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Implementation of Seamless Handover in High Speed Train Using LTE Femtocell

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ABSTRACT: In mobile communication, a handover is a process in which cellular data session is transferred from one cell site (base station) to another without disconnecting the session. Cellular services are based on mobility and handover, allowing the user to be moved from one cell site range to another or to be switched to the nearest cell site for better performance. Network mobility has a very challenging issue of long handover latency and QoS as the mobile devices moving with vehicular speed. In high speed train existing number of mobile terminal required the high quality communication and internet access services. As train speeds increases, wireless communication between mobile terminal in the train and the device mounted on the train encounters difficulties. In such case maintaining communication quality is a major challenge. The proposed system can resolve this issue by using an LTE femtocell based network mobility scheme that uses multiple egress network interface to support seamless handover for high speed train and avoid packet loss in network during handover. as well as use fuzzy logic control and AHP decision algorithm to provide better QoS to user

KEYWORDS: Handover, LTE, femtocell, QoS, BER, Delay;

I. INTRODUCTION

The rapid increase in the number of wireless access and increased capability of mobile handheld devices actively change the landscape of mobile networking. The mobile networking change from voice to data service. In communication wide band (sufficient to communication) is needed as well as the speed of network is essential for better communication, performance of network. The next generation having both of this key services. In Long Term Evolution (LTE) of 3rd generation partnership project for wireless access enhance the spectral and power efficiency and improved the peak data rate in their releases.

[2]Long Term Evolution (LTE) has been designed to support only packet-switched services. LTE aims to provide seamless Internet Protocol connectivity between user equipment (UE) and the packet data network (PDN), without any disruption to the end users' applications during mobility. It consisting Evolved Packet System (EPS). EPS uses the concept of EPS bearers to route IP traffic from a gateway in the PDN to the UE. A bearer is an IP packet flow with a defined QoS between the network conditions, system performance and user preferences for making the decision. Gateway and the UE. The EPS element as shown in fig 1. As the Core network consisting of mobility management entity (MME), Packet data Network Gateway (PDN-GW), Serving Gateway (S-GW).

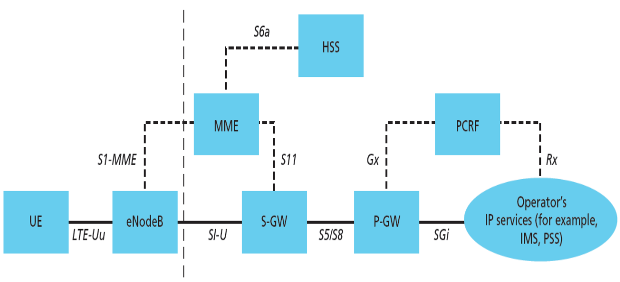

Fig 1 : LTE architecture

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(a)The MME is the main control node for the LTE SAE access network as shown in fig 1, handling a number of features, it can therefore be seen that the SAE MME provides a considerable level of overall control functionality. The protocols running between the UE and the CN are known as the Non Access Stratum (NAS) protocols.

(b) P-GW – The PDN Gateway is responsible for IP address allocation for the UE as well as QoS enforcement and flow-based charging according to rules from the Policy Charging and Rules Function (PCRF). PCRF is responsible for the filtering of downlink user IP packets into the different QoS-based bearers. It is performed based on Traffic Flow Templates (TFTs). The P-GW performs QoS enforcement for guaranteed bit rate (GBR) bearers, also serves as the mobility anchor for interworking with non-3GPP technologies such as CDMA2000 and WiMAX networks.

(c) S-GW – All user IP packets are transferred through the Serving Gateway, which serves as the local mobility anchor for the data bearers when the UE moves between eNBs. S-GW also retains the information about the bearers when the UE is in the idle state and temporarily buffers downlink data while the MME initiates paging of the UE to reestablish the bearers. In addition, the S-GW performs some administrative functions in the visited network such as collecting information for charging and lawful interception. It also serves as the mobility anchor for interworking with other 3GPP technologies such as general packet radio service (GPRS) and UMTS.

Functions related to bearer management – MME is the establishment, maintenance and release of the bearers and is handled by the session management layer in the Non access stratum protocol.

Functions related to connection management – MME the establishment of the connection as well as security between the network and UE.

