Multisystem Inter-Cluster Cell Reselection Failure Analysis for Terrestrial Trunked Radio (TETRA) Network

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Abstract: **The concept of seamless communication using a single technology is one of the key motivations behind the TETRA standard. By moving towards a single technology, government is capable to procure a single nationwide communication infrastructure, substituting the proprietary existing system. Bidding for such a system on nationwide scale would drive value for money. Terminal interoperability with any network would ensure strong competition, driving up functionality and lowering costs to end-users. This paper focuses on the cell reselection failure analysis based on measurement of RF data due to implementation of multisystem inter-cluster system to meet the needs of mission critical end-user organisation for increasing their operational capabilities and effectiveness. Methodologies used in this research are collection and analysis of RF measurement data using ARTEMIS tools. Another tool being used is ATDI which is to present the coverage prediction. Based on the analysis result, execution of the cell-re-clustering has successfully implemented and the post processing result has been validated to prove the effectiveness of the activity. The outcome of this study can be used to provide a better design concept on handover or cell reselection in multisystem inter-cluster of TETRA network thus reduce the drop call problem and improves the network key performance indicator.**

Keyword list – **Multisystem Network, Inter-Cluster Cell, Cell Reselection, Handover, Call Failure**

I. INTRODUCTION

Communication network is a comprehensive solution that is customised to address unique user requirements to enhance operational efficiency and effectiveness. It enables timely and decisive actions by integrating communications, information, resources and assets into one unified system. This unified system provides seamless connectivity, communication and sharing of information, making it ideal for mission critical environments with desired Service Level Assurance (SLA). The existing mission critical voice and data network are proprietary giving rise to complex and costly interoperability solutions. Multi-mode devices will allow public safety users to communicate anywhere, coordinated response and the integrated command connects multiple agencies, serving public safety, public service and public works, for a shared, real-time operational picture and effective event coordination.

In order to converge the demand for more efficient and flexible communication services which are requires to communicate everywhere at any time regardless of lack of network coverage, network resources and any type of network failure and always needs fast and secure communication, TETRA is the efficient trunked radio system to accomplish this need. This network offers consistent voice quality, even greater call privacy, very fast call setup and fully end to end encryption. Likened with the planning of public commercial mobile communication radio network, the planning and optimization in TETRA network has its particular characteristic. It covers terminal's receiving level value, base stations carrier's utilization, frequency reuse rate, frequency interference ratio (C/I), the successful access rate, bit error rate, service level and etc [2]. Resources are dynamically prioritized for the most critical responders and real-time, shared situational awareness empowers a coordinated response across multiple agencies.

Along with the development progress of telecommunication sector, some system will be enhanced by swapping it with the latest technology or the network need to be expanded with other type of system or manufacture. It will require revision in the existing configuration to enable the integration of multiple systems as well as the inter-cluster as shown in Figure 1. The initial design is based on the key philosophy which require full redundancy configuration that is represented in overlap geographical distribution to ensure TETRA coverage service availability is 99.99% in operation. Taking into account the mixture configuration, there are areas that might be affected with the changes although it should not have happened because all the standard parameter is set as per recommended. Coverage prediction simulation shows no changes on the transmit signal distribution between single vendor and multi vendors equipment cluster as shown in Figure 2.

