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Wireless cellular network for high speed (up to 500 km/h) vehicles

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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. Currently, commercial high data rate mobile services are pro-vided with a peak data rate of 28Mbps using a bandwidth of 5MHz. However, this peak data rate is insufficient and even higher transmission rates are already desired, especially when multiple users and multimedia traffic are considered. The development of high-speed railway makes people's lives more and more convenient; meanwhile, it puts forward much higher requirements on high-speed railway communication services. In this paper, the wireless cellular network for high speed train is designed that can be deployed in the environment where the passengers have speed up to 500 km/h. For this purpose, two different network architectures are designed for inside and outside the train respectively. Inside the train, the MSs are connected to the wireless access point to communicate. The APs are connected to one transceiver antenna on the top of the train by wired connections. In the outside of the train the BSs for railway is designed in a different manner. The Omni-directional antennas are used for the railway BSs for less energy consumption. The coverage area of one BS is overlapped with the nearest BS as a function of the average expected speed of the train. The railways Base Stations are connected to the BSC, MSC and PSTN as like the conventional cellular system as well as there is a point to point connection line between two adjacent BSs to transfer the control information firstly. When the train passes through the overlapping area of the cells, the handoff is occur and all the controls are transferred from the previous BS to the next BS to the moving direction of the train. For a train with maximum speed of 500 km/h we use the BS antenna that can cover an area of radius 10 km. The maximum distance between the overlapped boundary, (5*138) m= 690m (500000/3600= 138). So it will take 5 sec for a train to pass through the overlapping area. During this period of time, the handoff can occur smoothly.*

Keywords : *AP, BSC, BS, BBU, BWC, C-HSTC, CDMA, DAS, FDMA, GSM, GSM-R, MSC, MS, PSTN, QoS*

I. INTRODUCTION

Due to the lower energy consumption, less environmental pollution, larger transmission capacity and higher safety, high-speed railway has been playing an important role in mass transportation. In the last 25-30 years, wireless communications have become an essential part of people's lives all over the globe. The development of high-speed railway makes people's lives more and more convenient; meanwhile, it puts forward much higher requirements on high-speed railway communication services. Moreover, new challenges of train-to-ground communication have emerged caused by high mobility: Doppler frequency shift and mobility management (especially the fast handover control) are two of the most important problems. Rapid changing of radio channel and over-frequent handovers make mobile communication access much more difficult. Therefore, it has practical significance to design fast and smooth handover mechanisms which have high speed adaptively. In order to provide reliable communication service in high-speed train, the optimized handover scheme is introduced and analyzed in this thesis. Currently, commercial high data rate mobile services are pro-vided with a peak data rate of 28Mbps using a bandwidth of 5MHz. However, this peak data rate is insufficient and even higher transmission rates are already desired, especially when multiple users and multimedia traffic are considered. Meanwhile, high speed trains (HSTs) with a speed of more than 300km per hour are being deployed rapidly around the world, and have attracted a lot of attention in recent years as a fast, convenient and green public transportation system. For example, in the USA, a high speed rail plan has been outlined, which includes 10 regional high speed routes. In Europe and Asia, high speed rail has been expanding rapidly. Germany, France and Japan have been rapidly deploying their national high speed rail networks. By 2020, China's high speed railways will reach 18,000 km, the majority of lines of which will be longer than 1,000 km **[1]**.

The dominant wireless communication system for current railways is the global system for mobile (GSM) for rail (GSM-R), which only supports a maximum data rate of less than 200kbps, and is specifically used for train control instead of passenger communications. GSM-R cannot meet the requirements of high data rate transmissions. Using existing technologies, various schemes have been proposed for broadband wireless access on HSTs. In Europe, the multi-modal global mobile broadband communication (MOWGLY) technology has been developed, using wireless fidelity (WiFi) and satellite technologies for on-board and train-to-ground communications, respectively **[2]**. In Japan, a radio system based on leaky coaxial cable has been deployed in the HST "Series N700" **[3]** to establish the broadband connection between the train and the ground, while WiFi is also chosen for in-train communications. The "Series N700" can provide 2Mbps wireless data services to passengers in both downlink and uplink. In Taiwan, WiMAX has been tested for broadband transmissions on HSTs **[4]**.

