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Optimizing handover performance in LTE

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ABSTRACT: In telecommunications, 4G (LTE) is the fourth generation of cell phone mobile communications standards. It is a successor of the third generation (3G) standards. A 4G system provides mobile ultra-broadband Internet access, for example to laptops with USB wireless modems, to smart phones, and to other mobile devices. Conceivable applications include amended mobile web access, IP telephony, gaming services, high-definition mobile TV, video conferencing and 3D television. To achieve all the required customer satisfaction, End user should get smooth services in both Voice and Data platforms. For this there has to be regular monitoring of Performance KPI's of LTE network. There are mainly 4 types of KPI's which are to be monitored for maintaining LTE network, these are Accessibility, Retain ability, Mobility, Integrity. This Paper aims to strategize optimization across network segment (RAN, Backhaul, and EPC) to maintain and improve Mobility KPI (Handover Success Rate). Four types of Sample are selected by, segregated in terms Population and Usage pattern – (1) Densely Populated-highly urbanized / High Usage, (2) Sub Urban – Moderately Populated / Moderate Usage, (3) Highway / Transit Traffic and (4) Remote / Sparsely Populated area / Low Usage, as a final outcome of this thesis, there will be optimal recommendation on maintaining/increasing Mobility KPI HOSR in sample markets across all the network segments.

Keywords: LTE network, wireless modems, Voice and Data platforms, Mobility, RAN, Mobility KPI.

I. INTRODUCTION

Wireless technologies undoubtedly can be considered as one of the fastest ever growing technologies. This growth is indicated by the enthusiasm of consumers towards using wireless technologies. The developments in wireless communications not only have brought many business opportunities, but also have increased the quality of life for typical end-users. On the other hand, network providers as well as operators have been fully involved in improving the available systems to satisfy the eagerness of customers by providing new services and enhancing the quality of them. To provide acceptable services that can be used everywhere, there is a need for a unity between different providers and operators. This cooperation is needed in order to make different systems compatible with each other. Therefore standardization associations have been established for adopting unique pathways. So far many players have been actively contributing to standardizing the schemes and procedures for new technologies in

addition to adopting better ideas for performance enhancement of current systems. Performance Improvement can be achieved by optimization or by building a new environment that again can be considered as an optimization of the current ecosystem.

To cater this large no. of users Mobility plays very important and critical role in maintaining best user experience. In this thesis we will get to know

1. What Handover is
2. Types of Handover
3. Handover events
4. Counters and Timers which will be optimized to achieve best possible results

II. OBJECTIVE

a) Optimization of system architecture for packet-switched services, as in LTE there was no support for circuit-switched services.
b) Support for higher throughput comparing to former technologies due to the end-user higher bit rate demands.
c) Support for improvement in response time for activation and bearer set-up.
d) Packet delivery delay reduction.
e) Support for simplification of the whole system.
f) Interworking with other 3GPP access networks and other 3GPP technologies.

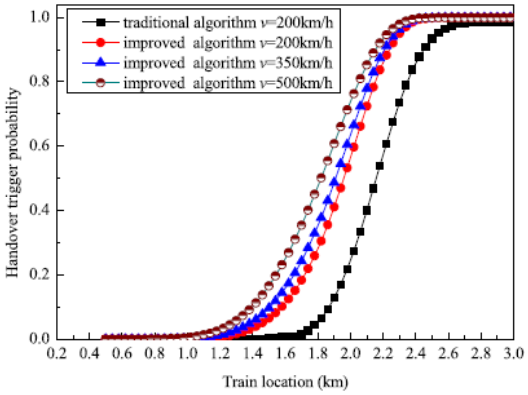
LTE aims to provide a seamless IP connectivity between the user and the Packet Data Network (PDN) in a network that only supports packet switched services. The mobility is fully supported by LTE and UEs should not be facing any disruption in getting services while they move. To make this happen, first an evolution in radio access and then in the core network to comply with radio access changes occurred. The evolved radio access network part is called LTE while the evolved core network part is called EPC. Besides EPC, other aspects also changed and System Architecture Evolution (SAE) was defined. EPC is a part of SAE. LTE together with SAE is known as EPS. The concept of bearers is used for routing data from a gateway in PDN to the UE. A bearer is defined as an IP packet ow with a defined quality of service which establishes between EPC and the UE.

