A Novel Scheme for Wireless Connectivity for Multimedia Services in High Speed Trains

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Abstract: The beginning of high speed trains launch new mobility patterns in wireless environments. The LTE-A(Long Term Evolution-Advanced)networks have mainly tackled the Doppler Effect problem and maintain wireless service with 100Mpbs throughput within a group in speeds up to 350 km/h. However much more repeated handovers across group significantly increases the possibility of service disruption, and the problem is major for multimedia communications that require both high-throughput and continuous connections. In this, paper a novel LTE-based solution is proposed to support high throughput and continuous multimedia services for high speed train traveler. The proposed solution is based on a Group Array that smartly organizes the groups along a railway, together with a Pico group service that collective traffic demands within individual train cabins. Given that the movement direction and speed of a high-speed train are known, Group Array effectively predicts the upcoming LTE groups in service, and enables a seamless handover that will not disrupt multimedia streams. To hold the extreme channel variations, Scheduling and Resource Allocation Mechanism (SRAM) is further proposed to maximize the throughput based on periodical signal quality changes. The results demonstrates that the proposed solution achieves much lower handover latency ,low handover failure rate ,low delay and higher data throughput, as compared to existing solutions. It also well defends against to network and traffic dynamics, thus enabling continuous quality multimedia services for travelers in high speed trains.

Key Words——Cellular Networks, LTE, Multimedia, High Speed Vehicles

1. INTRODUCTION

Since a railroad framework typically covers an inconceivable land territory, it is financially costly to fabricate a unique system just for the travelers, also that a large portion of the them don't generally remain focused trains. Thusly, general purpose systems administration ought to be embraced, especially LTE, the accepted standard for the new era of remote cell systems. The LTE physical layer can bolster high throughput information conveyance at velocities up to 350km/h and even 500km/h in rustic zones. Cutting edge executions of LTE [7] have the ability to backing no less than 200 dynamic information clients for each 5MHz of data transmission in a cell, which will further increment in LTE-Progressed. Yet a rapid train remains a test environment for LTE systems. To begin with, the remote channel condition changes radically [8], consequently aggravating the information rate; Second, handover crosswise over cells turns out to be significantly more incessant, accordingly interfering with associations. The two are profoundly undesirable for media interchanges given the stringent request on information data transmission and progression. To address these difficulties, novel LTE based answer is proposed in the paper for bolster high throughput and ceaseless media administrations for fast prepare travelers. The arrangement is taking into account a Cell Cluster that cleverly arranges the cells along a railroad, together with a Femto cell administration that totals traffic requests inside of individual train lodges. Given that the development heading and velocity of a fast train are by and large known, our Cell successfully predicts the forthcoming LTE cells in administration, and empowers a consistent handover that won't interfere with mixed media streams. In this paper, the flagging and activities are detailed in such a prescient handover. To suit the compelling channel varieties, further proposed a booking and asset assignment instrument to amplify the administration rate for Femto cell base stations, as indicated by periodical signs quality changes. This guarantees the mixed media administration quality inside of each Femto cell. The proposed arrangement is accessed under assorted system furthermore, rail configuration. The reproduction results demonstrate that it achieves much lower handover latency and higher information throughput, when contrasted with existing arrangements. It likewise well oppose to network and traffic progress, consequently empowering constant high-throughput sight and sound administrations for travelers in rapid train.

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2. RELATED WORK

Satellite interchanges were generally utilized for remote access over vehicles moving crosswise over immense geological areas [9].The satellite service however would be disconnected in passages or at terminals. Arrangements that adaptively change to Wireless Local Area Networks (WLANs) [2] or Distributed Antenna Systems (DAS) [1] in None Line Of Sight (NLOS) spots to improve integration have been proposed. By the by, the satellite interchanges stay costly, also the extremely constrained transfer speed, the high spread deferrals, and the high overhead with the improvements for NLOS.

A recent proposal expands the use of heterogeneous wireless connections to give ceaseless moderate associations and discontinuous quick associations for rapid vehicles [3]. Given the inconceivable geographical coverage of the high speed train railway, deploying such another system foundation can be immoderate.