However, without changes, those mobile communication technologies may not be suitable for the needs of data-intensive communications for high speed train passengers, since the relevant moving speeds are much higher and more challenging for communication designs, for example, the China Railways High-speed (CRH) train between Beijing and Shanghai at a speed of 350 kilometers per hour (kmph). In recent years, numerous efforts have been made on adapting the conventional Global System for Mobile Communications (GSM) framework to High-Speed Train Communication (HSTC) which gives birth to the railway specific GSM standard, GSM-R. In the high speed train scenario, although GSM-R has been so successful in voice communications **[5]**, it cannot support high-rate broadband data services, such as online video or gaming, for a train at a speed up to 500 km/h.

II. ORGANIZATION OF THIS PAPER

The paper is organized as; section 1 and 3 is about introductory discussion and previous works for mobile/ wireless communications in the high speed environments. Different solutions for the up- gradation of the existing technologies as well as the introduction of new technologies are also described in these sections. The summary of the system concept and the network architecture for the cellular system into the higher speed environment is summarized in section 4 and 5. The high speed train environment has taken into consideration for this purpose. In section 5, the network architecture both for inside and outside the train is given. The control transfer mechanism from one BS to another BS is given into section 6. The frequency reuse concept and moving frequency concept are illustrated in section 7 and 8 respectively. Finally the handoff mechanism for the high speed train is given into the section 9 and in section 10 the concluding remarks is given.

III. PREVIOUS WORKS IN THIS SECTOR

Some research summary in the sector of wireless communication for high speed users (inside high speed vehicles) are given below:

A research work had been made for high-speed train communication using baseband cloud (C-HSTC) system framework for providing continuous broadband services to highly mobile users [10]. This framework is featured with a new virtualized single cell design which mitigates the impact of conventional handover failures and guarantees continuous communication services. Through exploiting the baseband units (BBU) cloud and the full frequent frequency reuse in the virtualized single cell, a highly efficient joint transmit beam forming algorithm is proposed, targeting at compensating the inter-carrier interference (ICI) caused by severe Doppler frequency shift due to mobility. Numerical analysis shows that the new architecture and corresponding algorithms are suitable for high-speed train communication and can provide a continuous data rate of more than 100 megabits per second (Mbps) for passengers at a speed of 400 kilometers per hour (km/h). This would help to achieve satisfactory mobile broadband services for high speed train passengers.

In multi-hop cellular networks, mobile users can communicate with the base stations via relay stations (RSs), and handoff between different RSs [11]. This type of handoffs is referred to as inter-relay handoffs. In networks with highly mobile users, the inter-relay handoffs can occur very frequently. Making intelligent inter-relay handoff decisions is important in order to improve the network performance. In this article, the inter-relay handoff decision problem in a two-hop cellular network with highly mobile vehicles using a semi-Markov decision process was focused. The objective is to maximize the total reward, which is defined by taking into consideration the transmission rate of the user's link, the overheads for performing inter-relay handoffs, and the moving speed of the user.

With the deployment of high speed train (HST) systems increasing worldwide and their popularity with travelers growing, providing broadband wireless communications (BWC) in HSTs is becoming crucial. In this paper, a tutorial is presented on recent research into BWC provision for HSTs [1]. The basic HST BWC network architecture is described. Two potential cellular architectures, microcells and distributed antenna systems (DASs) based cells, are introduced. In particular, the DAS is discussed in conjunction with radio over fiber (RoF) technology for BWC for HSTs. The technical challenges in providing DAS-based BWC for HSTs, such as handoff and RoF are discussed and outlined.

The recent advent of high speed trains introduces new mobility patterns in wireless environments. The LTE-A (Long Term Evolution of 3GPP - Advanced) networks have largely tackled the Doppler Effect problem in the physical layer and are able to keep wireless service with 100Mpbs throughput within a cell in speeds up to 350 km/h. Yet the much more frequent handovers across cells greatly increases the possibility of service interruptions, and the problem is prominent for multimedia communications that demand both high-throughput and continuous connections. In this paper, a novel LTE-based solution is presented to support high throughput and continuous multimedia services for high speed train passengers. Our solution is based on a Cell Array that smartly organizes the cells along a railway, together with a femtocell service that aggregates traffic demands within individual train cabins.