[2]An E-UTRAN includes two types of base stations, named as eNBs and HeNBs. Each eNB is connected to one or more MMEs/S-GWs by S1 interface. A HeNB, as a low power access point, is typically installed by a subscriber in residence or a small office to increase the indoor coverage for voice and high speed data service. It works on the licensed spectrum and connects to the EPC over Internet via broadband backhaul. The HeNB is an attractive device for the operators to offer extended services and advantages of low costs and high quality of services. However, different from the eNB, HeNB is connected to the EPC through an insecure link and which brings new risks to the LTE network management. The E-UTRAN architecture deploy a Home eNB Gateway (HeNB GW) to allow the S1 interface between the HeNB and the EPC to support a large number of HeNBs. A HeNB may also directly connect to an EPC with S1 interface without the participation of a HeNB-GW. The UEs communicate with an eNB or a HeNB. Both of the eNBs and the HeNBs can be interconnected with the X2 interface. A HeNB with eNB is required to participate in the MME. to connect to an eNB with HeNB, where they cannot directly communicate with each other.

Handover:

Handover is process that transfer an ongoing call from one cell to another as a user move through the coverage area of a cellular network. Handover provide continues connection and good QoS. For example fig 2 shows user move from one base to other base station.

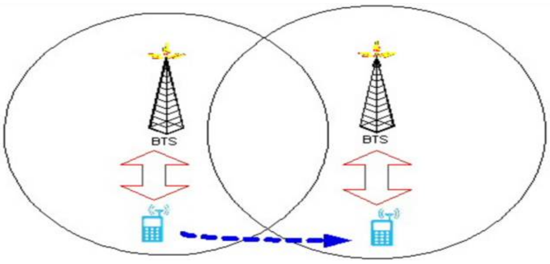

Fig 2 : Handover scenario

Type of handover :

There are basically two types of handover as:

- Horizontal-

The transformation of an ongoing session from one cell to another cell having the same access technology is called Horizontal Handover .For example if user equipment is connected with the radio ink with the GSM network the horizontal handover must be from GSM to GSM. Similarly the handovers between two UMTS network is the horizontal handover.

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- vertical handover -

The transformation of an ongoing session or call from one cell to another cell having different access technologies is called Vertical Handover. For example a mobile user is moving from GSM based network to the UMTS network, here the access technologies are changed so the handover in this case is the vertical handover.

The rest of the paper is organized as follows. Section 2 describes the related work. Section 3 consists of proposed system design and assumptions. Section 4 and 5 consists of proposed selection decision module. Section 6 consists of experimental set up and simulation result Section 7 consists of conclusion and future work.

II. Related work

Swapping of connectivity among different types of wireless technologies is called vertical handoff. It constitutes four phases: handoff initiation, network discovery, handoff decision and handoff execution. The MN acquires the neighbor networks information like: available bandwidth, monetary cost, security of the network, delay and packet loss in the network discovery phase. During the decision phase, by using the information obtained from neighbouring networks, the MN decides which network it will be connected. After that in the handoff execution stage, the MN carries out handoff to the target network.

Radio over fiber link : Author [3] propose The standard WiMAX access in high speed railway (HSR) using radio over fiber (RoF) link. the typical WiMAX-RoF optical link consisting of a head-end (HE) and several distributed remote antenna units (RAUs) separated by a span of optical singlemode fiber (SMF). The architecture of WiMAX-RoF transmission system providing high quality broadband services to the high-speed train. For the ground-to-train connection. The downlink WiMAX signal is broadcasting from each BS through the distributed RAUs by using the proposed RoF system along the railway. The downlink WiMAX signal can be received by the train access point (TAP) act as intermediate access between ground-to-train and intra-train. The TAP is considered as the gateway to the train. Finally, the Intra-train RoF network provides both external broadband internet services and internal on-demand select services to the individual passenger using wireless access to each carriage. In that for the simply increase the coverage not consider multi attribute constraints and may chance failure handover in critical situation.

Moving cell: moving cells is proposed in [4]. A Cell Array smartly organizes a number of cells along the railway. When the HST is in Cell A, the Cell A, B, and C form Cell Array. If the HST has entered Cell B completely, Cell A will be removed from Cell Array I, and Cell D is added in. Then Cell B, C, and D form Cell Array II. In the interior of the HST, there are several ‘‘moving’’ LTE femtocells which are equivalent to eNBs. The femtocell aggregates service traffic within one train carriage. Since the moving direction and speed information of the HST is generally known, the Cell Array predicts the target LTE cell to achieve seamless handovers. it also well resists to network and traffic dynamics.