The accessibility of remote cell arrange in both urban and country ranges, which kills the requirement for usage of another infrastructure for high velocity trains, improves it an option. Computerized remote television with Global System for Mobile Communications - Railway (GSM-R) for high velocity train travelers has been exhibited in [3], which consents the Chinese advanced TV standard [4]. For high-quality general purpose wireless gets to, a progression of measurements have shown that, even with such new generation of benchmarks as High Speed Packet Access (HSPA) [5], 3G, and 3.5G, wonderful execution debasement would at present happen over rapid trains, especially when the velocity is over250km/h. Including the user mobility information in join adaption for LTE to gauge the sign quality to pick the Modulation and Coding Scheme(MCS)and Multiple Input Multiple Output (MIMO) alternatives have been considered . The most recent remote standard, LTE-Advanced, could keep up quality connections for pace up to 350-500 km/h. Yet, dissimilar to a satellite that covers a huge area, an LTE cell is generally small. Highly frequent handovers and fast variations in signal quality hence get to be extreme issues that must be tended to .

There are proposition to upgrade the handover dormancy for fast prepares. A three level system topology taking into account heterogeneous remote systems for consistent remote integration has been proposed. They additionally proposed a probabilistic quick handover technique with diminished dormancy when contrasted with ordinary IPv6 handoff yet regardless it has higher normal handoff inertness contrasted with typical LTE consistent handover and WiMAX EBB handover component. Then again, Moving Extended Cell (MEC) [7] is proposed as a solution to accommodate mobility in Radio over Fiber (RoF) systems. RoF is another standard for fast remote access at 60GHz [8]. The observable pathway prerequisite of 60GHz sign and air proliferation misfortunes confine the cell scope in these systems, which confounds the entrance at high speeds. The proposed answer is at first roused by the MEC idea, however taking into account LTE Femto-cell [9]. The proposed answer likewise lives up to expectations in the wide recurrence band of LTE systems and it consolidates hard and delicate handovers, and also known data about fast prepares to enhance the handover experience for high velocity train travelers.

3. SYSTEM OVERVIEW

The issue of consistent high-throughput remote access for High Speed Train (HST) travelers in a territory secured by LTE cells and gives a consistent handover arrangement. Each LTE cell [9] has an external span of r, and a recurrence reuse separation of D meters. In reasonable executions of LTE systems, r is commonly 250-500 m for urban cells, and 1-10 km for rustic cells. A base station is the client access purpose of a cell, alluded to as eNodeB or eNBs in short. A user, connected to an eNB by its User Equipment (UE),can move freely across the cells, and a handover takes place when a UE changes the serving base station (eNB). The strategy of a hard handover incorporates the enlistment of the client to the new cell, cancellation of its data from the past eNB, and transforming its steering way to the new eNB. A HST H is a course of M lodges. Every lodge is l meters long and can suit up to n travelers. For simplicity of piece, we expect that all HST travelers are LTE clients and are utilizing Mobile User Equipments (MUEs). The train H is moving at speed $0 \leq s \leq SMax$, where SMax is up to 500 kmph, which has yet to be accomplished in today's frameworks. The clients in a LTE cell, especially the MUEs in the HST, are moving in the multi-cell arrangement .Therefore, d_i, the separation of each MUE *i* to its currently serving eNB is changing after some time. Figure 1 demonstrates the settings and the key framework parameters for the HST remote access.

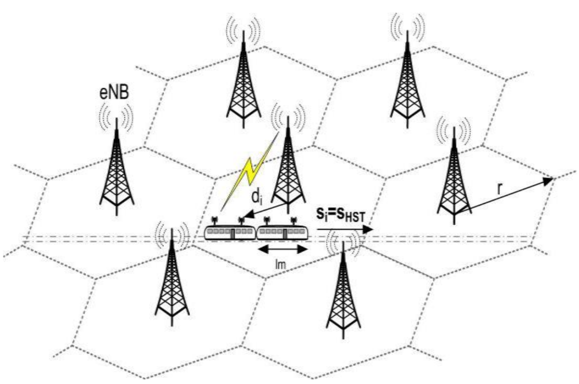

Figure 1: System settings for LTE network access for high speed trains

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4. SEAMLESS HANDOVER WITH CELL ARRAY

The proposed solution is completely based on LTE-Advanced networks to enhance the HST user connectivity and provides a novel vehicle-to-infrastructure communication solution to enhance the HST user connectivity.