LITERATURE SURVEY

1. **YONG CHEN, KAIYU NIU, ZHEN WANG – "Adaptive Handover Algorithm for LTE-R System in High-Speed Railway Scenario", in April 19, 2021.** With the rapid development of high-speed railway, the LTE-R communication system has more requirements for the handover success rate. An adaptive handover algorithm based on random suppression in high-speed railway scenario is proposed. The algorithm establishes an elliptic function relationship between the hysteresis threshold and the train speed, so that the hysteresis threshold can be adjusted adaptively with the train speed, which lessens the challenge of high-speed train forward handover.

2. **Hendrawan, AyuRosyida Zain, Sri Lestari Harja – "Performance Evaluation of A2-A4-RSRQ and A3-RSRP Handover Algorithms in LTE Network" in December 2019 -** In this study, the performance of the A2-A4-RSRQand A3-RSRP algorithms was evaluated through simulation and measurement. For a variety of scenarios from the simulation, the best handover parameter values are obtained which give the best system performance. The results of the simulation also provide values that are not much different from the measurement results especially for

RSRP-based algorithms. Therefore, a simulation is then performed to find the HO parameter values which give the best performance for the scenario where each EU has a random speed in the range of 20 to120 KmPh. It has been shown that, for the A3-RSRPalgorithm a combination of TTT value of 480 ms and Hysteresis of 12 dB gives the best HO performance, while for the RSRQ algorithm the combination of Neighbor Cell Offset of10 dB and Serving Cell Threshold of 30 dBm gives the best HO performance.



FUNDAMENTALS/METHODOLOGY OF HOSR (MOBILITY KPI)

Handover Success Rate is the KPI which needs to be monitored for maintaining Mobility in LTE Network. It is calculated on the basis of below 4 components –

1. Intra-eNodeB handover: LTE-LTE handover between channels/cells hosted by the same eNodeB is handled by the eNodeB.
2. Inter-eNodeB handover (X2 handover): If the eNodeBs are neighbors and are associated with the same MME then neighboring eNodeBs can handle the handover natively using the X2 interface,
3. Inter-eNodeB handover (S1 handover): Where an X2 connection does not exist between to two eNodeBs, or the eNodeBs are associated with different MMEs, then an S1-based handover is required. S1 handovers are treated them same as X2 handovers.
4. LTE-3G (Inter-RAT) handover The UE initiates an inter-RAT handover when the LTE coverage is no longer satisfactory due to either lack of equipment or congestion.