Thus, it can provide uninterrupted services. We find that this Cell Array actually has only two active cells. So the 3-cell configuration is a bit redundant. However, this redundant configuration has robustness for network dynamics. But in high speed environment for the seamless handover need fast handover mechanism to uninterrupted service provide. and for the cell array need more hardware required to establish a whole network.

Train Relay station : The author [5] propose the dual link handover scheme based on two hop architecture. In TRS two antennas are installed on the train one is on front end other is on the rare end. When train is at the cell boundary, the front antenna perform handover to targeted base station (target eNB). While the rare antenna still communicating with serving eNB. Maintain the connection during entire handover mechanism. In that use of bi casting method to support the lossless handover. As shown in fig 3 bi-casting from serving gateway to serving eNB and target eNB during handover. In which some delay may occur due to same data forwarding to both station as serving and also target eNB.

In paper [8] SAW, the overall score of a candidate network is determined by the weighted sum of all the attribute values. The score of each candidate network i is obtained by adding the normalized contributions from each metric rij multiplied by the importance weight assigned wj of metric j. It is probably the best known and widely used method. The overall score of an alternative is computed as the weighted sum of all the attribute values. It is simple and easy to understand. An evaluation score is calculated for each alternative by multiplying the scaled value given to the alternative of that attribute with the weights of relative importance directly assigned by decision maker followed by

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summing of the products for all criteria.It was initially proposed for vertical handover decision in [11] and lately it has been used as a baseline for performance comparison with other vertical handover decision methods as shown in [13]. If all the parameters have the same measuring units, then SAW can compute the score directly. However, if the parameters have different measuring units (i.e., as in the case of vertical handover), then the values of the parameters require to be normalized. The SAW method , underlying additive values function and compute as alternatives score.

In [7] paper proposes a novel handover network decision mechanism with QOS provision based on analytic hierarchy process (AHP) and grey relational analysis(GRA) methods. In this achieve integrated QoS factors, weighting factors, and network priority factors to select the best network for mobile user. AHP was adopted to achieve weighting factors and GRE was utilized to prioritize the networks.

In [6] vertical handover decision processes and criteria and presented some existing Handover decision mechanism. Then proposed a solution that aims to satisfy user preferences and takes into consideration applications requirements. It uses contextual information that is collected during the information gathering step and processed to be used as the input data for the network selection stage. focus on the handover decision aspect providing flexibility and high users consideration by combined context-aware decision algorithms using Fuzzy Logic and Analytic Hierarchy Process.

III. PROPOSED LTE FEMTOCELL BASED HANDOVER IN TRAIN

For seamless handover propose network mobility protocol for high speed train. Use the LTE femtocell for seamless handover. Solve the IP routing using LTE femtocell with multiple egress network interface [1]. Also include pre handover mechanism for reduce handover latency and avoid packet loss.

In fig 3 deployed Enhance HeNB on train to serve the user equipment (UE) in train. Enhance HeNB is act as small base station as well as big UE on train.

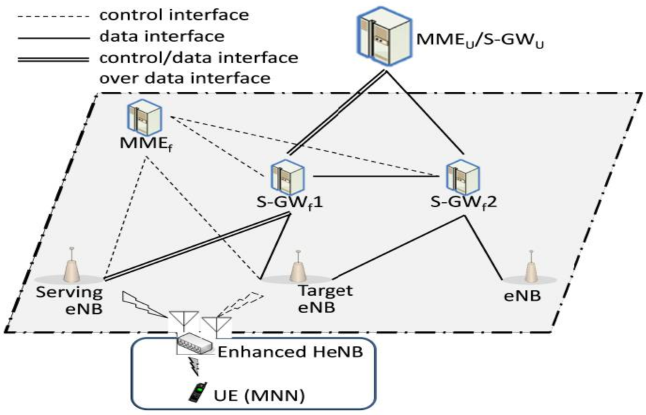

Fig 3 : Enhanced HeNB Handover system

The enhance HeNB egress interface has two antenna, one deployed on the head carriage and one deployed on trail carriage to provide seamless handover. Only one IP address allocate by egress interface. This address used by enhance HeNB to connect MME and S-GW of user. The eNB is recognize by Enhanced HeNB by eNBs IDs. The communication monitoring by head antenna for handover condition.