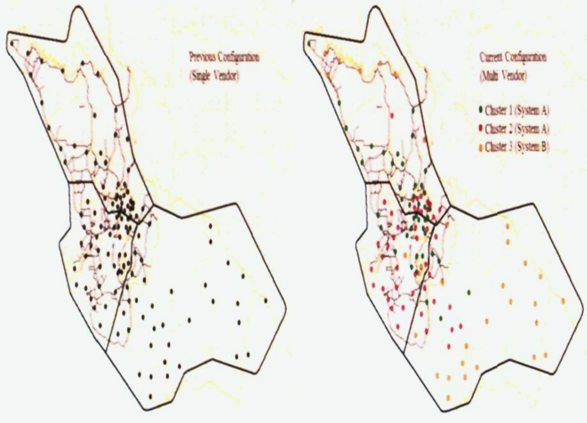

Figure 1 : TETRA Sites Distribution

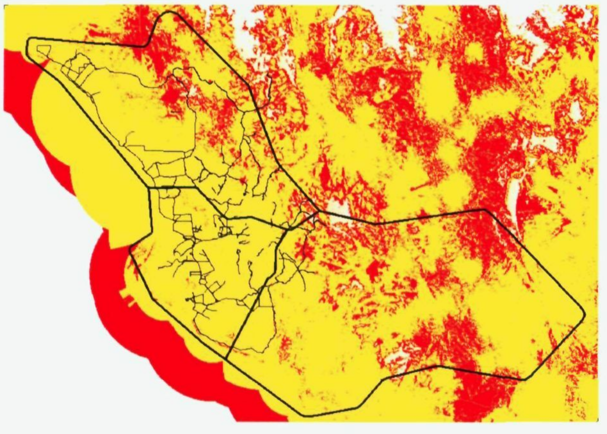

Figure 2 : TETRA Coverage Prediction

The network coverage health checks are assessed to measure the RF performance. The audits are done with the method of overlaying the transparencies plots between recent drive test result and coverage prediction plots. The results finding are certain areas facing quality degradation of key performance indicator for the handover, or in TETRA is named as cell reselection. The process of cell reselection is totally different in compare to commercial 2G or 3G GSM-UMTS Networks. Drop call data and cell reselection failure is increased in the multisystem inter-cluster border and at the cell edge especially in rural and sub urban area. Review of the RF coverage planning is needed to optimize the network quality in order to provide better service availability and cost saving to the users.

The objectives of this research are to measure the RF signal strength at identified area of multisystem inter-cluster cell edge and border and analyse the cell reselection failure from drive test result and simulate coverage prediction of re-cluster arrangement of the selected cell. Then the re-clustering configuration will be execute and take another measurement to verify the revised configuration shows improvement on the handover performance by compare with the previous measurement result.

This paper is organized as follows; section I provides the overview of the implementation of multisystem inter-cluster indigence in the current network that indirectly induces the cell reselection failure in certain area. Methodology of the research is presented in section II while analysis and result are provided in section III. Concluding remark is given in section IV.

II. METHODOLOGY

Figure 3 shows the research framework during analysis. The important elements of the research are outlined as follows:

(1) Collecting sample of RF measurement data from various case areas using the ARTEMIS drive test tools. Handover data will then be analysed using post processing tools including all the parameters such as neighbour configuration, C1/C2/SRH/FRH and etc. The cell reselection failure rate will then be recorded,

(2) Revision of sites plot configuration in the Map Info software tools according the proposed design for multisystem integration. Criteria in the design must identify the suitability of the coordinate to swap the base station and the adjacent neighbour to ensure the cell reselection efficiency. A coverage plot can then be produced using ATDI platform to simulate the suggested area to be covered as per network requirement,

(3) Validation based on the analysis result, implementation to re-arrange cell in multisystem integration network will then be executed. RF data measurement after execution will be analysed and will be compared with previous taken data.