There are a lot of handovers failed in high-speed mobile environment because the handover can't be completed in time although the field strength values are sufficient availability along the tracks. A mobile relay based fast handover scheme is proposed which is suitable for high-speed mobile environment. Two reference points are introduced to ensure handover in time. Pre-preparation and packet bi-casting is introduced to reduce communication interruption time and realize seamless handover. The performance of the proposed scheme is analyzed in terms of handover delay, communication interruption time and bi-casting time.

IV. SUMMARY OF THE SYSTEM CONCEPT

The development of high-speed railway makes people's lives more and more convenient; meanwhile, it puts forward much higher requirements on high-speed railway communication services. In this paper, the wireless cellular network for high speed train is designed that can be deployed in the environment where the passengers have speed up to 500 km/h. For this purpose, two different network architectures are designed for inside and outside the train. Inside the train, the MSs are connected to the wireless access point to communicate and no call handover occur here. The APs are connected to one transceiver antenna on the top of the train by wired connections. In the outside of the train the BSs for railway is designed in a different manner. The directional antennas are used for the railway BSs for less energy consumption. The coverage area of one BS is overlapped with the nearest BS as a function of the average expected speed of the train. The railways Base Stations are connected to the BSC, MSC and PSTN as like the conventional cellular system as well as there is a point to point connection line between two adjacent BSs to transfer the control information firstly. When the train passes through the overlapping area of the cells, the handoff is occur and all the controls are transferred from the previous BS to the next BS to the moving direction of the train. For a train with maximum speed of 500 km/h we use the BS antenna that can cover an area of radius 10 km. The maximum distance between the overlapped boundary, (5*138) m= 690m (500000/3600= 138). So it will take 5 sec for a train to pass through the overlapping area. During this period of time, the handoff can occur smoothly.

V. NETWORK ARCHITECTURE

There are two different network architectures for inside and outside the train. Wireless access points are used to connect all the MSs inside the train which is connected to the transceiver antenna on the top of the train. The transceiver antenna is connected to the BSs which are connected to the BSC, MSC and PSTN like the conventional cellular system. Cell architecture for the Railway cellular network is given in the figure- 1. Both network architectures are given below:

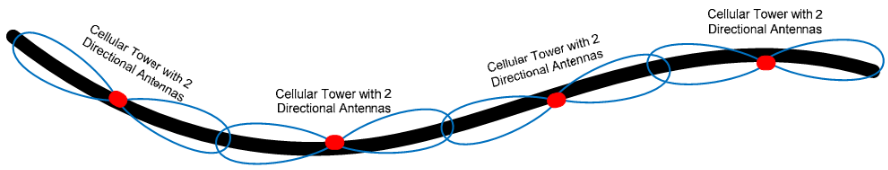

Figure 1: Cell style for Railways

1) NETWORK ARCHITECTURE INSIDE THE TRAIN

1. There is a transceiver antenna on the top of the train which is connected to the wireless access points inside the train. This connection may be established by any supported physical media/ cable.
2. There may have one or more wireless access points inside a car of the train, depending on the size of the car or the power of the wireless access point. It's the best practice to use only one device (AP) in the middle position of the car, which is placed on the inner roof of the car in ground direction.
3. The wireless access point must have the capacity to serve the maximum number of MSs inside the train. This number can be calculated depending on the average expected number of users.
4. The network design inside the train is illustrated in the figure- 2.
5. Dynamic IP allocation system can be deployed for the communication between the MS and the wireless access point.