Proposed selection decision module

In heterogeneous environments, criteria to select the best network is one of the main challenges for seamless mobility as there is no single factor than can provide a clear idea of which to select. Some of the most important decision factors are:

- lower latency
- User satisfaction degree

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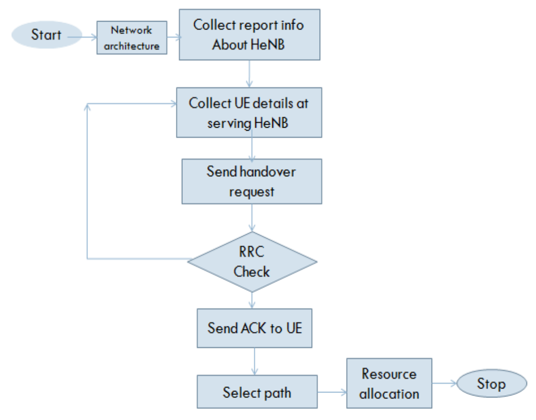
- Velocity
- Interference

Each network selection method proposed in related work has its own advantages. They are all designed to meet individual mobile user's needs in bandwidth, reliability. The proposed system to less delay, reliable network selection.

IV. PROPOSED ALGORITHM

1. The serving eNB receiving measurement report from enhanced HeNB periodically. The report contains signaling information, such as the received signal strength indication, bandwidth of the head antenna for handover decisions.
2. Information received from head antenna based on that and radio resource management serving eNB take the handover decision.(information stored in repository of serving eNB).
3. The serving eNB issues a Handover Request with the necessary information prepare for handover to the target eNB and Admission Control is used to increase the likelihood of a successful handover. The target eNB replies to the serving eNB with a Handover Request Acknowledgement message to confirm the handover.



Algorithm flow

4. Serving eNB send request message for Establish reconfiguration connection to Enhanced HeNB. The message contains the channel access parameters that can be used to attach to the target eNB.
5. Enhanced HeNB synchronizes with the target eNB and uses the head antenna to access the target cell. After the head antenna is attached to the target eNB, the enhanced HeNB forwards up-link traffic to the target eNB through the head antenna. While, the serving eNB continues sending packets to the enhanced HeNB via the tail antenna, and the SN Status Transfer is canceled.
6. The target eNB sends a Path Switch Request to the MME of femtocell (MMEf)to inform it that the enhanced HeNB has changed to a different cell.
7. The MMEf sends a Modify Bearer Request with the target eNBs ID to the S-GWf .
8. The S-GWf switches the down-link data path to the target side.
9. As a result, the downlink packets are now forwarded to the enhanced HeNB through the target eNB and the head antenna. the Modify Bearer Response, Path Switch Request Acknowledgment and UE Context Release messages are identical to the standard.
10. Finally the serving eNB releases the unused resource.

V. HANDOVER DECISION

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Vertical handover decision making used in Multiple Attribute Decision Making algorithm for handover the system work in 3 steps as Information gathering , Decision making and Execution

The above solution allows both imperative and alternative handovers. The Received Signal Strength (RSS) can trigger imperative handovers. If the home network RSS is below threshold value then directly jump to condition of handover to new network. Otherwise a Fuzzy Logic Controller (FLC), based on Fuzzification/ Defuzzification mechanisms as described in fig.4,

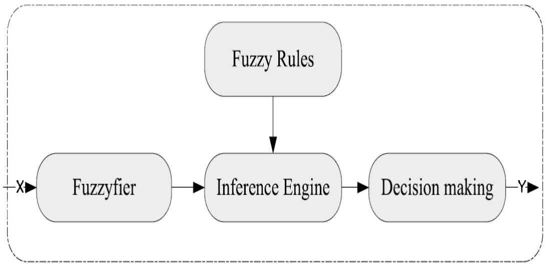

Fig.4: fuzzy interface system

checks whether the current network is still able to provide the required QoS. Given the running application class of service, it uses QoS information namely, bandwidth, load, delay, jitter and BER, as input parameters**.** If the current network is no longer able to offer an acceptable QoS to the running application, the FLC initiates an alternative handover. For instance, the input parameters depending on their availability and on the requirements of the running application are fed into a fuzzifier where they are transformed into fuzzy sets. A fuzzy set may have different membership degrees that are obtained by mapping the real values of a given variable into a membership function. For example the membership function of the bandwidth input parameter has three fuzzy sets which are low, medium and high as shown in table 1 . The fuzzy sets are then fed into an inference engine, where a set of fuzzy IF-THEN rules are applied to indicate whether a handover is required. (e.g. if we consider a steaming application: IF Bandwidth = high AND Jitter = low AND Ber = High AND Delay = medium THEN Handover= NO) as shown in fallowing table 2 . Finally, the overall obtained fuzzy sets are defuzzified to make a final precise decision (VHO is required or not). If a handover is required the network selection process is activated.

