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Strategy of Handover in Mobile Relay Group in LTE-Networks

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Abstract — The small cell technology is giving rise to a new field known as mobile cell, which is expected to dominate the networks of the future. Mobile relay is an important component of mobile cells because it enables mobile user equipment (UE) to keep their network connectivity with a high quality of experience to the microcell base station even while they are moving at high speeds in their vehicles. The use of group handover is a great option for managing the large number of handovers that are caused by transferring user equipment (UEs) within the mobile cell. In this research, we present a group handover technique that is both effective and efficient for mobile cells operating in LTE-Advanced systems. Using the group handover approach that has been proposed, a mobile relay node (MRN) that is attached to a high-speed train will transfer all of the communication that is relevant to UEs from the source donor eNB (DeNB) to the target DeNB. moreover, in contrast to the majority of previous works, which make use of a fixed relay design, this work makes use of a mobile relay architecture. The proposed group handover approach was implemented on the mobile cell, which resulted in a significant reduction in numbers of handovers and the probability of calls getting dropped throughout the system.

Keyword: Handover, High-speed railway, LTE, DeNB, MRN, Relay node.

1- Introduction

Long Term Evolution Advanced, or LTE-A for short, is a standard that is currently under development and has the potential to fulfill the IMT-Advanced specifications for mobile networks of the fourth generation (4G). In a network that uses LTE-A, There are a great number of Evolved NodeBs that are connected to each other (eNBs), They come together to provide the universal terrestrial radio access that has evolved network (E-UTRAN). The eNBs are linked to the mobility infrastructure. management entity (MME), serving gateway (S-GW), and management entity (MME) In an advanced packet core, a packet data network gateway, or P-GW, is used. (EPC) network that provides many different types of services, such as signalling, handover, security procedures, and the like[1] , Each user equipment (UE) in the network establishes a connection with a serving eNB to obtain user and control plane services. A UE's data speeds for uplink and downlink can reach 500 Mbps and 1 Gbps, respectively. To serve passengers travel large distances, high speed wagon networks have been developed or are currently being built in numerous nations. Given that passengers may spend a lot of time in trains and vehicles, offering data services to them will be appealing. The fact that every UE in a train and car must do handover often and at the same times makes it a difficult job. As a result of this occurrence, network performance suffers. The LTE-A standard working group is currently[2],Some mobile relays, according to[2],may be placed inside of a in wagon, and each one has the following capabilities, 1) For UEs, it works as an eNB. 2) The uplink data packets from UEs are redirected to the eNB (DeNB) placed along the wagon lines. 3) It distributes the network's downlink data packets to UEs. 4) It acts as a proxy for those UEs (that connect to it) to carry out handover operations.

The relays connect the small cells to the eNBs via wireless backhaul. An intelligent and wireless relay node (RN) can enable communication between a mobile user equipment (UE) and an eNB. Similar to the communication between eNBs and UEs, that which occurs between eNBs and RNs makes use of point-to-point (PMP) interconnection. In other sayings, similar to how a femtocell uses an IP backhaul connection to the core network, the RNs and the eNB continue to communicate with one another wirelessly[3]. After that, the RN will set up a PMP link with the UEs in order to provide them with uplink and downlink. We call the connections between the eNB and the RN and the RS and the eNB access links, and the connections between the RS and the UE are called relay links. The essential duty of a relay node in a cellular network is

