that gives it access to ETAN. To record the state of a train's movement, light sensors are installed on the boundary of two adjacent cells. (e.g. its location and speed). A handover request is triggered and sent to the Central Station (CS) to begin a fresh link when the train passes LS-A. Another handover request will be created to delete the old link after the train crosses LS-B.
2. Because the train's movement characteristics are closely linked to the wireless signal coverage and strength information, as depicted, the movement status of the train can provide an indication of the wireless signal's strength. The next subsection discusses it hypothetically.
3. The CS makes a choice and uses an optical switch unit to transfer its signal from its initial BS to the following BS. (which is applicable because up-to-date optical switch technology can complete switching within 10 ns).

The following table 1 compares the speed and frequency of data on various Access Technologies.

CONCLUSION

This paper compares the performance of ROF(Radio Over Fiber) , ETAN(Express Train Access Network), WiMaxon access network, among these three networks radio over fiber network produces better result compare to other networks. Integrating sensor technology into ETAN, resulting in the creation of a specific handover choice system with the ideal fusion of sensors (such as pressure or light sensors) and optical switch technologies will give better result than ROF. Simulation findings show that our proposal can effectively address the handover issue and offer express train passengers seamless wireless service.

REFERENCES

1. D. Pareit, *Broadband Internet access for trains with quality of service by interworking of heterogeneous wireless networks,* Sep. 2020.
2. C.-H. Yeh, C.-W. Chow, Y.-L. Liu et al., "Theory and technology for standard WiMAX over fiber in express train systems", *IEEE/OSA J. Lightwave Technol.*, vol. 28, no. 16, pp. 2327-2336, 2021.
3. [online] Available: http://en.wikipedia.org/wiki/High-speed-rail-in-China.
4. B. Lannoo, D. Colle, M. Pickavet and P. Demeester, "Radio-over-fiber- based solution to provide broadband Internet access to train passengers", *IEEE Commun. Mag.*, vol. 45, no. 2, pp. 56-62, 2020.
5. J. Guillory, E. Tanguy, A. Pizzinat et al., "A 60 GHz wireless home area network with radio over fiber repeaters", *J. Lightwave Technol.*, vol. 29, no. 16, pp. 2482-2488, 2021.
6. B. Mukherjee, "Optical WDM Networks" in, Springer, 2020.
7. Zhao, F.; Tian, H.; Nie, G.; Wu, H. Received Signal Strength Prediction Based Multi-Connectivity Handover Scheme for Ultra-Dense Networks. In Proceedings of the 2018 24th Asia-Pacific Conference on Communications (APCC), Ningbo, China, 12–14 November 2018; pp. 233–238.
8. 3GPP, TR 28.801 V15.0.0. Study on Management and Orchestration of Network Slicing for Next Generation Network (Release 15). 2018.
9. Dahlman, E.; Parkvall, S.; Skold, J. 5G NR: The Next Generation Wireless Access Technology; Elsevier Science: Amsterdam, The Netherlands, 2018.

10. Lu, Y.; Koivisto, M.; Talvitie, J.; Valkama, M.; Lohan, E.S. Positioning-Aided 3D Beamforming for Enhanced Communications in mmWave Mobile Networks. IEEE Access **2020**, 8, 55513–55525.
11. Sammour, I.; Chalhoub, G. Evaluation of Rate Adaptation Algorithms in IEEE 802.11 Networks. Electronics **2020**, 9, 1436.

Table. 1. Comparison of Access Technology

Access Network Technology	Data Rates	Frequency of Handoff	Technology Maturity	Comments
IEEE 802.11	Upto 54 mbps	High	Mature	Tested in the access network, as a gap filter
WiMax	Upto 104 mbps	Medium	Mature, other draft standards are added to improve performance	Used by southern rains
GPRS	Upto 171 kbps	Medium	Mature	Used by southern trains
Satellite	512 kbps (upload)2mbps (download)	Low	Mature	Used by SNCF train
Radio-over-Fiber	Targeting 0.5-5 gbps	High	Immature	Not yet deployed