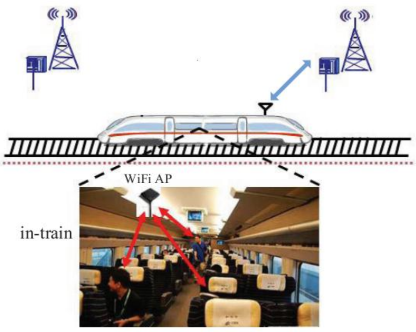

Figure 2: Network Architecture inside the train

2) NETWORK ARCHITECTURE OUTSIDE THE TRAIN:

1) All BSs are under control of MSCs and PSTN like the conventional Cellular System.
2) The Omni-Directional antennas may used for the Railway BSs for the consumption of less energy. Because it requires to cover less area around the Rail line rather than the coverage system of conventional cells.
3) For a train with maximum speed of 500 km/h we can use the BS antenna that can cover an area of radius 10 km.
4) The maximum distance between the overlapped boundary, (5*138) m= 690m. (500000/3600= 138)
5) So it will take 5 sec for a train to pass through the overlapping area.
6) There must have a different point to point communication line between two adjacent BSs to transfer the control information.
7) The distance between two BSs must known to the corresponding MSC.
8) The coverage area of each BS is overlapped with the coverage area of the nearest BSs as a function of the average expected speed of the train.
9) The overlapping area is expected to be large enough, so that the passing time of the train through the overlapping area must be less than the control transfer time from the previous BS to the next BS.
10) As a result, the handoff can occur smoothly, without dropping the call.
11) The network design outside the train is illustrated in the figure- 3.

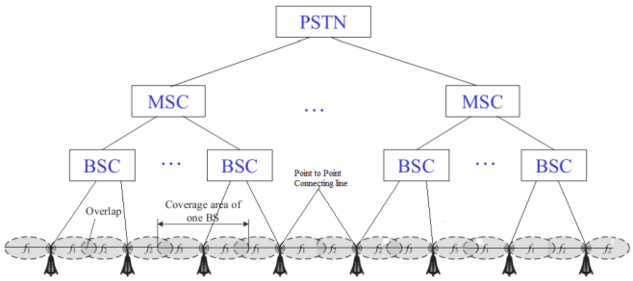

Figure 3: Network Architecture inside the train

VI. CONTROL TRANSFER

1) Control transfer of the BS means the transfer of overall functionality of the current BS to the next BS in real time with a dynamic algorithm.
2) Keep the value of the central position of the coverage area of each BS into DB.
3) Suppose that, the train is now within the coverage of nth BS. So the previous (if exists) was the (n-1)th BS that is just now visited and next is the (n+1) th BS, that is going to visit.
4) Read the position of the train within the current coverage area of t th and (t+1) th time.
5) If (CPV of (n-1)th BS + Position value at t th time) is less than (CPV of (n-1)th BS + Position value at (t+1) th time) then the train is in the direction from nth to (n+1) th BS. Here CPV stands for Central Position Value. Otherwise it is in the direction from nth to (n-1)th BS.
6) When the train enters into the overlapping coverage area, the handoff is occurs and the whole control process is transferred to the target BS. This transfer process is accomplished through the direct point to point connection line of the BS.

VII. FREQUENCY RE-USE CONCEPT

Frequency reuse concept can be used for the railway BSs. The key characteristic of a cellular network is the ability to re-use frequencies to increase both coverage and capacity. The adjacent cells must use different frequencies; however there is no problem with two cells sufficiently far apart operating on the same frequency. The elements that determine frequency reuse are the reuse distance and the reuse factor [17].

The reuse distance, D is calculated as $D = R\sqrt{3N}$, where R is the cell radius and N is the number of cells per cluster. Cells may vary in radius in the ranges (1 km to 30 km). The boundaries of the cells can also overlap between adjacent cells and large cells can be divided into smaller cells.

The frequency reuse factor is the rate at which the same frequency can be used in the network. It is 1/K (or K according to some books) where K is the number of cells which cannot use the same frequencies for transmission. Common values for the frequency reuse factor are 1/3, 1/4, 1/7, 1/9 and 1/12 (or 3, 4, 7, 9 and 12 depending on notation).

In case of N sector antennas on the same base station site, each with different direction, the base station site can serve N different sectors. N is typically 3. A reuse pattern of N/K denotes a further division in frequency among N sector antennas per site. Some current and historical reuse patterns are 3/7 (North American AMPS), 6/4 (Motorola NAMPS), and 3/4 (GSM).