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to increase capacity through the reuse of frequencies. If multiple UEs can communicate with both the eNB and the RN over the same frequency, capacity can be increased[4],in [5] Due to their inexpensive implementation costs and wireless backhaul connection to the network, they also offer better coverage and throughput increase , [6] This facilitates the ad hoc activation of RN in regions where the eNB cannot offer enough coverage (i.e. cell edges and shadow areas). Additionally, when there is a backhaul connection between the eNB and the RNs as opposed to a direct link between the eNB and the UEs, superior propagations, including less shadowing and route loss as well as good Line-of-Sight (LOS), are encountered. The influence of LOS, path loss, and vehicle penetrating loss at various frequencies have been calculated in [7], Furthermore, RN may well be shared by several operators to lower the cost of network construction [8]. Fixed relays and mobile relays are the two primary types of relays. Fixed relays are supported in a wide variety of use scenarios and have been specified in the 3GP LTE version 10 specifications[9]. On the other side, mobile relay nodes (MRN) are able to handle a greater variety of use cases. Fixed relay nodes (FRNs) are typically installed by controllers in a more specified way, — for example through coverage holes. Mobile relay nodes (MRNs), on the other hand, can be equipped in a flexible manner, especially in situations in which FRNs are either unavailable or not economically justifiable[10]. MRN satisfies important needs for networks, such as having low latency, reducing the amount of time that handovers disrupt service, and having great bandwidth efficiency. When mounted on top of a moving vehicle (like the train or metro utilized in this research) [11], MRN is able to construct its own cell within the vehicle and provide efficient service to vehicular users and equipment (UE). In [12] MRN is able to concurrently handle several service connections to the DeNBs that are positioned all along metro and railway lines, which results in an increase in signal strength to the UE as well as a decrease in the amount of signaling overhead. By strategically positioning antennas in mobile relays, it is possible to cut down on the vehicular penetration loss that so frequently manifests itself in vehicle communications. In furthermore, cos of their lower size and power requirements,[11] MRNs are able to improve their communication capabilities by employing advanced antenna designs and signal processing methods. MRNs, on the other hand, are confronted with a variety of obstacles, such as the necessity of developing an effective interference management technique and an appropriate handover scheme for collective handover.

Previous research in [13] has demonstrated that the deployment of cooperative and coordinated relays on top of trains may considerably improve the quality of service (QoS) of UEs [14] within a train. Current alternatives to the dedicated MRN were given and contrasted in [11], including layer 1 repeaters, WiFi access points, and dedicated macro eNBs that service the vehicular UEs. The dedicated MRN installations significantly improve the vehicle user experience when compared to alternative approaches, as demonstrated by[9],[15]. The difficulties with MRN implementation were also emphasized by the authors. To minimize interference and handover-related issues, they include the necessity of effective interference and mobility management schemes. For the purpose of reducing the quantity of signaling messages maintained by the network nodes, the authors in [9]modified fixed relay design for the mobile relay and proposed the global tunnel idea. In order to decrease changeover failure, a CoMP-based handover was proposed in[16]. It would allow trains to receive numerous signals from nearby base stations as they pass through overlapping zones. [17]made a suggestion for group handover management for moving cells based on LTE-A. In this paper, a moving cell design for a future network was suggested, and the control and user plane protocol stacks for managing group handover were also presented. Although the architecture for enabling mobile relay was provided in [3], the mobile relay lacked a group handover management method. It was apparent that in the majority of relevant research, fixed relay architecture was taken into account for group handover in mobile relay. On the basis of this, we describe a group handover approach for an LTE-A network mobile relay node. The MRN architecture mentioned in [3]will serve as the foundation for the proposed group handover. The primary goal of the suggested group handover strategy is to minimize the number of handovers connected to MRNs while preserving the radio linkages between the UE and MRN during the changeover process. As shown in Fig. 1, the MRN switches its point of attachment from the source DeNB (S-DeNB) to the target DeNB (T-DeNB). For the sake of clarity, we have taken into account the deployment of MRN on public trains, although the suggested work may be applied to any high-speed vehicle system.