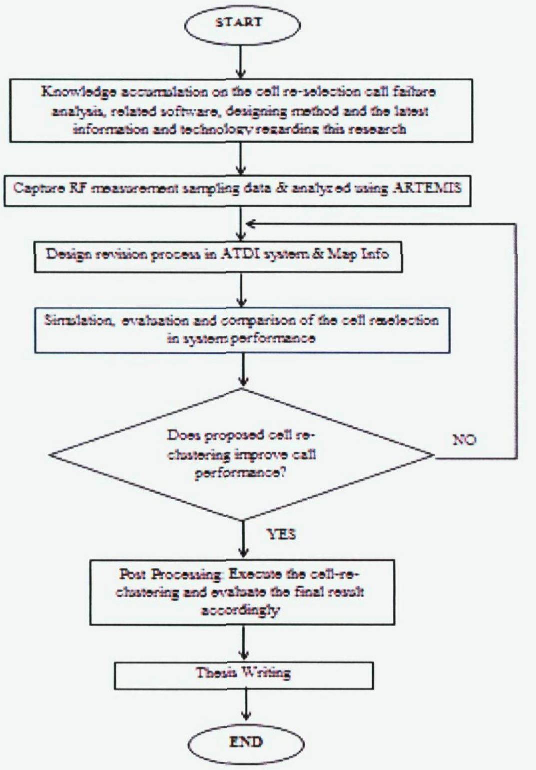

Figure 3: Research Framework

A. Cell Reselection Parameter

The key parameter and configuration are idle for the case of single system. For multisystem or cluster this required further analysis as the idle case may not be suitable if the mobile terminal need to perform cell reselection between two different systems, to be specific the serving and adjacent cell contain a mixture or combination of several multiple system with different manufacturer, especially in the sub urban or rural area. Most key parameter for reselection process must be configured according to the manufacturer stipulation.

Unlike the handover process in GSM or LTE which are determine by both mobile terminal UE (User Equipment) and base station, in TETRA, the cell reselection it is determine only by mobile terminal UE. Cell Reselection is an affiliation activity concerned with moving the mobile terminal UE from one cell to another [5].

The radio's cell reselection decision is governed by a set of criteria which are defined in the ETSI TETRA Standard and are the same for all TETRA Terminals. Cell reselections are governed by the relative values of the C1 & C2 Parameter as expressed in equation (1), (2) & (3):

C1/C2 = RSSI - RXLEV_ACCESS_MIN - Max (0, MS_TXPWR_MAX_CELL - PM) (1)

C1<0 = RADIO_LINK FAILURE (2)

Where

RSSI is the averaged DL RX level (or equivalent signal quality measurement) and RXLEV_ACCESS_MIN is the minimum permissible value of the field strength for RX at which the UE may be logged on in the cell. The value here refers to the Receiver path for the UE and thus the value of the field strength used by the UE to receive the base station.

This value is announced for the UE's own base station and for the neighbour cells. Mostly this is setting at -105 dBm RSSI. All reselection parameter are based on this level, and they are calculated from this Level.

MS_TXPWR_MAX_CELL is a maximum transmitter power with which the MS may transmit. This value is announced for the UE's own base station and for the neighbour cells.

- For Handheld Radio 1 Watt = 30 dBm

- For Mobile Radios 10 Watt = 40 dBm

PM = maximum TX power of the MS (UE) (3)

The TETRA network being study is working between 380-400 MHz with 10 MHz duplex spacing. For the base station the RX range is in between 380-390 and TX range is in between 390-400 MHz.

Table 1 and 2 show the sample of measurement of C1 and C2 with the given value of RSSI, RXLEV_ACCESS_MIN, MS_TXPWR_MAX_CELL and PM as indicated in the table.

Table 1: Example C1:

Parameter	Value
RSSI Measured and averaged level	-70 dBm
RXLEV_ACCESS_MIN	-100 dBm
MS_TXPWR_MAX_CELL	30 dBm (1W)
PM	35 dBm (3W)

C1 = -70dBm-(-100dBm) - Max(0, 30dBm-35dBm)

Table 2: Example C2:

Parameter	Value
RSSI Measured and averaged level	-70 dBm
RXLEV_ACCESS_MIN	-100 dBm
MS_TXPWR_MAX_CELL	35 dBm (3W)
PM	30 dBm (1W)

C2(n) = -70dBm-(-100dBm) - Max(0, 35dBm-30dBm)

As shown in Figure 4, in theory re-selection is initiated if the serving cell is declared radio improvable and service criteria are the same on serving cell and neighbour cell. If the service provided by the neighbour cell is worse than in serving cell, re-selection is postponed until serving cell is radio relinquishable as shown in Figure 5. If the service provided by the neighbour cell is better than in serving cell, re-selection is performed when the neighbour cell is radio usable.