If the total available bandwidth is B, each cell can only use a number of frequency channels corresponding to a bandwidth of B/K, and each sector can use a bandwidth of B/NK.

Code division multiple access-based systems use a wider frequency band to achieve the same rate of transmission as FDMA, but this is compensated for by the ability to use a frequency reuse factor of 1, for example using a reuse pattern of 1/1. In other words, adjacent base station sites use the same frequencies, and the different base stations and users are separated by codes rather than frequencies. While N is shown as 1 in this example that does not mean the CDMA cell has only one sector, but rather that the entire cell bandwidth is also available to each sector individually.

VIII. FREQUENCY REUSE CLUSTER (FREQUENCY REUSE FACTOR = 1/4) FOR HEXAGONAL CELLS

This means that the allocated band is divided into 4 bands and the four sub bands are reused in an alternating fashion as given in figure- 4. No neighboring cells have the same frequency in this configuration. Note that if the a slightly different configuration can be achieved with 4 cells in the cluster that performs worse than this configuration.

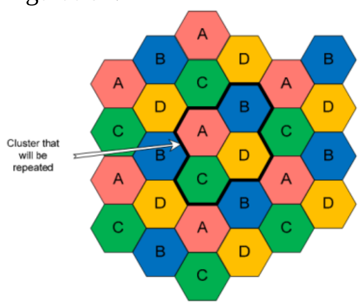

Figure 4: Frequency reuse cluster for hexagonal cells

IX. FREQUENCY REUSE CLUSTER (FREQUENCY REUSE FACTOR = 1/4) FOR RAILWAY CELLS

For the Railway Cellular system, the Omni- directional antennas are used in the BSs. The frequency reuse concept can be used for cells in different way. The frequencies f1, f2 and f3 are used for cell 1, 2 and 3 respectively. That means a cluster of three cells is formed. The same frequency bands are used for the next three cells and repeat this process again and again. The number of cell can be increase in the cluster to avoid the interference. The structure of the cell cluster for Railway cellular system is given in figure- 5.

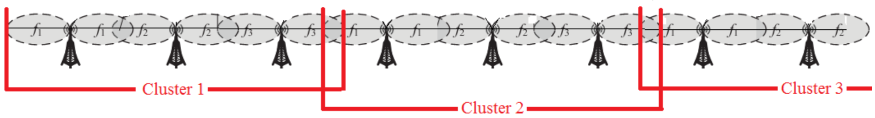

Figure 5: Cell cluster for Railway Cells

X. MOVING FREQUENCY CONCEPT

The "moving cell" concept was introduced in [15] to avoid frequent handoffs in highway communication. The idea was to construct a separate rail to convey BSs, which physically move in the same direction and at the same speed as the main traffic flow along the highway. Since the BS or cell moves with their MTs, ideally handoffs are not needed since the BS moves at the same speed as the main traffic flow. Although some vehicles may move faster or slower than the main traffic flow and handoffs are needed for these vehicles, the number of handoffs for these vehicles can be significantly reduced relative to the conventional cellular system. However, because the construction cost of a separate rail is high, the implementation of such a moving cell concept is difficult to be implemented in practice. The moving cell concept can be replaced by the moving frequency concept [16], as shown in Fig- 6.