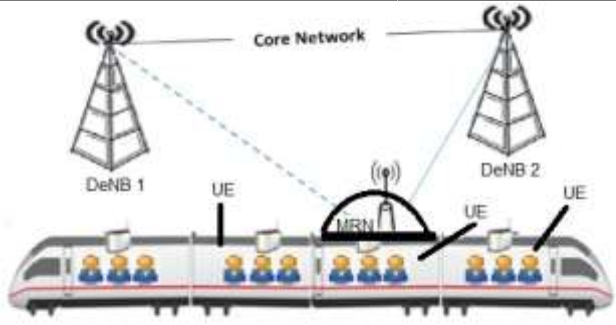

Fig.1. scenario Of Group handover in train.

In some situations the train will departing far from that DeNB, there is a possibility of an improper handover occurring. this status happens if there are any traverse (like hills , mountains and tunnels) between the train and signal source , figure (2).

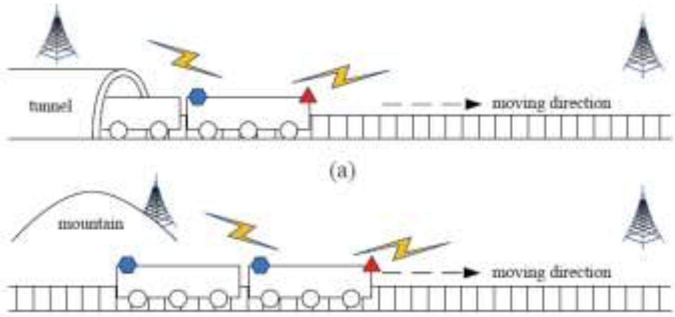

Fig. 2. Examples of inappropriate handovers

The following is the structure that this paper has adopted,In Section II, In Section III, the suggested group handover approach has been examined in order to handle the process of handover between MRN and eNBs with increased QoS for moving big UEs in the vehicle. In Section IV, an analysis of the suggested group handover approach with MRN has been conducted. In Section V, the suggested work has been compared to fixed relay node (FRN) and direct UE to DeNBs methods in terms of call dropping probability and number of handovers. The work is concluded and future approaches are suggested in Section VI.

2- Mobile Relay Architecture.

Studying femtocells, relays, and mobility cells in future networks as well as the necessity for effective handover monitoring for moving cells in an LTE-A network was the motivation for this research. Due to changes in the DeNB servicing the MRN brought on by mobility, two topologies for mobile relay are feasible. As seen in Fig. (3), these architectures are referred to as original GW and relocating GW architectures. For the purpose of ensuring that mobile relay functions normally, the MRN PGW/SGW is permanently located just at S-DeNB (initial DeNB) in the design shown in Figure 2(a). The S-DeNB is responsible for the function of storing the MRN and the content of the UE, in addition to the role of forwarding data packets between the S-DeNB and the T-DeNB. During MRN mobility, additional network signaling is not needed for the handovers between nodes in the network,The relocation of the SGW/PGW and the Relay GW to the T-DeNB can be seen in the Fig (3) which depicts the architecture of the GW relocation.

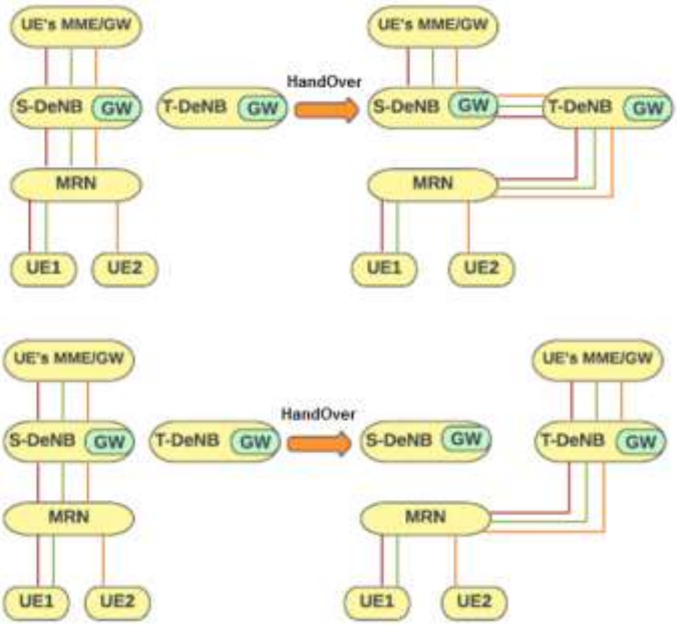

Fig. 3. The MRN HO technique, with a GW relocation.