4.1. Moving Femto cell
4.2. Cell array architecture
4.3. Predictive Handover Mechanisms

4.1. Moving Femto cell

A Femto cell is a little cell base station, intended for restricted scope of 10 to 40 meters. The Femto cells are customarily utilized for stretching out remote administration scope to the indoor spaces or for office or home use. The regular length l = 25m of a HST lodge its well inside of the scope range of a LTE Femto cell. Two LTE Femto cells are used to provide vehicle-to-user communication within an HST lodge as represented. A Femto cell base station is represented as Moving eNB (MNB) all through this paper. Utilizing Femto cells, the HST clients can get to LTE remote administrations through their neighborhood MNB. An LTE Femto cell uses the same frequency bands as an LTE macro cell. The number of allocated frequency subcarriers [24] can be chosen in view of the quantity of the remote clients inside of the Femto cell. In the proposed configuration, each Femto cell covers 50% of a HST lodge and up to 50 clients. A frequency band of 5MHz supports wireless access for the users in each Femto cell. To accommodate the versatility of Femto cells along the rail line, the recurrence band of the MNBs and their recurrence reuse separation D must be considered in frequency band choice. Then again, a MNB ought to likewise get the total traffic for all MUEs through the LTE air interface. Therefore, each MNB includes two interfaces that work within two different frequency groups. One for cabin-to-infrastructure correspondences, i.e. get the total download traffic from the foundation LTE organize, and send the solicitations and feedbacks .In this some piece of the communication, the MNB is an MUE for the infrastructure LTE cells. The other interface is used to speak with the MUEs inside of the cabin, where the MNB capacities as a LTE Femto cell base station.

4.2. Cell Array architecture

A Cell Array is defined as an amplified cell building design made out of three cells consecutively along the way of the high velocity train rail line. The cells are A, B, and C. Cell A is the cell that prepare is halfway or totally in at the present time. Cell B is the neighboring cell that is in front of cell A along the rail route way. Train can be part of the way in cell A and mostly in cell B in any given time. When the entire train is in cell B, cell A is no more in the amplified cell configuration. The cell cluster reconfigures when the train totally leaves cells A and enters cell B. Figure 2 demonstrates the cell exhibit reconfiguration process as the train moves along the path. When cell D joins the expanded cell, the first cell A is erased and the cells are renamed to A, B and C once more. The cell array structure is used to include the known railway way and the velocity of train in the handover mechanisms. It facilitates fast hand over and helps us minimize the measure of information to be exchanged among the eNBs if there should be an occurrence of a handover. We generally have the data of the MNBs registered in the greater part of the three cells in the cell array. Only cell A and sometimes cell B are transmitting to the MNBs. Therefore, there is no compelling reason to exchange the entire downlink information to the majority of the eNBs in the cell exhibit. Just the eNBs of the transmitting cell will get the downlink information. Inclusion of cell C in the cell array is to facilitate frequency range task for MNBs of the HST without administration corruption in a LTE cell. We call it a delicate handover. It additionally gives booking and prescient buffering chances for non continuous traffic. It is significant that the reason we augment the cell cluster in three cells along the way is to easily clear the range for vehicle to client correspondence without irritating the right now dynamic clients in the cell, and additionally to cushion non-continuous information in the event of postponed

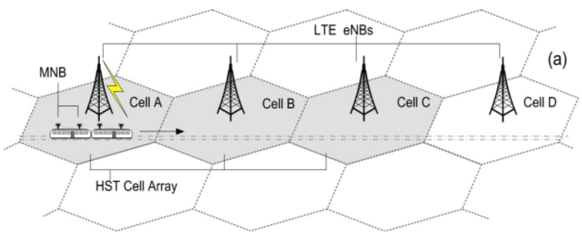

Figure 2: Cell Array reconfiguration along the railway path

4.3. Predictive Handover Mechanisms

Proposed system details two different types of predictive handovers for successfully reconfiguring the cell array as well as performing the hard handover for the MNB along the railway path. Proposed predictive handover Mechanisms benefit from the group array architecture to shorten the handover time and keep the service uninterrupted in high mobility conditions.