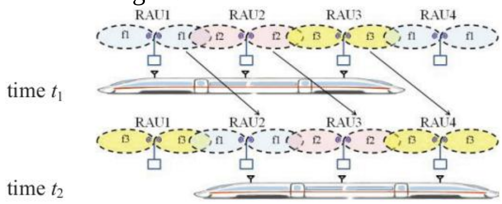

Figure 6: Moving Frequency Concept

The basic idea of the moving frequency concept is to move the radio frequencies of RAUs according to the positions of the trains (or carriages). For example, the radio frequencies of RAU1, RAU2, RAU3, and RAU4 are f1, f2, f3, and f1, respectively, when the train is in the position at time t1, shown in the upper part of Fig. 6. However, when the train moves to the position at time t2, shown in the lower part of Fig. 6, the radio frequencies to be used by the RAUs are moved according to the position of the train. At time t2, the frequencies used by RAU1, RAU2, RAU3 and RAU4 are f3, f1, f2, and f3, respectively. In the moving frequency concept, the radio frequencies of the BWC APs on the train are unchanged, while the frequencies of the RAUs are moved with the train. The moving frequency concept removes the need for handoffs as long as the train is within the coverage of one CU. However, when the train moves across into the coverage of another CU, handoff is still needed. If one CU contains a large number of RAUs and covers a rather long distance of rail, the need for handoff from one CU to another CU should be less frequent. The moving frequency concept can be implemented by using optical switching technologies. Firstly, each RAU is installed with a fixed optical add drop multiplexer (MUX) (OADM) to obtain a fixed wavelength [9]. Secondly, the CU is equipped with a wavelength division multiplexing (WDM) laser and some optical switches to modulate any particular wavelength with a chosen radio frequency. For instance, RAU1, RAU2, RAU3, and RAU4 are associated with fixed wavelengths, λ1, λ2, λ3 and λ4, respectively. As shown in Fig. 7, at time t1, the CU modulates radio frequencies f1, f2, f3 and f1 on wavelengths λ1, λ2, λ3 and λ4, thus RAU1, RAU2, RAU3, and RAU4 obtain radio signals of f1, f2, f3 and f1, respectively. In this case, the train receives f1, f2, and f3 from RAU1, RAU2 and RAU3. At time t2, the train moves forward. The CU maps f3, f1, f2 and f3 to wavelengths λ1, λ2, λ3 and λ4. Thus, RAU2, RAU3 and RAU4 are sending radio signals with frequencies f1, f2 and f3 to the train. In this way, the frequencies move with the train and conventional handoff can be replaced by optical switching with a time order of ns or µs, which is much less time-consuming. The moving frequency concept has been demonstrated in [4], although not with RoF links.

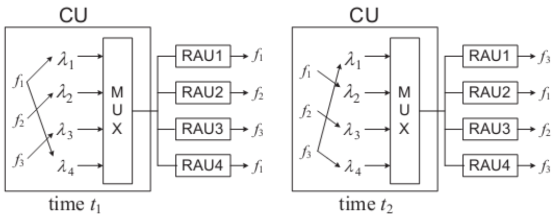

Figure 7: Frequency- Wavelength Mapping

XI. HANDOFF

Handoffs are broadly classified into two categories—hard and soft handoffs. Usually, the hard handoff can be further divided into two different types—intra- and intercell handoffs. The soft handoff can also be divided into two different types—multi way soft handoffs and softer handoffs. In this paper, soft handoff is mainly focused. Figure- 8 shows the Group Handoff.

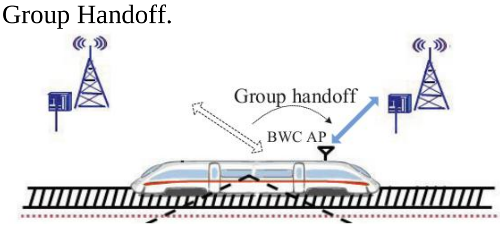

Figure 8: Handoff for a group of call with transceiver antenna, from one BS to another

1) *FIRST STEP OF HO PROCESS*

This step performs the actual handover to a new target BS. After the MS (the transceiver antenna that handles a group of calls) has become aware of the network topology and optionally did some scanning and association, it can start cell re-selection in order to choose the target BS. The criteria for target BS selection is not defined in the standard and is left open to different implementations. After target BS selection, the MS initiates the handover process by exchanging certain management messages with the BS indicating to the serving BS that the MS has decided to handover to another BS. Subsequently, the MS starts to tune to the target BS, obtains downlink and uplink channel parameters, and synchronizes to the new target BS.

Once synchronized with the target BS, the MS resumes the normal sequence of operations for re-entry into the target BS, including ranging, basic-capability negotiation, authentication, traffic key establishment, and finally registration. However, some or all of the operations required for re-entry may be eliminated if the target BS was able to obtain this information over the backbone from the serving BS. If this information is not needed by the target BS, it is indicated to the MS under a field called "HO Process Optimization" which is transmitted in the MOB NBR-ADV message.