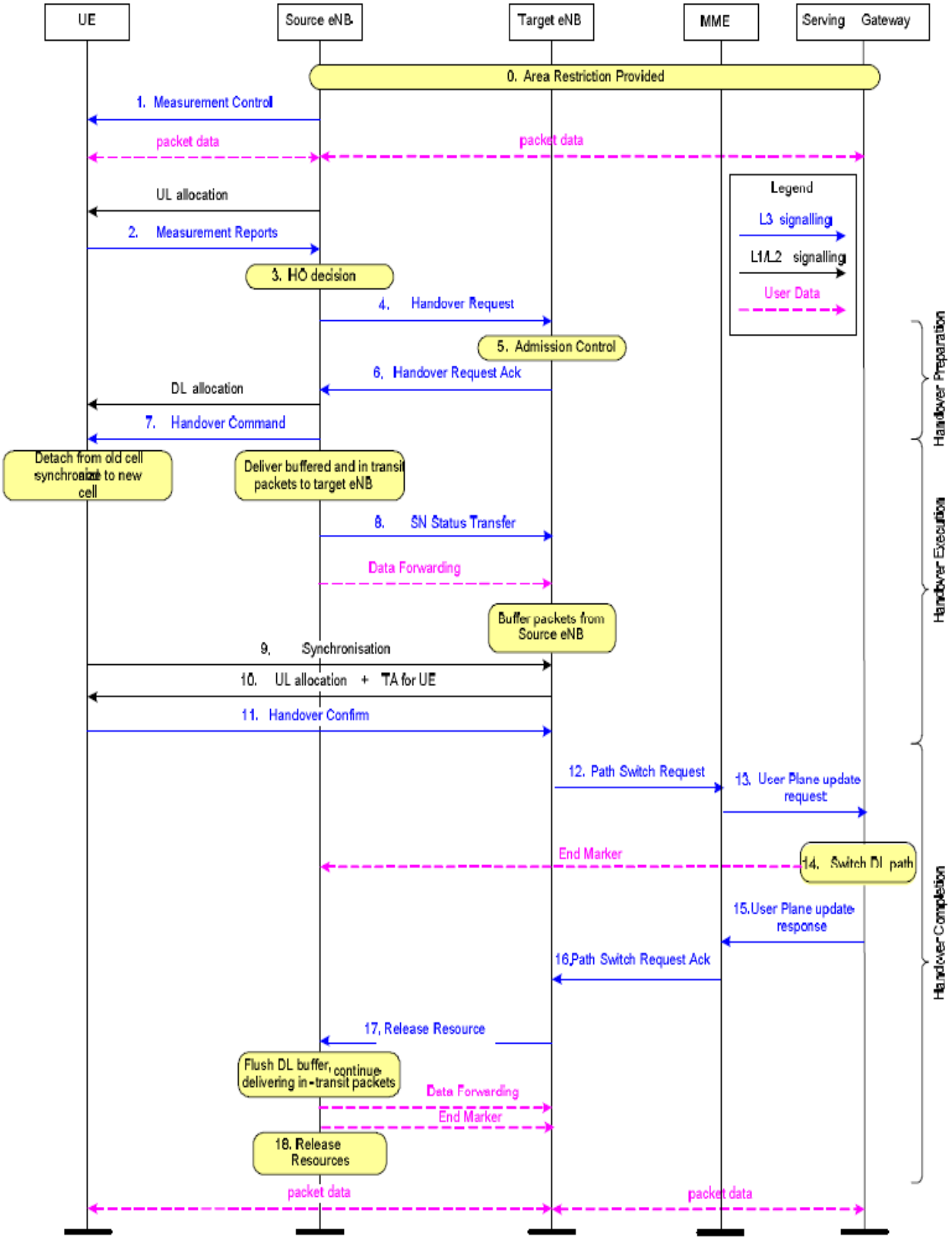
III. Steps of Handover

Mobility can be divided into two groups while performing KPI Optimization

- **Handover preparation**
  Handover preparation is the phase in which the target cell assigns the necessary radio resources for taking over the connection and sending back a handover command message containing the new radio parameters to the source cell
- **Handover execution**
  The handover execution phase starts when the previously received handover command message is sent to the UE and successfully finished after the UE has arrived at the target cell request on an unlocked cell which requires the cell to be taken down temporarily.

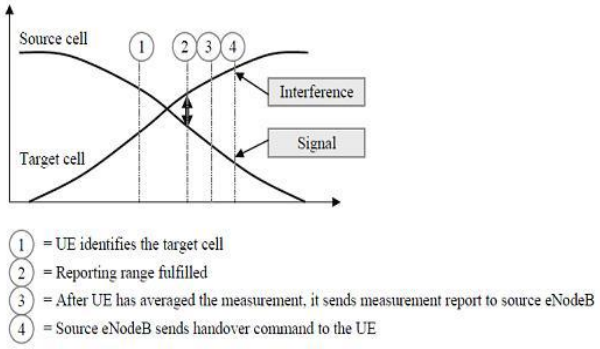
Handover procedure

1. Based on the area restriction information, the source eNB configures the UE measurement procedure.
2. MEASUREMENT REPORT is sent by the UE after it is triggered based on some rules.
3. The decision for handover is taken by the source eNB based on MEASUREMENTREPORT and RRM information.
4. HANDOVER REQUEST message is sent to the target eNB by the source eNB containing all the necessary information to prepare the HO at the target side.