1. Predictive Hard Handover

2. Predictive Soft Handover

1. Predictive Hard Handover (PHHO)

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A hard handover is the procedure of registering a UE, which is the MNB of the moving Femto cell in proposed solution. Handover Mechanism is predictive because it predicts two groups ahead by adding them to the group array. Three different network elements can initiate a PHHO:

1. The MNB crossing the group boundaries
2. The front neighboring MNB
3. The current eNB (group A)

All these three elements are able to initiate a handover request so if any of them fails, others will be able to do the handover and initiate the cell array re-configuration. The first PHHO request is initiated by the MNB crossing the cell boundaries. When an MNB crosses cell A and enters cell B, it sends a handover request to the eNB of cell A. The eNB of cell A informs eNB of cell B of the handover. The second PHHO request mechanism is provided by the front neighboring MNBs. Since the speed of the train is known for each MNB, when sending a handover request for itself, an MNB can send the handover request for the MNB following it. As high speed train moves at 50-100m/s. the next MNB in the train will be reaching the handover point in fraction of a second. It will still be connected in cell A, but as soon as it can receive signal form target cell, handover is confirmed and its connection is established with cell B. Now, this MNB can request handover for its next in row MNB on the train. During the time it is registered in cell A and the handover request is initiated, new non real time download traffic to this MNB is forwarded to cell B. The third PHHO request mechanism is initiated by the eNB of cell A. In case any of the previous two handover initiation mechanisms are not started before signal degradation for the MNB, the eNB of cell A can start it. The eNB of cell A knows the next cell in the cell array, therefore it can start the handover process without negotiating with neighbors. The MNB will remain connected to cell A, but as soon as it can receive signal form cell B, the handover is confirmed and its new connection will be established. All these handover mechanisms and their associated signaling are illustrated in Figure 3. The handover responses are sent both to the current cell eNB and To the MNB itself .This is because the MNB may move during the hand over and might already have entered the new cell. As such, sending the handover response along with the random access code directly to the MNB will speed up the handover process.

When the eNB of the cell A receives the handover response, it tries to inform the eNB of the hand over response. It sets a timer and sends the handover response to the MNB. After the timer expires, the eNB deletes the information of the MNB. Therefore, during the handover the MNB is still registered in cell A. The handover response sent through the eNB A is useful for the MNB if the reception of the MNB is still better through the eNB A. Otherwise, it can receive the hand over response directly. This is possible, because other needed information are exchanged among the eNBs A and B before the hard handover, when arranging the cell array In all the three handover initiation mechanisms, both cells B and C already have the registration information of the train MNBs. Buffering of traffic to cell B starts as soon as the handover request is initiated. As soon as all the train MNBs are transferred to cell B, cell A is deleted from the cell array configuration. The next cell along the railway path will be selected to be added to the cell array. This selection will be made in the Predictive Soft Handover Mechanism (PSHO).