Network Selection: Network selection is an important process before the handover execution. It is very complex as it should consider multiple factors based on the parameters defined in section III-A and reflecting services requirements, networks availability and users preferences. During the selection phase the network that satisfies the most the users preferences and offers acceptable QoS to the running application will be selected. We propose to perform network selection in three steps, namely, network quality scoring, network cost scoring and final decision making.

Bandwidth	BER	Jilter	Delay	
80 mbps	50	40	60	High
10 mbps	30	15	40	Medium
512 kbps,1mbps	10	5	10	Low

Table 1 : fuzzy set

Bandwidth	BER	Jilter	Delay	Condition (handover)
High	low	low	low	True
medium	low	low	low	True
medium	low	high	high	False
high	medium	low	low	True
high	high	low	medium	False
high	high	high	high	false

Table 2 : fuzzy logic rule

Network quality scoring

Let N be the set of available networks.

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N = N1,N2,N3, ...,Nj,
Let S be the set of services that may be provided.
S = s1, s2, s3, s4 A Network Quality Scoring Function QNj (sk) is defined to estimate the quality of service that will be offered by network Nj considering the running applications class of service sk. QNj (sk) is based on QoS parameters, namely BER (ber), delay (d), jitter (J) and bandwidth (Bwd). The importance of these parameters depends on the running application. It is expressed through weights which are calculated using the Analytic Hierarchy Process as explained in the following. The first step in AHP is to decide of the relative preference of the QoS parameters (Objectives) considering the different class of services. The importance of the objectives is expressed through priority scores between 1 and 9 as explained in the following. Let aij denote the relative importance of Objectivei (Oi) in comparison with Objectivej (Oj).

Class of service	Bandwidth	BER	Jilter	Delay
Bandwidth	1	a_{12}	a_{13}	a_{14}
BER	$1/a_{12}$	1	a_{23}	a_{24}
Jilter	$1/a_{13}$	$1/a_{23}$	1	a_{34}
Delay	$1/a_{14}$	$1/a_{24}$	$1/a_{34}$	1

Table 3 AHP Matrix

The AHP matrix as matrix table 3 above of each considered class of service is calculated as follows. The AHP matrix of each class of service is then normalized and values bij for each row are obtained. The required QoS parameters weights are finally given by equation
(bi1+bi2+bi3+bi4) /4
A Network Quality Scoring Function is given by: $QNj\ (sk) = W_{ber(sk)}.ber_{Nj} + W_{J(sk)}.J_{Nj} + W_{d(sk)}.d_{Nj} + W_{Bwd(sk)}.Bwd_{Nj}$

Handover Execution:
This last stage of the handover process includes network association, resource allocation and routing. It also relies on higher level layers like Mobile IP.

VI. Simulation Results

We run our experiments in omnet++ simulator version 4.4 that has shown to produce realistic results. omnet++ simulator runs deployable C++ or python code, but here use C++ code. In our simulations, we use heterogeneous environment for communication. For seamless handover in heterogeneous environment use network mobility (NEMO) protocol handover use vertical handover decision algorithm for that use the fuzzy logic control and AHP algorithm. This algorithm help to choose best network in wireless network and also help to get best QoS to user equipment. Handover done simulate in omnet++.NED file show the simulation of all over architecture which proposed. We have considered there topologies of nodes as shown in Figure 5, 6,7respectively. The placement of node are random in wireless network, as heterogeneous network consisting of GSM, 3G, and LTE that are connected with core network also having 2 antenna and user equipment that deployed on one train . Limit the train speed and show its movement in simulation environment. The network design of proposed work is shown in Figure 5.and it defines the high speed train having two head and tail antenna which access the in the heterogeneous wireless network environment and one user equipment (RED). The Figure 6 defines that how the tail antenna provide connection to UE and head antenna take access from new base station. The Figure 7 define the network design which to handover into new network without interruption using the head antenna. In that design provide seamless handover to user equipment in high speed train.