The MRN's SGW/PGW and Relay GW are moved to the T-DeNB in the event of a transfer from the S-DeNB to the T-DeNB. With in initial GW architecture, there is an extremely long routing path if the MRN goes far from the S-DeNB [3]. Additionally, an additional signaling overhead is guaranteed if the GW relocation takes place each time the MRN performs a handover, as is the case with the GW relocation design. In [3],a combine solution is presented.

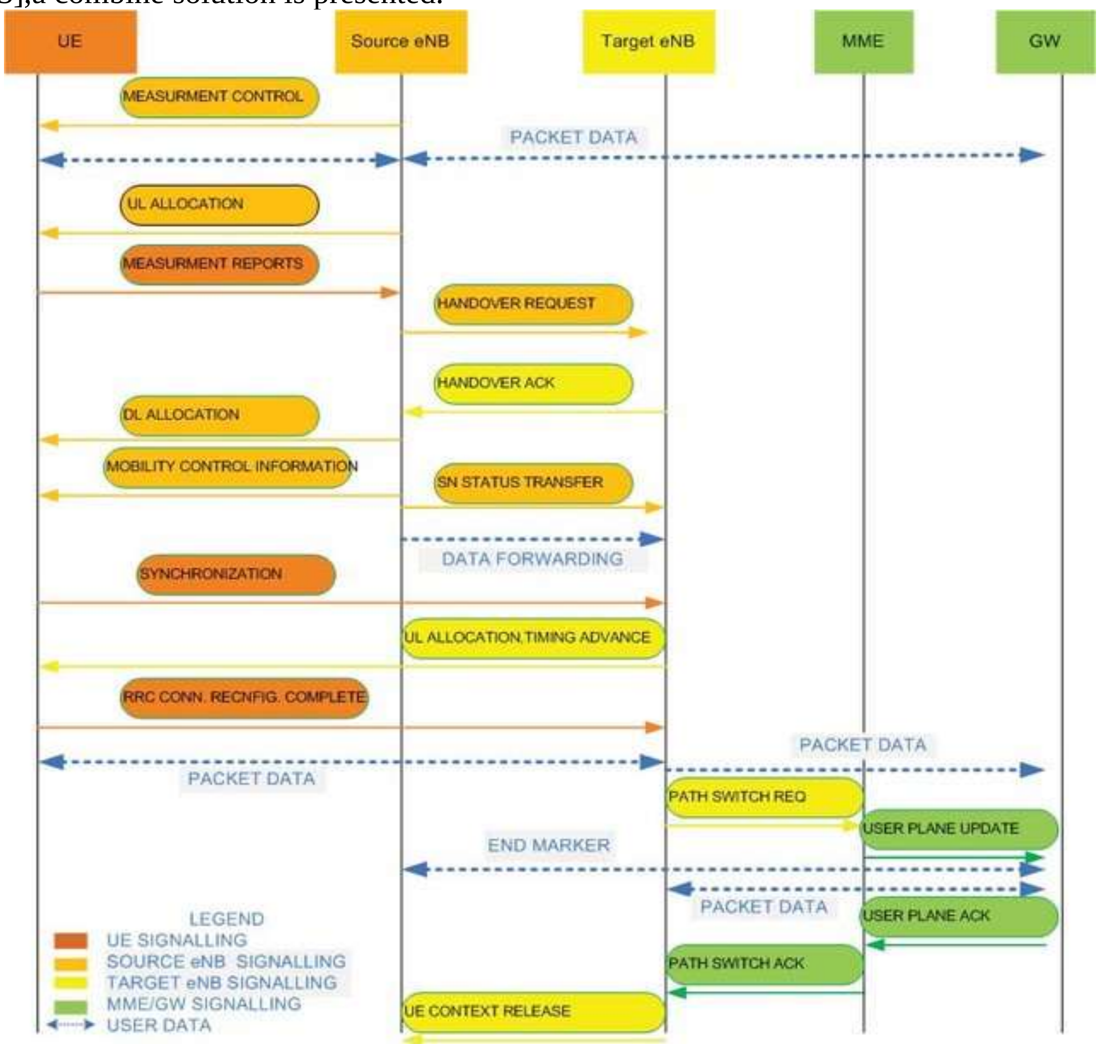

Figure 4. MRN handover procedure

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3- Proposed Group Handover Strategy.

The suggested group handover for such MRN may be graphically displayed by flowchart in Fig. 3, which can be found in this section. As can be seen in Figure 1, a relay node that is installed on a high-speed railway and equipped with wirelessly backhauls can provide group handovers of passengers who are using the railway's services. An single group handover approach, such as the one shown in Figure 4, would guarantee the smooth transfer of customers that are being serviced by MRN between two DeNBs in this fashion. In addition to minimizing the amount of handovers and call drops, group handover may significantly reduce both radio interface overheads as well as the overheads on the network, which ultimately results in decreased latency for all users.

We have chosen to assume that the deployed MRN is equipped with a tiny device that we will refer to as (mdev). The purpose of this device is to not only determine the position and direction of DeNBs but also prepared the MRN for prompt handover to the DeNBs.

MRNs are able to handle numerous radio access technologies since they function as conventional eNBs, which gives them this capability [11] . The following are the necessary stages for carrying out the recommended strategy:

1- MRN takes a reading of the signal strength being sent to the S-DeNB and evaluates it in relation to a threshold signal.