2) *THE PROPOSED ALGORITHM*

In this section, a service-flow aware new handover algorithm is proposed that is fully compliant with the IEEE 802.16e standard. The main objective of the proposed algorithm is to minimize the handover delay while acquiring the best possible target BS. In selecting the target BS, the algorithm looks for the BS that can best support the QoS requirements for the service flows in the MS. The operation of the proposed algorithm is elucidated by the flow diagram shown in Figure 8 and explained in more detail in the following sections.

3) *SECOND STEP OF HO PROCESS*

From the short list obtained in the previous step, the MS has the freedom now to pick up any BS from the list as the target BS. The MS can decide to handover or initiate a handover when the RSSI value received from the serving BS is below a lower threshold. This condition is the main trigger for initiating a handover to another BS. Once the MS has decided to handover, the MS should start sending a MOB MSHO-REQ message to the serving BS. This message indicates to the BS that the MS is about to perform handover and includes a short list of BSs as obtained before during the network topology acquisition phase. Once this message is transmitted, the MS should wait for a response from the serving BS as indicated by receiving a MOB BSHO-RSP message. When the MS receives this MOB BSHO-RSP message, it transmits a MOBHO-IND message to the serving BS indicating the target BS. Once this message is transmitted, the MS can start tuning to the RF channel or sub channel to connect to the target BS. Depending on the "HO Process Optimization" field transmitted in the MOB NBR-ADV message, the MS starts doing some or all of the following: basic capability negotiation, authentication, key establishment, and registration.

Figure- 8 shows the flow chart for the proposed handover procedure. Figure 8(a) shows the action to be taken by the MS when receiving a MOB NBR-ADV message. According to the flow chart, the MS saves, into a list, the set of neighbor BSs included in the message. Figure 8(b) shows the handover flow chart. Note that the handover procedure starts whenever the MS detects that the RSSI of the serving BS is less than a preset threshold, in which case the MS decides to perform a handover to another BS. The MS makes use of the BS list which is saved when the MOB NBR-ADV message is received, and subsequently starts to build a short list containing those BSs that support the current active service flows. BSs in the short list are scanned by the MS in order to evaluate their RSSIs. If one or more of the scanned BSs have their RSSI values above the preset threshold, their IDs will be sent by the MS in a MOBMSHO-REQ message to the serving BS. When the MS receives a MOB BSHO-RSP, it selects a target BS and sends a MOBHO-IND to the serving BS. The MS starts normal re-entry procedure with the new target BS, using such steps as initial ranging and registration.

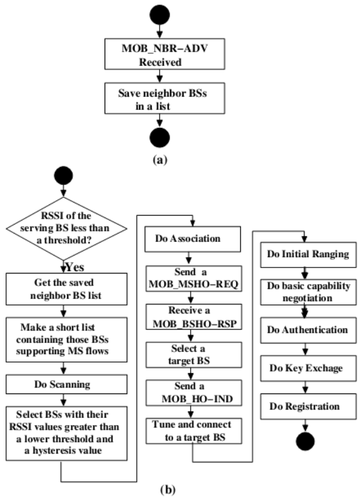

Figure 9: Flow chart for the proposed handover procedure

XII. CONCLUSION

The wireless cellular network for high speed train is designed in this paper that can be deployed in the high speed environment (speed up to 500 km/h). Two different network architectures are designed for inside and outside the train respectively. Inside the train, the MSs are connected to the wireless access points and the APs are connected to one transceiver antenna on the top of the train by wired connections. In the outside of the train the BSs for railway is designed in a different manner, on the other hand. The Omni-directional antennas are used for the railway BSs for less energy consumption. The coverage area of one BS is overlapped with the coverage of nearest BS as a function of the average expected speed of the train. The calculations, based on speed and direction of the train is given in this paper. The moving frequency concept, which is one of the forms of frequency reuse concept, is used for the channel allocation of BSs. Finally an algorithm for handoff procedure is proposed. The railways Base Stations are connected to the BSC, MSC and PSTN as like the conventional cellular system as well as there is a point to point connection line between two adjacent BSs to transfer the control information firstly. This architecture can be used in the cellular systems for high speed vehicles because of the improved capacity. I am still working to develop a more efficient algorithm for handoff mechanism and also trying to develop an architecture that will be compatible with the environment having more speedy users.