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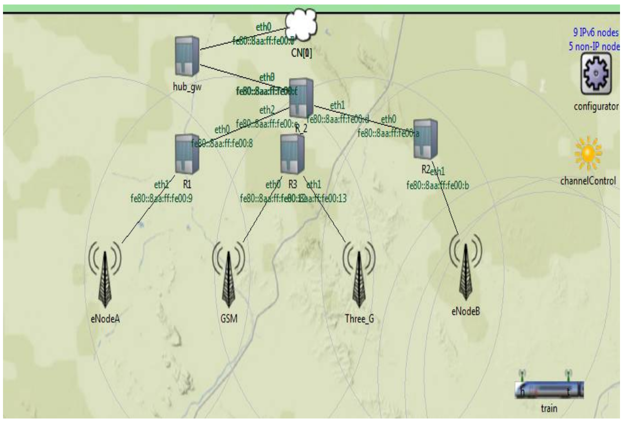

Fig 5 Network design for Heterogeneous wireless environment

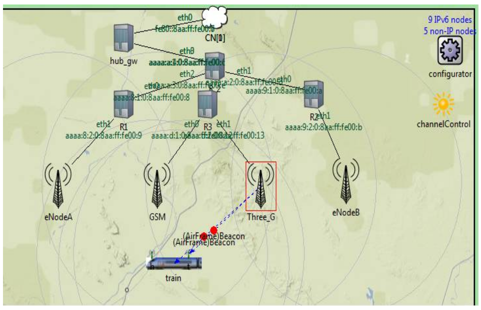

Fig.6. Network design give seamless handover

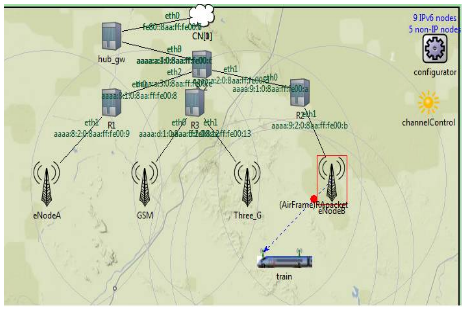

Fig. 7 Network design while Connection handle by tail antenna

Handover Latency :

The Latency is main parameter which will affect on quality of service of network. The disruption time is computed from the time when the train begins the handover procedure from its serving eNB to the target eNB.TRe-entry is the time that the UE require for the re-entry, and TRe-connect is the time taken to re-establish an UEs connection if the call was dropped because of a long handover latency. Both the TRS scheme and the MEN-NEMO scheme use multiple antennas scheme to improve the handover procedure Therefore, the average handover latency of the TRS and that of the MEN-NEMO scheme and HLProposed are formulated as follows:.

HLProposed = Ps(THOs)+(1-Ps) (TReentry + TReconnect)

where Ps denotes the probability of successful handover under the TRS, the MENNEMO , And proposed work schemes. THOs is the handover time under both schemes. It includes the time required for link switches and auto-configuration of the IP address.The handover delays of the entire schemes are low because the UE/enhanced HeNB does not need to change its IP address Figure 8 shows the handover latency of three schemes in Scenario. And fig 9 shows handover latency with respect to train speed.

The vertical MEN-NEMO uses not only The MEN-NEMO but also choose better QoS using Analytic hierarchical process. And The MEN-NEMO scheme outperforms the LTE-individual and the TRS methods because its handover decision policy reduces the number of unnecessary handover operations. The handover latency of the LTE-individual method increases because the UE only uses single antenna to perform the handover procedure, which includes changing to a new IP address and results in a longer handover delay.