2- If the signal measured in (a) above is lower than expected, the MRN takes a measurement of its signal level to a T-DeNB and compares it to the threshold signal.
3- Resources at the T-DeNB were determined based on the fact that the signal in point (b) above is bigger than the threshold.
4- When the resources are available, then the MRN hand over the UEs' group communication info to a TDeNB. If they are not, however, the MRN stays with the SDeNB and continues to repeat the steps until a new TDeNB is located.

4- Results And Performance Analysis

The proposed group handover strategy's performance on UE communication may be validated against two scenarios:

- the first in which the UEs connect and handover to a T-DeNB direct (eg no group handover).
- the second in which FRN nodes (including group handover) are applied instead of MRN nodes (with group handover).
- A event-based simulation we created in C# may be used to evaluate metrics such as number of handovers and call dropping likelihood. We considered that perhaps the train travels in a straight track, with DeNBs stationed along the railway track. FRN and MRN are deployed independently over the train's top to depict distinct scenarios.

In another situation, the UEs were forced to speak with the DeNBs directly. mdev within MRN monitors and identifies signals from DeNBs in a few seconds for our approach. If the suggested strategy's condition is met, the mdev embedded with in MRN initiates the group quantity and prepares the MRN to appropriate handover.

The threshold and other parameters were set using the [18], the default parameters values as that show in table 1.

Parameter	Default Values
Bandwidth	10 MHz
Frequency	2.6 GHz
Train speed	Up to 300 km/h
Transmit power (eNB/DeNB)	46 dBm
Transmit power (Relay)	10 dBm
Path Loss Model	32.4 + 20 log (f) + 20 log (d) dB

Table 1 : default values and parameters used in MAGNETIC PROPERTIES.