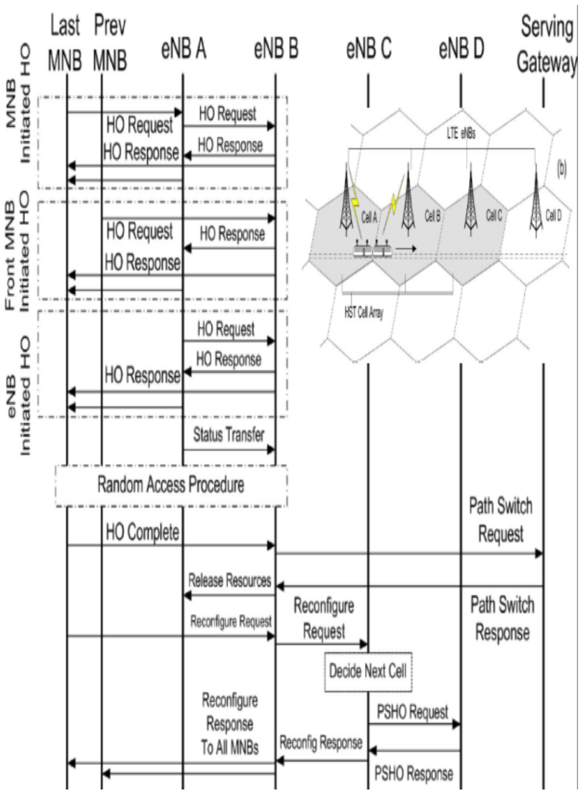

Figure 3: PHHO and PSHO handover mechanisms for high speed trains

2. Predictive Soft Handover (PSHO)

PSHO provides a predictive Mechanism to register user information in a cell array. Since the railway is on a known path, it is considered as initial frequency band selection of LTE groups so that the frequency used by HST Femto cells will not be used by the Infrastructure LTE groups. Cell C's eNB approximates the time it can still use the spectrum according to the speed of the train and diameter of its region. Cell C is registered in the cell array to announce the Femto cell frequency band. This is to prepare cell C for probable allocation of a large chunk of its frequency spectrum to MNB Femto cell traffic. Since the railway is on a known path, it could be considered in initial frequency

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band selection of LTE cells so that the frequency used by HST Femto cells will not be used by the Infrastructure LTE cells. In the rare case of sharing the same spectrum, cell C should be aware not to use that frequency spectrum in the next scheduling and RB allocation cycle and send the scheduled UEs to their next preferred band with the highest Channel Quality Index (CQI) value. The eNB for cell C will be informed by the previous cell C''s (before reconfiguration) eNB.

5. SCHEDULING

Although the moving Femto cell and the Cell array architecture along with the predictive handover Mechanisms enable fast handover for seamless wireless connectivity, HST multimedia service users need continuous high throughput connectivity for seamless multimedia services. The wireless coverage is not uniformly distributed as the signal is stronger near the eNBs and weaker as the high speed train moves towards cell edges. The scheduling algorithm [6] is proposed that uses the information of high speed trains for high throughput scheduling within a LTE infrastructure cell.

5.1 OPTIMAL SCHEDULING

The Modulation and Coding Scheme (MCS) decides the number of bits to be transmitted in each RB. Variable x_{ift} is the scheduling variable, indicating the final scheduling decision. If N be the number of users in a cell, and T be the scheduling period in which the maximum rate is targeted. A scheduling period is a duration T, where K = T × F Resource Blocks (RB) are allotted to the LTE cell users. F is the number of available frequency subcarriers. In the 3GPP LTE standard, a Resource Block (RB) is the smallest allocation unit in the LTE OFDM radio resource scheduling. Each RB can be independently modulated and assigned to a user. Each RB contains 6 or 7 symbols, with 12 adjacent sub-carriers of 15 KHz (=180 kHz) in the frequency domain. Two resource blocks from one time slots (1ms) in the time domain. The Modulation and Coding Scheme (MCS) decides the number of bits to be transmitted in each RB. The scheduling period is 10 ms in an LTE network. Variable x_{ift} is the scheduling variable, indicating the final scheduling decision. Value of the scheduling variable x_{ift} is 1 if the RB on the frequency block f, and time slot t is assigned to the user i, and 0 otherwise.
The rate maximization problem in an LTE cell, containing an HST, can be formulated as follows:

Maximize

$$\sum_{i=1}^{N}\sum_{f=1}^{F}\sum_{t=1}^{T} a_{ift} \times x_{ift}$$

Subject to

$$\sum_{i=1}^{N}\sum_{f=1}^{F}\sum_{t=1}^{T} x_{ift} \leq F \times T \quad (1)$$

$$\sum_{i=1}^{N}\sum_{f=1}^{F}\sum_{t=1}^{T} x_{ift} \geq 1, \forall i \in \{0, \dots\dots, n_m\}$$

$$x_{ift} \in \{0,1\}$$

where n_m is the number of passengers in cabin m of the HST. a_{ift} is the scheduling coefficient, which indicates the importance of each RB on time t and frequency subcarrier f to the user i. a_{ift} can be defined as:

$$a_{ift} = p_{ift} \times c_{ift} \times h_{it} \quad (2)$$

where p_{ift} is the scheduling preference coefficient. The scheduling preference coefficient indicates the user feedback element in the scheduling coefficient. Channel Quality Index (CQI), speed and direction of mobile users is used to estimate the p_{ift} during the scheduling period T. Every user *I* sends a $\overline{CQI}$ ={CQI_{ift}}F×T feedback vector containing supported CQI ∈ {0, ...,CQImax} values for F × T RBs to the eNB after receiving a scheduled RB (in LTE CQImax = 15). The CQI value is an integer that represents effective Signal to Interference and Noise Ratio (SINR) as observed by UEs (the MUEs or the MBNs for the HST). The UE can provide the CQI values for the whole frequency band or a number for each selected frequency subcarrier.

The frequency selective CQI, where the CQI values is reported for each frequency subcarrier. An eNB is capable of calculating speed and direction of the movement of a user based on its previous and current position in the cell, which is available to the eNB. A user provides its speed information during the registration to a cell. We define speed vector $\vec{S}$= {s_i}1×N. Speed values can be up to the maximum speed a cell can provide connectivity to $0 \leq s_i \leq s_{max}$. The direction vector is defined with $\vec{E}$= {e_i}1×N. $e_i \in \{-1, 0, 1\}$ shows if a user is moving toward or away from high signal area, or there is no change in its signal region.

$$e_i = \left[\frac{Avg(\overline{CQI_i}) - Avg(\overline{CQI'_i})}{avg(\overline{CQI_i})}\right] \quad (3)$$

In normal mobility patterns, the changes in the channel conditions is not fast enough to change the channel and signal quality from the last CQI report to the transmission time. Therefore, scheduling is based on the last reported CQI of the user. This CQI value which is based on the user's last received data and is quite accurate for scheduling purposes in normal mobility patterns. In fast mobility scenarios, eventhough physical layer is combats Doppler effect and provide connection, but CQI might be changed

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due to fast movement can reduce throughput. To address this problem, we try to predict the values of CQI on the transmission time:

$$\overrightarrow{CQI'_i} = (1 - |\alpha_i|) \times \overrightarrow{CQI_i} + \alpha_i \times \overrightarrow{CQI^{\wedge}2_i} / \overrightarrow{CQI'_i} \quad (4)$$

where CQI_i are old CQI_i values. $0 \le \alpha \le 1$ brings the speed and direction into account. It is computed as follows:

$$\alpha_i = 1/2 \times \frac{s_i}{s_{max}} e_i \quad (5)$$

At the fastest speed of the train, the newly received CQI values will weight for the half of the forward CQI value. We use these CQI values as well as Quality of Service (QoS) parameters of each user to calculate p_{ift} values:

$$p_{ift} = CQI_{ift} \times q_i^s \quad (6)$$

Where q_i^s is the set by the quality of service parameters . C_{ift} Shows the potential capacity of an RB if assigned to user *i*. C_{ift} is the MCS value which will be acquired based on the CQI feedback of the user. $C_{ift} \in \{0, ..., 64\}$. Finally, h_{it} provides the handover probability of the user *i* in time t. $0 \le h_{it} \le 1$ shows if user *i* is currently in the cell or performing a handover to or from the cell. If it is completely in the cell at time t, the probability should be 1 (or higher than a preset threshold). The presented scheduling formulation for high speed trains is a 0-1 integer programming problem. It can hardly be implemented in real time because scheduling decisions must be carried out in every sub frame, that is, every 10ms of LTE scheduling time. Therefore, it is necessary to further simplify the formulation model.

5.2 Real-time Scheduling

The scheduling problem is converted to a Linear Programming (LP) formulation as

Maximize

$$\sum_{i=1}^{N} \sum_{f=1}^{F} \sum_{t=1}^{T} a_{ift \times x_{ift}} \quad (7)$$