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REFERENCES

[1]. J. Wang, H. Zhu and N. J. Gomes “Distributed Antenna System for Mobile Communications in High Speed Trains”, IEEE Journals on selected areas in communications. Vol. 30, No. 4, May 2012.
[2]. G. Barbu, “E-Train - Broadband Communication with moving trains Technical Report - Technology state of the art,” Jun. 2010, available online at http://www.uic.org/etf/publication/publication-detail.php?codepub=19014.
[3]. Japan Central Railway Company, “Extensive Internet Environment on the Next Generation High-Speed Train ’Series N700’,” available online at http://www.docin.com/p-98849721.html.
[4]. “ITRI claims success in WiMax trial on high-speed train,” available for members at http://www.digitimes.com/Tornado/V4/SearchEnd.asp#top1.
[5]. Wikipedia, the free encyclopedia, “Global System For Mobile Communications- Railway”, http://en.wikipedia.org/wiki/GSM-R.
[6]. H. Zhu, S. Karachontzitis, and D. Toumpakaris, “Low-complexity resource allocation and its application to distributed antenna systems,” IEEE Wireless Commun., June 2010.
[7]. H. Zhu, “Performance comparison between microcellular and distributed antenna systems,” IEEE J. Sel. Areas Commun. , vol. 29, pp. 1151-1163, June 2011.
[8]. X. You, D. Wang, B. Sheng, X. Gao, X. Zhao and M. Chen, “Coop-erative distributed antenna systems for mobile communications,” IEEE Wireless Commun., June 2010.
[9]. D. Lin, “A Comparative study on uplink sum capacity with co-located and distributed antennas,” IEEE J. Selected Areas in Commun. , vol. 29, pp. 1200-1203, June 2011.
[10]. Dr. L. Qinglin, Dr. F. Wei, Dr. W. Jinsong and Prof. C. Qingchun, “Reliable broadband wireless communication for high speed train using baseband cloud”, EURASIP Journal on Wireless Communications and Networking.
[11]. Mr. W. Di, Prof. Z. Gang and Prof. Z. Dongmei, “Inter- relay Handoff in two-hop relaying networks with highly mobile vehicles”, EURASIP Journal on Wireless Communications and Networking.

[12]. Mei-Hsien Lin, Hsu-Yang Kung, Tai-Yang Wu and Wei-Kuang Lai, "Vehicular Streaming Handoff Control Mechanism based on the Prediction Buffer Control" Department of Computer Science and Engineering, National Sun Yat-sen University, TAIWAN.

[13]. Ouldooz Baghban Karimi, Jiangchuan Liu, and Chonggang Wang, "Seamless Wireless Connectivity for Multimedia Services in High Speed Trains", IEEE JOURNAL ON SELECTED AREAS IN COMM UNICATIONS, VOL. 30, NO. 4, MAY 2012.

[14]. Q. Huang, J. Zhou, C. Tao, S. Yi and M. Lei, "Mobile relay based fast handover scheme in high- speed mobile environment", Institute of Broadband Wireless Mobile Communications, Beizing Jiaotong University, Beizing, China, NEC laboratories, China.

[15]. C. D. Gavrilovich, G. C. Ware and F. LLP, "Broadband Communication on the Highways of Tomorrow," IEEE Commun. Mag. , pp. 146-154, Apr. 2001.

[16]. Y. Zhou, Z.G. Pan, J.L. Hu, J.L. Shi and X.W. Mo, "Broadband Wireless Communications on High Speed Trains," in Wireless a Optical Communication Conference 2011, invited paper, Apr. 2011.

[17]. Wikipedia, the free encyclopedia, "Cellular network", http://en.wikipedia.org/wiki/Cellular_network.

[18]. H. Fattah and H. Alnuweiri, "Anew Handover Mechanism for IEEE 802.16e Wireless Networks", Department of Electrical Engineering, Texas A & M University.