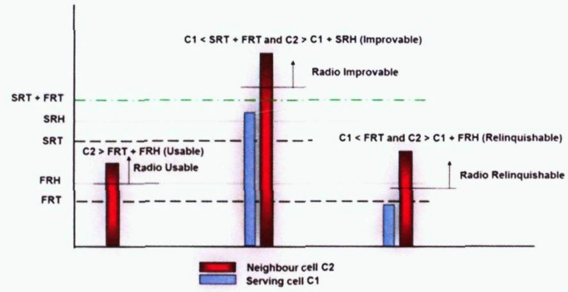

Figure 4 : Criteria in cell reselection

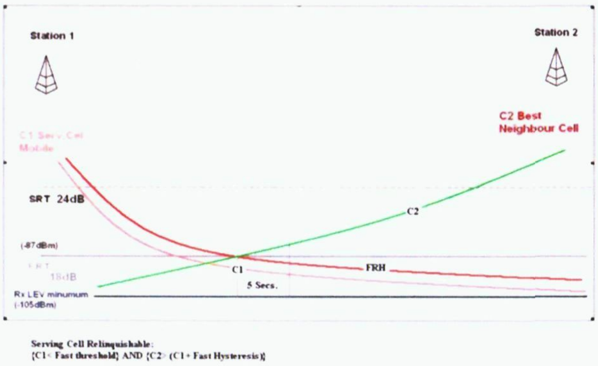

Figure 5 : Cell relinquishable

According to ETSI TR report [9], most of elements to enhance network performance are difficult to quantify by users. Some of the aspect requires substantial standardization effort, which will compete for standardization resources and, as such, compromise each other [8]. To allow full core integration and handover between different manufacturer of TETRA network, technology use standardized Inter System Interface (ISI). TETRA standards give the equipment manufacturers the edge to research and develop different state of the art solution based on different network architectures as the TETRA standard does not define the core network infrastructure elements. For example Centre for Inter-Systems Integration Server (CISIS) is a gateway, which provides 100% integration of TETRA NEBULA systems from other vendors using the radio interface [10].

III. RESULT & ANALYSIS

The private TETRA network coverage was assessed on area that have been identifying with the cell reselection failure issue. Based on the result analysis, cell configuration of affected inter-cluster cell reselection or handover has been revised. The design has been optimize by re-clustering the cell accordingly and change the location area code of the neighbouring cell. All new configurations have been executed and the parameter setting has been update into the live network.

Another activity of measuring and collecting RF handover data has been done to confirm the failure of cell reselection is eliminated from the network. Full drive test result before and after the re-clustering activity is executed as shown in Figure 6.

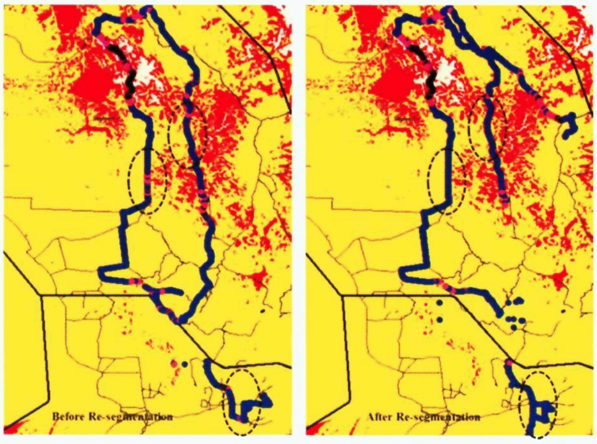

Figure 6 : Drive Test Result

Three (3) sample results of measuring and collecting the RF handover data from 3 different locations have been analysed in details. RF measurement data was taken before and after the change of cell configuration. Details result as per explain in the next section.

In summary based on the coverage prediction, the status for the area should get at least -86 dBm which is good for the handheld coverage, as indicated by the yellow colour. However, due to the transition between Cluster 2 to Cluster 1 and vice versa, the handover is not smooth as indicated by the purple color of the RF measurement. User will experience call connecting and sometimes call is dropped during the handover, even though the coverage along the route is good. Refer to Figure 7 and Figure 8 on the coverage prediction and RF measurement indicator.

Figure 7 : Coverage Prediction Indicator

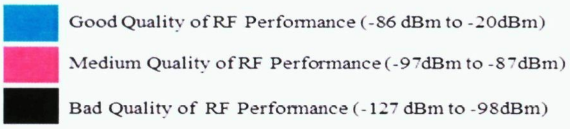

Figure 8 : RF Measurement Indicator

Figure 9 shows the pre & post analysis for sample 1. From drive test measurement of pre-analysis result, it is clearly shows the handover issues between two different cells (Cell 224 – Cluster 2 and Cell 125–Cluster 1) even though the RSSI level is good for handover in the same cell. This is due to the neighbour cell is in two different clusters (inter-cluster issue) which affects the handover process.