Subject to

$$\sum_{i=1}^{N} \sum_{f=1}^{F} \sum_{t=1}^{T} x_{ift} \le F \times T$$

$$\sum_{i=1}^{N} \sum_{f=1}^{F} \sum_{t=1}^{T} x_{ift} \ge 1, \forall i \in \{0, \dots\dots, n_m\}$$

$$0 \le x_{ift} \le 1$$

This formulation does not exactly specify the download RB allocated to each. Since x_{ift} can take values between 0 and 1, each block may be assigned to more than one user with fractional values. To avoid this, in algorithm, a Weighted Round Robin (WRR) is run on users to select the user to be scheduled next. The LP-based scheduling is then solved for each user W_i times and the highest values of variables found for user *i* are selected as the RBs assigned to that user. If the highest x_{ift} is on the RB already assigned, the next best values f the x_{ift} for that user is used. The decided variables are omitted from the LP and their x_{ift} values are assumed as 1. The LP is solved again for the remaining variables and the same process continues. Since the scheduling in the LTE-based systems takes place every 10ms and the subcarrier placing is 15 KHz, all LTE users in the cell may not be allocated an RB in one scheduling duration. That is why all the F × K RBs are allocated to users. To have even a better time complexity, select all W_i variables are selected for user *i* in one run of the LP. The same algorithm is used to schedule both HST passengers in the cell and the normal LTE users. The only difference is in how we compute the a_{ift} values for these two types of users. For the normal users, a_{ift} can simply be a CQI report without update with speed and direction information.

6. SIMULATION RESULTS

6.1 Handover Latency

As shown in Figure 4 the proposed solution provides significantly lower handover latency compared to the normal LTE with seamless re-entry. The parameter variations have less impact on latency value because the cell array architecture ensures the selection of the target group well ahead of the hard handover time, eliminating the need for searching the target group in the MNB, and that for negotiating the hard handover time in the eNB.

Handover latency is a summation of different delays in the process of registering to a new group:

$T_{HOLatency} = T_{HO} + \mathrm{Tre{-}entry} + \mathrm{Tre{-}establish}$ T_{HO} is the handover time which is the sum of the group search and negotiation, registration and random access times. If the handover fails, the user should go through a re-entry process. Tre−entry is the time it takes for the re-entry. Tre−establish is the time it takes to re-establish a connection if it was dropped because of a long handover latency.

These times are considerably shorter as the handover process in cell array simplifies the search for new target group. This also increases the probability of success in each step, and hence increases the possibility of proposed HST to successfully register to a group within the T_{HO} deadline. Although the handover latency is not highly variable in different speed patterns, users with higher mobility experience longer handovers. Figure 4 illustrates the handover latency changes with increasing the HST

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speed. The handover latency noticeably increases in the normal LTE and HST urban access. This is because of the need for frequency handovers and the need for the eNBs to provide random access to a large number of users entering a cell in a short period of time. In LTE and HST rural areas the handover latency is almost very low. The handover latency in proposed solution is lower and increases more smoothly as the speed increases.

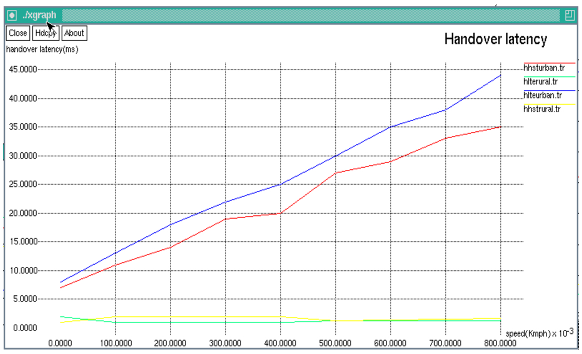

Figure 4: Handover latency

6.2 Handover Failure Rate

Figure 5 illustrates the handover failure rate at different speeds. The failure rate increases in higher speeds because a user resides for a short duration certain group area. In the normal LTE, this usually happens when a handover initiated by the eNB fails and the UE has to start a re-entry process. While a user has to search and find a new eNB during a re-entry process, it might reach the group edges already. In this case, the user may not be able to establish the connection to the found group before it enters the new group, thus breaking the connection. The predictive handover mechanism [9] in the cell array eliminates the need for the search for a new eNB when the HST is in the group. Thus, the handover latency is considerably shorter and the probability that the handover is successful in the target group increases. In LTE urban as the speed increases failure rate increases where as in LTE rural areas as the speed increases failure rate remains unchanged. In HST urban and rural areas as the speed increases the failure rate is negligible.