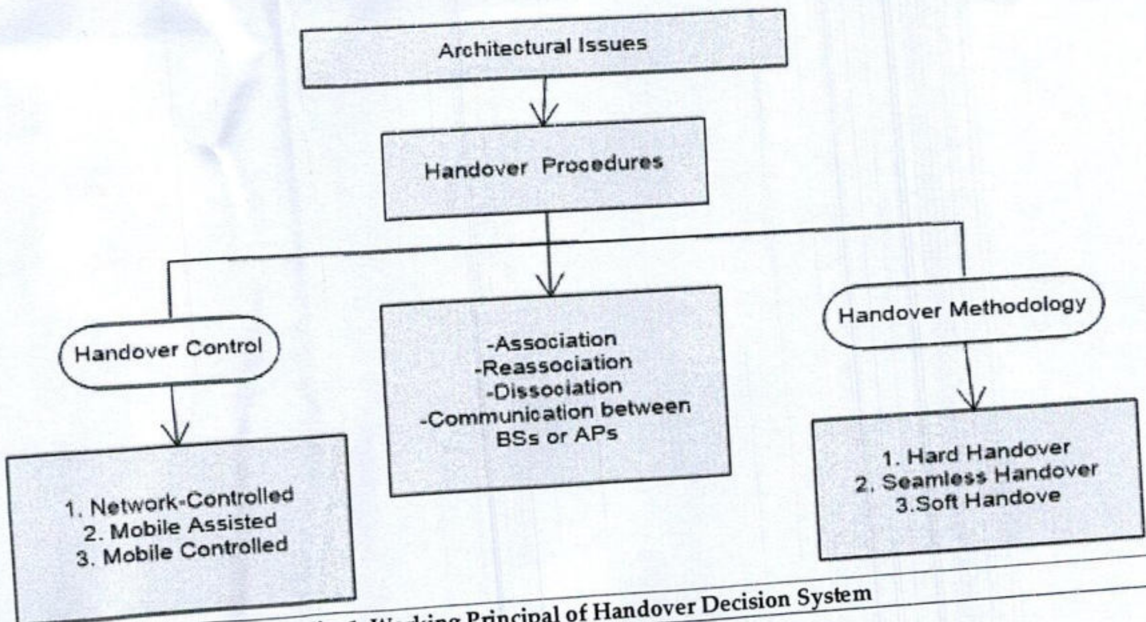

Fig. 1. Working Principal of Handover Decision System

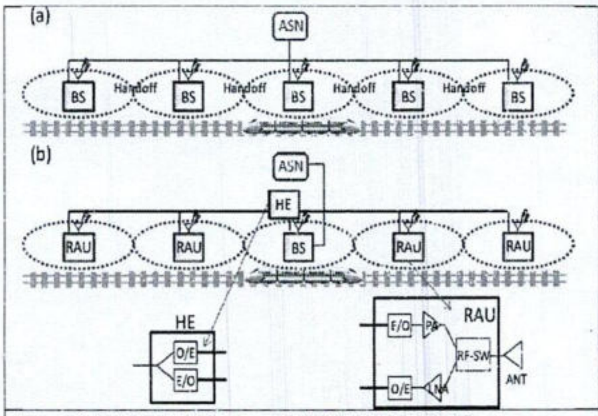

Fig. 2(a) WiMAX System (b) WiMAX-ROF System

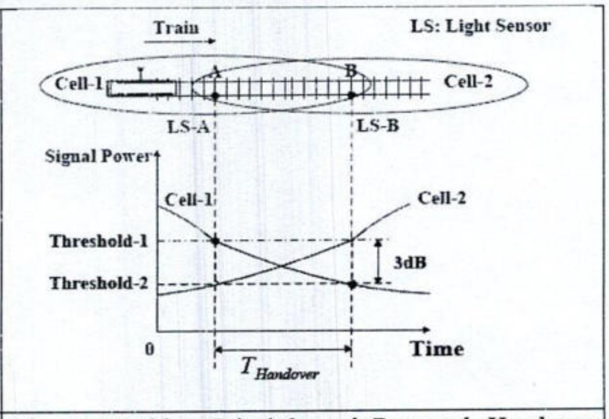

Fig. 3. Working Principles of Proposed Handover Decision System