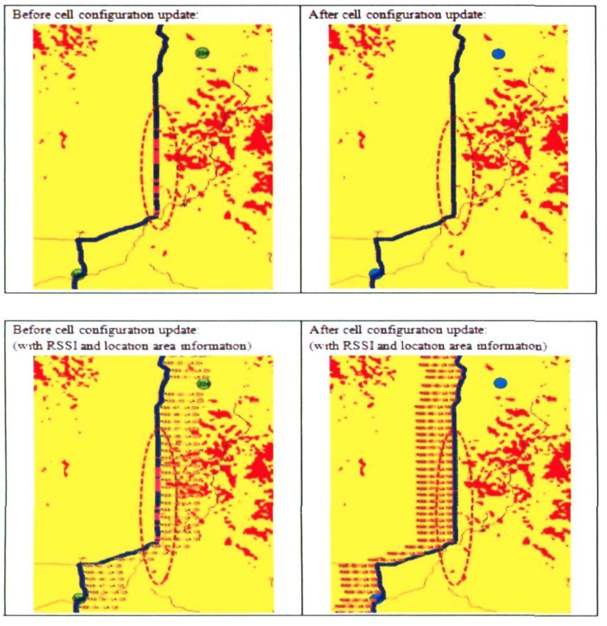

Figure 9 : Pre & Post Analysis Result for Sample 1

Figure 10 shows the pre & post analysis for sample 2. From drive test measurement of pre-analysis result, it is shows the handover issues between two different cells (Cell 339 – Cluster 3 and Cell 149– Cluster 1). For this sample, the coverage is available. However the RSSI is not in a very good level for handover in the same cell due to the geographical terrain factor. By re-segment the cluster, it shows some improvement on the result (after).

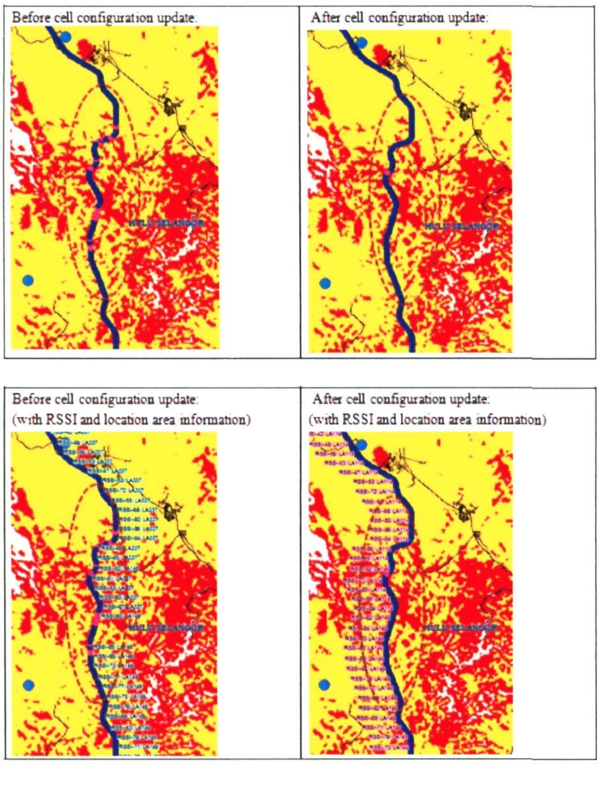

Figure 10 : Pre & Post Analysis Result for Sample 2

Figure 11 shows the pre & post analysis for sample 3. From drive test measurement of pre-analysis result, it is clearly shows the handover issues between few different cells (Cell 109 – Cluster 1, Cell 218– Cluster 2 and Cell 150 – Cluster1). The coverage at this whole area is very good based on the indicator of yellow for coverage prediction and the RSSI level is good for handover in the same cell. However, due to the neighbour cell is in few different clusters (inter-cluster issue), it affects the handover process. After the re-clustering execution, the whole result shows improvement.