UE
Source eNB
Target eNB
MME
Serving Gateway
0. Area Restriction Provided
1. Measurement Control
packet data
packet data
UL allocation
2. Measurement Reports
3. HO decision
4. Handover Request
5. Admission Control
6. Handover Request Ack
DL allocation
7. Handover Command
Detach from old cell synchronize to new cell
Deliver buffered and in transit packets to target eNB
8. SN Status Transfer
Data Forwarding
Buffer packets from Source eNB
9. Synchronisation
10. UL allocation + TA for UE
11. Handover Confirm
12. Path Switch Request
13. User Plane update request
End Marker
14. Switch DL path
15.User Plane update response
16.Path Switch Request Ack
17. Release Resource
Flush DL buffer, continue delivering in-transit packets
Data Forwarding
End Marker
18. Release Resources
packet data
packet data
Legend
L3 signalling
L1/L2 signalling
User Data
Handover Preparation
Handover Execution
Handover Completion

HANDOVER ZONE ANALYSIS

When the UE drives around the corner in an urban area there might be a high probability that the signal level from the source cell degrades fast while the signal level from the target cell improves slowly. In this case, for maintaining the service, a fast handover is inevitable. The UE should receive the handover command before the signal from the source eNB degrades too much. Therefore minimizing the network delay in response to the measurement report done by the UE is crucially necessary for providing a reliable handover. In Figure all necessary timings for handover are shown.



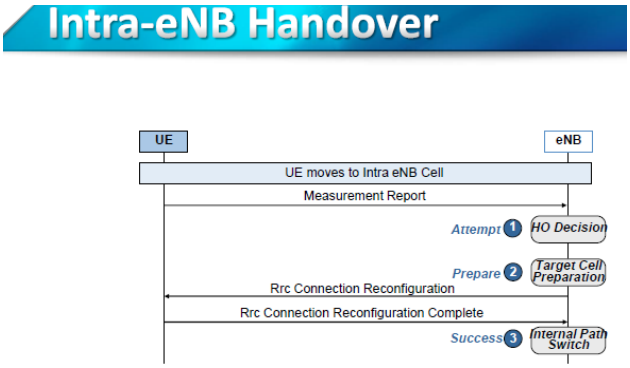
Data forwarding is one of the steps in the handover procedure that can be configured in a network to ensure a lossless handover. If data forwarding is configured, during handover, the source eNB forwards all the downlink PDCP SDUS, which have not been acknowledged by the UE to the target eNB. Before the path switch, some new packets may also arrive in the old S1 path that should also be forwarded to the target eNB. The target eNB will then start transmitting these packets to the UE without waiting to receive all the packets. The forwarding is done at the PDCP level. At the RLC level, all the remaining downlink RLC PDUs will be discarded without being forwarded to the target eNB. The handover in LTE is initiated by the network and assisted by the UE. For the handover, RSRP and RSRQ measurements are made in the UE and they are sent to the eNB regularly. In the following the main criteria for designing handovers are discussed.