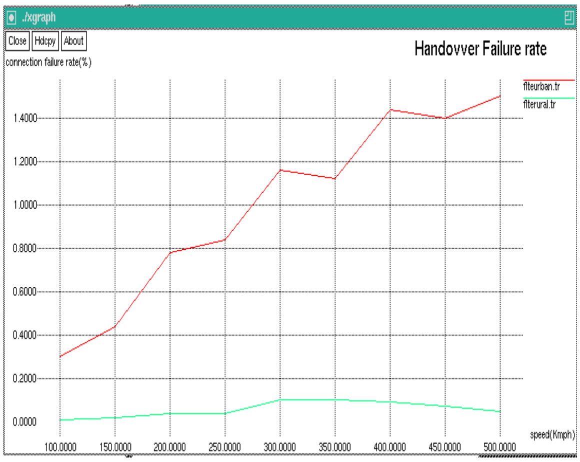

Figure 5: Handover failure rate

6.3 Throughput

With increasing the speed, the enhancement of the proposed algorithm experiences an improvement of 10% to 35% as shown in figure 6 when compared to individual HST . It is mainly because (1) the decreased latency and (2) the handover process does not take place for each user. The latter, decreases the registration overhead that affects the RB allocation for a new user in a group. For the HST in proposed algorithm, the handover only happens once for each MNB and an aggregate traffic is requested for the RB allocation. The throughput of the proposed solution experiences lower fluctuations with changing path and speed. There is an obvious drop in throughput in the normal LTE performance in the urban area compared to that of the rural groups. Proposed solution only experiences a slight drop only. This is due to the more frequent handovers while moving across smaller urban groups. This minor drop in throughput in proposed solution is largely caused by the lower SINR values in the urban areas due to higher interferences.

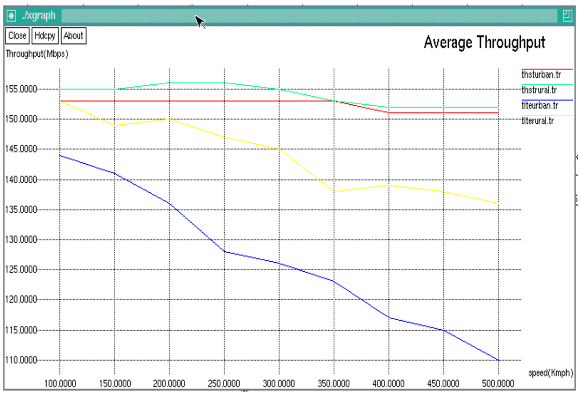

Figure 6: Average Throughput

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6.4 Delay

As shown in figure 7 5%-18% lower delay is experienced in the proposed solution mainly due to the lower handover latency for each user. Some sudden increases in delay occurs when a handover takes place. These delays are for data forwarding to the new group. Since the delay is mostly on the non-delay sensitive data, it is negligible.

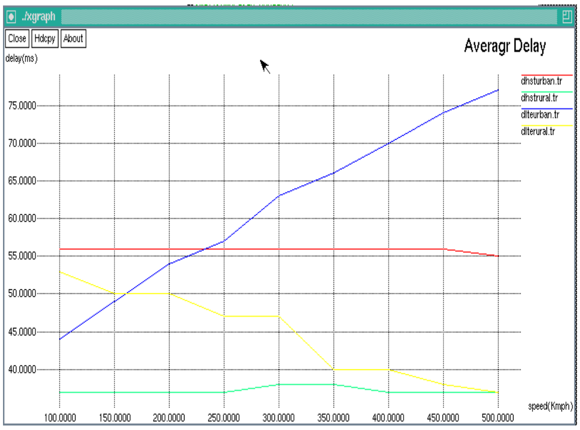

Figure 7: Average Delay

7. CONCLUSION

In this paper the cell array organization effectively utilizes the railway trajectory to predict upcoming LTE cells in service thus enables seamless handover without any interruption in multimedia streaming. Low Handover latency , low Handover failure rate, higher data Throughput ,lower Delay and uninterrupted quality multimedia services is achieved compared to the existing methods for High speed Railways. In nearby future Energy aware scheduling and predictive buffering can be implemented for irregular cells

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