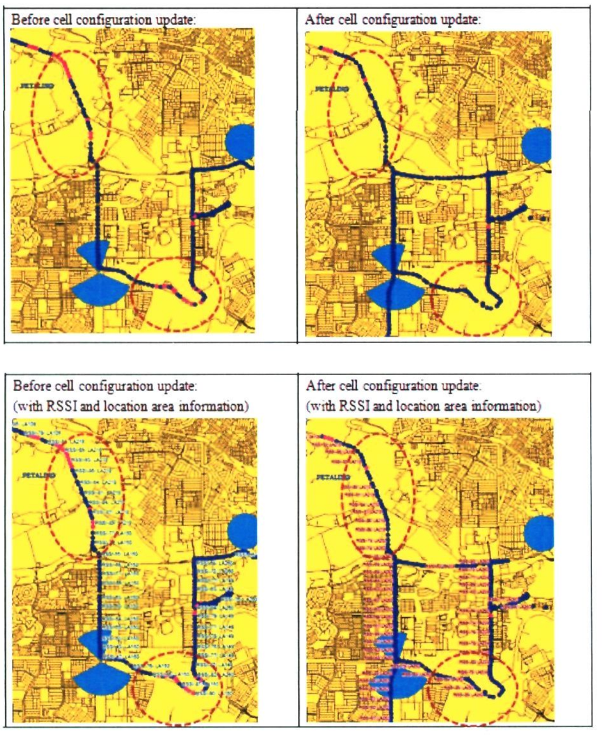

Figure 11 : Pre & Post Analysis Result for Sample 3

Figure 12 shows one of the samples of cell re-selection from old LAC to new Lac of raw data used for this study. It shows the handover from different segmentation ie cluster 1 to cluster 2 or vice versa. The reason why the segmentation is in the mixed configuration is due to the initial plan to ensure the redundancy of the base station attached to different switch during the beginning of the rollout without realizing the limitation of the cell reselection failure issue.

	A	B	C	D	E	H	I	L	P
1	NAME	LOGTIME	GPSSTAT	LAT	LONG	SPEED	DIRECTION	OLDCELL LAC	NEWCELL LAC
2	Cell Reselection	7509.05	A	3.15077	101.55299	53	S	109	218
3	Cell Reselection	7708.24	A	3.12348	101.56015	61	SE	218	109
4	Cell Reselection	7846.43	A	3.1127	101.5732	58	E	109	218
5	Cell Reselection	7872.42	A	3.11187	101.57539	2	SE	218	109
6	Cell Reselection	7974.81	A	3.11022	101.57992	64	E	109	218
7	Cell Reselection	8125.58	A	3.09083	101.5917	71	S	218	150
8	Cell Reselection	8462.68	A	3.05548	101.61318	63	E	150	260
9	Cell Reselection	8524.16	A	3.05984	101.61333	37	NW	260	149
10	Cell Reselection	8676.52	A	3.07322	101.61347	47	SW	149	260
11	Cell Reselection	8814.66	A	3.07684	101.62084	1	NE	260	149
12	Cell Reselection	9202.54	A	3.08129	101.61348	21	NW	149	260
13	Cell Reselection	9253.94	A	3.08427	101.61358	15	NE	260	149
14	Cell Reselection	9539.95	A	3.08306	101.64038	46	E	149	260
15	Cell Reselection	9881.85	A	3.09324	101.64621	27	W	260	247

Figure 12 : Sample Cell Re-selection from Old LAC to New LAC

IV. CONCLUSION

This paper has demonstrate the result and analysis of call reselection failure using the ARTEMIS tools for RF measurement and ATDI tools to present the coverage prediction. Based on the analysis result, execution of the cell-re-clustering has successfully implemented and the post processing result has been validated to prove the effectiveness of the activity. This study can become the reference for future planning of multisystem inter-cluster TETRA network. Private TETRA network do not have the same subscriber numbers as commercial cellular network, making the economic justification for simply adding base station and other coverage solution are much harder.

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