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The formerly described two DeNBs, S-DeNB and T-DeNB, can be denoted as Bs and Bt,respectively. D refers for the distance between Bs and Bt, and V for the train's speed. Where d be the length between mdev in MRN and DeNB, and v ε (Bs and Bt). We can provide signal strength between mdev to DeNB as:

$$R(v.d) = K - 10y\log(d) + \overline{\omega} \qquad (1)$$

with K refers for a constant and v's current transmit power. $\overline{\omega}$ is a zero-mean Gaussian-random variable, and the deviation σ refers for shadowing fading.

We had considered that DeNBs can send messages about signal strength to a MRN via the mdev and vice versa. Moreover, if the mdev determines that the signal quality in T-DeNB is larger than a threshold U in dB, a measuring report could be automatically triggers in the MRN. These 2 relays techniques of signal forward are discussed at[19]. Just after measuring report is initiated, mdev wait for Bs to respond with the radio resource connection (RRC) reconfigure from Base Station (BS). these activation happen in time Td,

Last but not least, the mdev receives the RRC configuration; otherwise, the radio link fails. In the event that the message is not successfully delivered, the Bs will resend it within the predetermined period of time Tr. At long last, the mdev gets the RRC configuration; if it does not, the radio link will fail to work effectively.

If the measure report is generated at a position X of the mdev (or MRN), and Bs transmits an RRC connection reconfigure, a mdev with MRN might have relocated with railway to location X1 through that point.

$$Where\ X_1 - X = V \times T_d \qquad (2)$$

Whenever the mdev is at position X2, the Bs could resend the signal if the RRC connection reconfiguration is just not successfully received by mdev.

$$Where\ X_2 - X_1 = V \times T_r \qquad (3)$$

Due to the fact that the handover can be initiated between Bs and Bt, the possibility of a successfully handover conducted by mdev during the handover procedure can be described as:

$$P = \frac{1}{D}\int_0^D P\{R(B_t, X_t) + R \supseteq U\} \times \left(1 - \sum_{X\epsilon\{x_1, x_2, \dots\}} P\{R(B_s, X_s) \subset S\}\, d(X)\right) \qquad (4)$$

According to Equation. (4), if the signal quality detected plus R is equal or greater to U, the handover operation will be initiated when mdev is at Bs. With R is a reward parameter that used mdev to move closer to a near DeNB and trigger a measurement report more quickly. Additionally, the handover is considered to have been successful if the signal quality in Bs is higher than S at any point in set Xs.

5- Proposed Group Handover Strategy Performance Evaluation

In this part we talk about two important points, the first one is the Call Dropping Probability (CDP), initially there is no strategy to begin preparing each UE for handover beforehand and to ascertain the resource availability at the T-DeNB, the majority of the UEs' calls are dropped when they attempt to conduct handover to a T-DeNB independently in the DIRECT-HO, where users communicate directly with the DeNBs. This is also observed in FRN GRP-HO. As the train moved a certain distance when the UEs were connected to a S-DeNB, there were small call drops, as illustrated in Fig. 5 Nevertheless, when the train continued to travel forward approximately 1500m, we observed that call drops increased from this point onward and throughout the remainder of the turnover to the T-DeNB on time, and there was no procedure in place to plan the handover in advance. Because UEs were unable to handover to a T-DeNB in time and there was no mechanism in place to prepare handover in earlier time, we observed the highest call drops from this point onward during the entire train trip in DIRECT-HO. Due to the group handover scheme but lack of a plan to help the group become ready to handover to the T-DeNB on time, the call drop rate in the FRN GRP-HO is lower than in DIRECT-HO. However , which assesses how close the MRN to the T-DeNB and prepares the MRN ready for a prompt handover to the T-DeNB, causes the MRN GRP-HO to have the lowest reduction in call drop activity.