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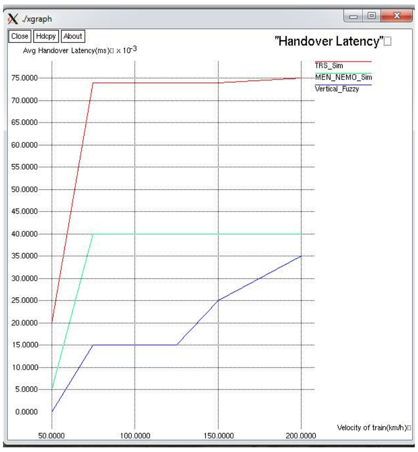

Fig 8: Handover Latency

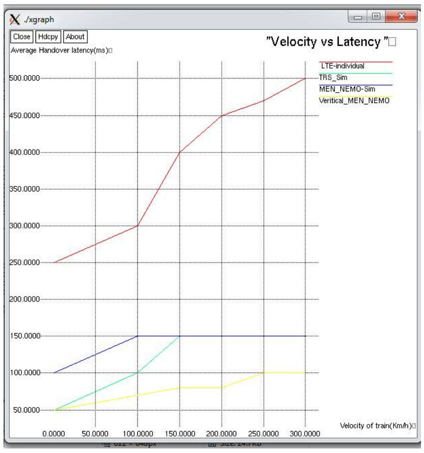

Fig 9: Handover Latency Vs Velocity of train

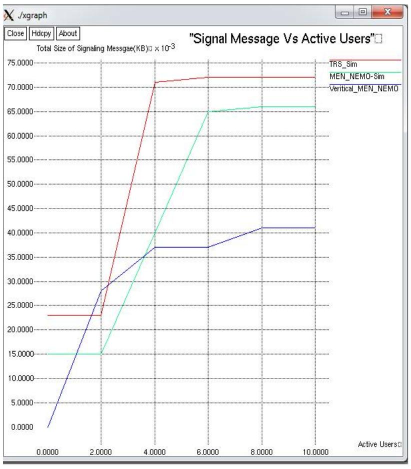

Fig 10 : Signal message vs active user

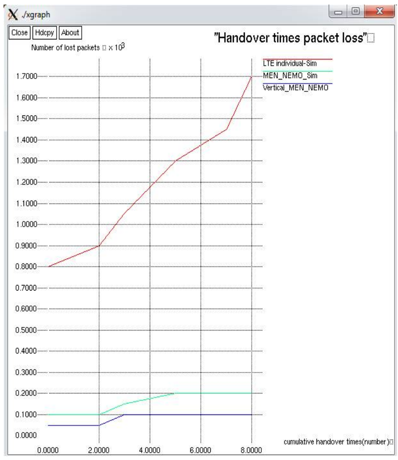

Fig 11: handover times Packet loss

The Size of Handover Signaling Messages :

Figures 10 illustrate, respectively, the advantages of using the femtocell-based configuration and the MR. The signaling overhead incurred by changing the IP address. Note that the LTE-individual scheme exchanges a large number of signaling messages to configure the new IP address in Scenario . In the Vertical MEN-NEMO scheme, the enhanced HeNB uses the MR function to reduce the signaling overhead. Therefore, the total message size remains low when the number of active users increases.

Packet Loss :

The another Quality of Service(QoS) parameter is packet loss ratio. This QoS parameter calculated based on number of packets sent and received. Vertical MEN-NEMO scheme outperforms the other schemes in terms of packet losses. The LTE-individual scheme loses lots of packets because 1) the UE only uses one interface to perform the handover procedure resulting in higher handover failure probability and 2) the higher handover latency causes more lost packets. In Scenario fig 11, the lost packets of the LTE-individual scheme increases obviously since the train may change its IP address and increase handover latency. However, Vertical MEN-NEMO, TRS and MENNEMO still have few lost packets. But proposed work (i.e Vertical MEN-NEMo) choose network with better quality of service (QoS). This results show the advantage of multiple antennas scheme on the train.

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VII. CONCLUSION

Improvements in high train speeds are bumping up against similarly impressive achievements in smart mobile device technology. Customers are increasingly desiring and expecting uninterrupted mobile Internet access, even on long train rides. Providing wireless communication to high-speed trains relies on the precision of BS planning, which requires high monetary and manpower costs. The Enhanced HeNB scheme effectively alleviates the problem of improper BS-planning, and is easy to deploy. By considering the protocols and capacities in both the train (local) network and the wide-area wireless access technology, and estimating the future train infrastructure wireless link quality, the QoS provisioning of admitted sessions is ensured. addition, by deploying two Antenna under E HeNB, and designing new messages and functionality in the IPv6-based infrastructure, the handover latency as well as packet loss is reduced while adding negligible extra data transmission delay. And also use of fuzzy logic control and AHP algorithm provide QoS to user equipment in train.

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