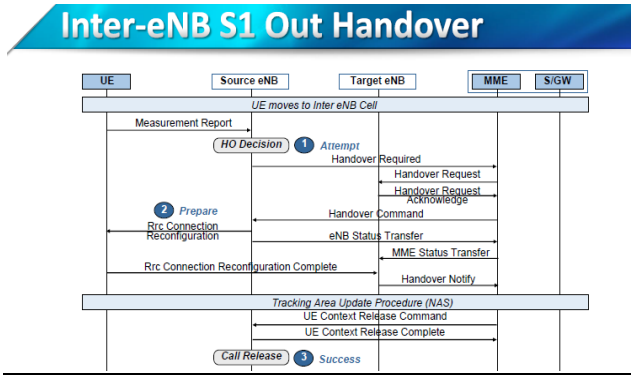
- **Minimizing the number of handover failures:** Minimizing the number of handover failures is necessary for avoiding call termination during handover time and letting the UE be connected and continue conversation or down/upload data during and after handover.
- **Minimizing the number of unnecessary handovers:** handovers is to guarantee the communication quality and to avoid suffering from the large number of the handovers that increases the signalling load in the network. Minimizing the number of handovers also avoids increasing the risk of call drops related to interruption in handover.
- **Minimizing handover delay:** Due to the fact that handover in LTE is a hard handover and interruption might be noticed by the user; a fast handover is needed not to let the user experience service degradation or interruption.
- **Maximizing the amount of time that the UE is connected to the best cell:** Handover is performed to have the UE connected to the best cell. Achieving this goal will be easier if the handover is designed in a way that prolongs the amount of time that the UE is connected to the best cell.
- **Minimizing the impact of handover on system and service performance**: Minimizing the impact of handover on system and service performance can be obtained by optimizing the handover procedure. Some of the goals mentioned above are in contradiction to each other. For example, maximizing the amount of time that the UE is connected to the best cell increases the number of handovers. Therefore making a trade of between these goals to approach the required ultimate goal will be necessary.

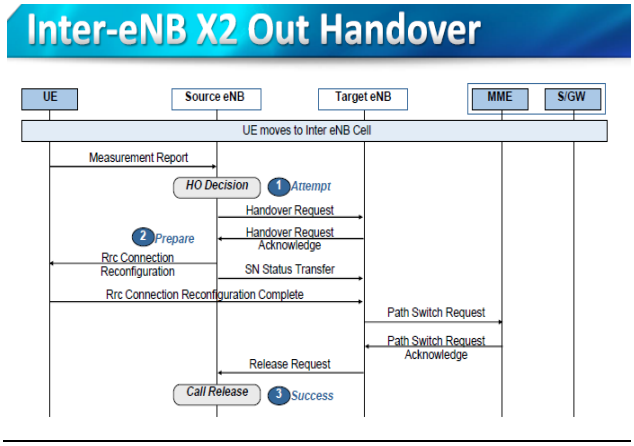
- **Handover initiation threshold level:** If handover initiation threshold level decreases, the handover will be triggered faster and if it increases the probability of having late handover will increase.

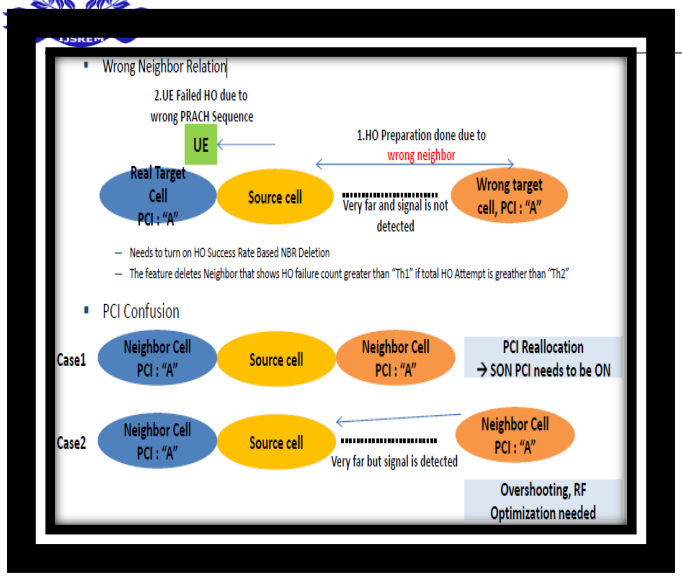
IV. Problem Finding (Inter and Intra Handovers)

Computational complexity and Handover delay are two important factors to be optimized. Limited availability of line of sight (LOS) signals is one of the core reasons for call drop during handover in urban areas. Handover initiation in LTE is either based on RSRP or RSRQ, while the UE is measuring RSRP of the neighboring cell which is considered to be a candidate. If the RSRP of one of these candidates becomes better (larger) than in the serving cell, then the handover will be triggered. If handover decision cannot be obtained using RSRP, RSRQ will be used instead.