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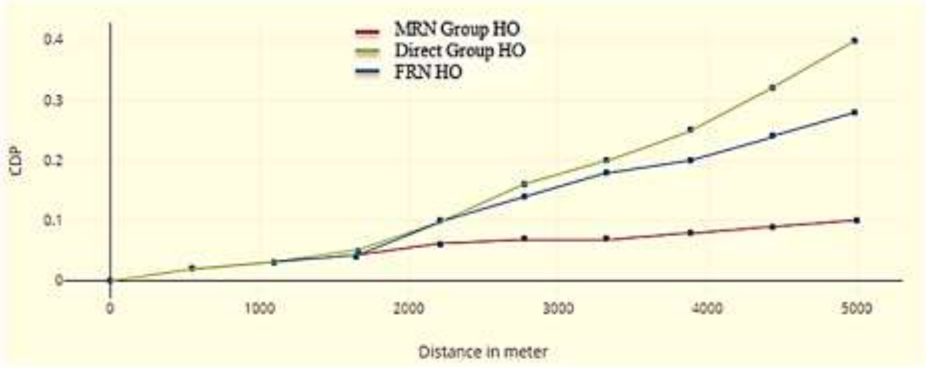

Fig. 5. Call dropping probability.

The second point is the Handover Number (HON), the Fig. 6 shows the total number of handovers that were observed in the three scenarios. UEs could not longer retain connection with the S-DeNB because to signal loss, and the MRN is unable to recognize the T-DeNB to communicate with, therefore the frequency of handovers in prior work, such as Direct-HO and FRN GRP-HO, rises as the train goes farther. Due to the UEs' continued connection to the MRN throughout the journey, the number of handovers is the same and significantly lower in MRN GRP-HO. As a result, utilizing MRN GRP-HO results in much lower control signaling overhead when compared to Direct-HO and FRN GRP-HO. However, the number of handovers in FRN GRP-HO is lower than that of Direct-HO because FRN offers a superior connection, especially at the cell's borders, in comparison to direct UE connection to the DeNB.

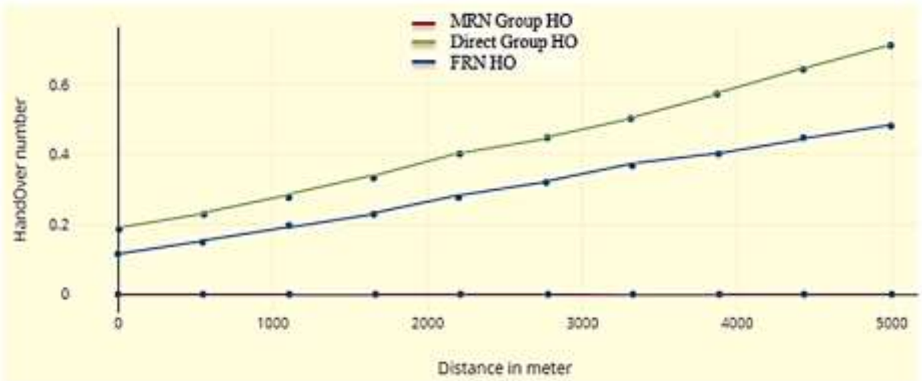

Fig. 6. The handover number

6- Conclusions.

An effective group handover technique for user equipment (UEs) in LTE-A high-speed train systems has been suggested as part of this research body. It has been discovered that the handover frequency is extremely high while using the traditional handover approach, which involves the UEs communicating directly with the DeNBs. As well, the more recent LTE-A fixed relay node and mobile relay node answers, which brought about group handover management, though decrease the frequency of handover as well as the possibility of call drops to some extent, it is not effective without the need for an additional strategy or mechanism to prepare the group information for timely handover as a result of speed of the train. Because of this, the technique for managing a handover of the group has been improved using our strategy in order to make it much more robust. As a direct result of this, the amount of handovers that occurred in the system, as well as the probability of calls being dropped, decreased. Within future, we want to investigate on how additional calls can be allowed into the T- eNB via dynamic borrows technique to accept additional real-time calls while preserving the ongoing non-real calls. This will allow us to maintain the ongoing non-real calls.

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