EVENT_B1

– IRAT neighbour becomes better than threshold

EVENT_B2

– Serving becomes worse than threshold1 and IRAT neighbour becomes better than threshold2

0 **PERIODICAL**
Periodical reporting.

1 **EVENT_A1**
Serving cell becomes better than absolute threshold.

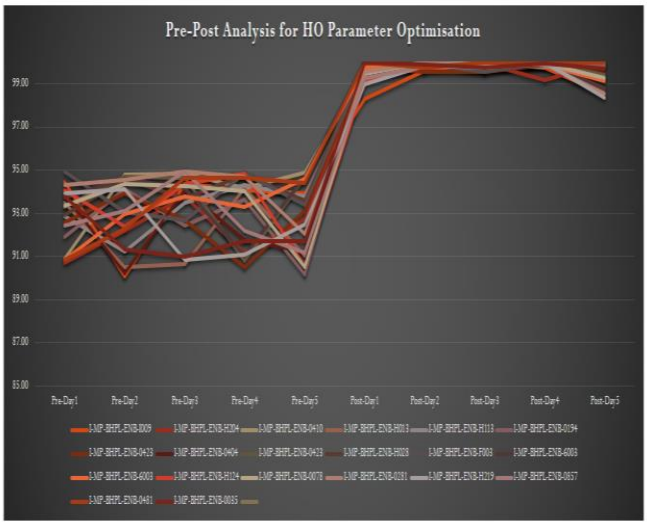
2 **EVENT_A2**
Serving cell becomes worse than absolute threshold.

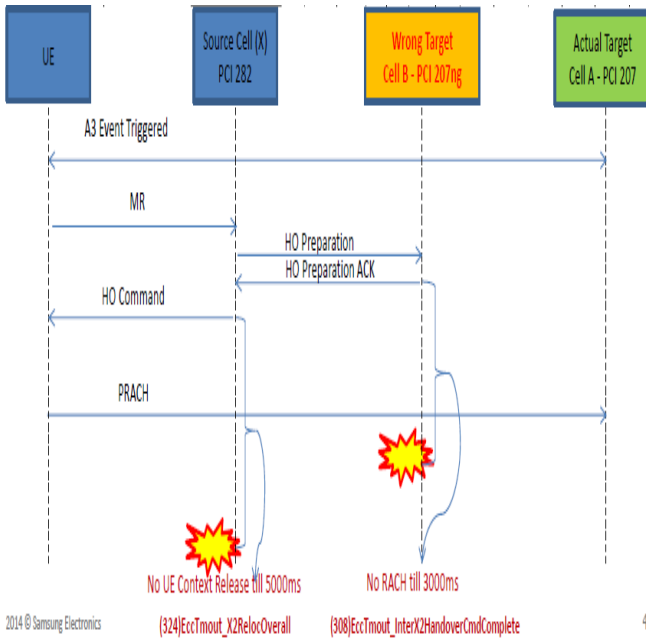
3 **EVENT_A3**
Neighbor cell becomes amount of offset better than serving.

4 **EVENT_A4**
Neighbor cell becomes better than absolute threshold.

5 **EVENT_A5**
Serving cell becomes worse than absolute threshold1 AND Neighbor cell becomes better than another absolute threshold2.

Parameter Optimisation Pre-Post KPI





CONCLUSION

- For a perfect LTE Network Mobility (HOSR) should be >=98%
- Handover Event parameters, Trigger Thresholds should be properly optimised
- There should be No PCI collision/confusion in neighbour cells.
- No Ping Pong Handover should happen.

After Clearing above 4 issues, improvement observed in HOSR.

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