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Identification of Suitable Conditions for Handoff in Real Time Mobile Network Technologies

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ABSTRACT
Handoff is an essential process of cellular communications. In most cases, handoff that occurs to avoid sudden termination of the call in between the ongoing conversation is preferred instead of new call origination. Therefore, while managing handoff requests, prioritizing handoff to avoid such abrupt terminations of the ongoing calls over origination of new calls is done which is termed as handoff prioritization. Prioritizing handoff reduces handoff failure and therefore is essential to improve system performance. Also, a handoff algorithm which uses fixed parameters only or the one which tries to reduce the number of handoffs in heavy traffic situations results in poor performance. Again in such situations, prioritizing handoff helps in improving the performance of the system. But there are still some conditions when simply prioritization of handoff is not helpful. This paper describes such situations and identifies those different conditions which are responsible for a fruitful handoff process by comparing receiver level and receiver quality in different mobile networks like UMTS and GSM.

Keywords
UMTS, GSM, C/I Level, E_b/N_t, Pilot channel, Ping pong effect, Margin, RNC

1. INTRODUCTION
When a mobile moves from one cell to another cell, the call is automatically transferred to a new channel belonging to a new base station. This process of transferring the channels between two cells or transferring of call from one cell to another is referred to as handoff. Handoff strategies includes identification of a new base station and also allocation of voice and control signals to channels associated with the new base stations.

Handoff processing is essential in communication systems but handoffs should be successful and imperceptible to users and also frequent handoffs must be avoided as they cause ping pong effect. Thus, to meet these handoff requirements, an optimum signal shall be specified at which a handoff must be initiated. Also the margin value used should not be very large or very small because when the margin is large, handoff occurs frequently resulting into ping pong effect and when it is small there is insufficient time to complete a handoff process before a call is lost.

There may be situations when the signal drops below the minimum acceptable level but still there is no handoff. Such situations can happen when there is an excessive delay by the MSC in assigning a handoff or in other words when the margin is set too small for the handoff time in the systems. Such delays by the MSC may occur due to high traffic conditions or when no channels are available on any of the nearby base stations.

2. LITERATURE REVIEW
In this paper [1] author has proposed that in multi-network environment, integration plays a vital role in providing seamless services to the users and the main focus is on handoff and its decision making parameters. The input parameter used for decision process is coverage for achieving seamless mobility.

In [2], the author has proposed an identification scheme which identifies different parameters like RSS, bandwidth, speed, cost, direction, SINR etc. which are responsible for a fruitful handoff process. The algorithms for the path traversed by the handoff decision process had also been studied in this paper.

In [3], the author has proposed a seamless approach to perform vertical and horizontal handoff. It helps in reduction of the probability of call blocking and dropping during the handoff process. The paper also proves that the defined process also helps in reducing the unnecessary handoffs in networks.

The author proposes a novel approach of handoff decision making in the context of heterogeneous wireless network which aims at selecting the most suitable radio access network [4]. Also simulated results guarantee QoS requirements and reduce the blocking probability of new and handoff calls.

According to paper in [5], the divination of heterogeneous wireless networks is one of the most anticipated features of fourth generation systems. It also presents a tutorial on the different aspects of handovers, and discusses handover design and performance of related issues.

In [6], author proposes a Mobility based multi-attribute vertical HO (MMVHO) scheme based on the node mobility characteristics which has a centralized HO control. There is also a pre handoff algorithm which picks the correct access point. The HO trigger depends on the signal coverage of the access point and also implements centralized HO control which leads to HO failure probability to be 1.

The author proposes a Multi-criteria vertical handoff process model with pre selection scheme using mobile terminal speed, RSS, location of mobile terminal/base station/access point and QoS of the serving network based on Fuzzy logic [7]. The pre-selection scheme checks the

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mobile terminal distance and checks its velocity with the threshold for performing HO while minimizing unnecessary HO. The process model can also be combined with HO network selection module to obtain seamless and successful HO.

In this paper [8] author has proposed prioritized network based vertical handoff, the important factors considered to make control of VHO process are location, speed, time with respect to signal strength threshold. Using this algorithm it is possible to predict handoff before it is estimated. The number of handoffs is reduced as the RSS of the VHO gets stronger and the MS resides for longer time in the network without break in the service.

Author has proposed a multi-criteria vertical handoff (MVHO) decision making which consists RSSI, moving speed, traffic by the MS and also the network occupancy as the deciding parameters [9]. By doing so the author achieves a reduction of 46.21% in the number of HO and the mean initial number of HO has been reduced to 73 as compared to that obtained from conventional method which is 157. The main factor used for decision making is Network occupancy.

In [10] author proposes an Adaptive fuzzy based handoff decision which tunes itself with respect to the device and network capabilities. In this algorithm decision quality has been improved with the help of Markov decision processes with Q-learning and genetic algorithms. The accuracy of handoff decision, QoS and resource consumption are evaluated and also maximum throughput has been obtained with greater accuracy in decision making.

3. PROPOSED SOFTWARE TOOL

The software tool used is ATOLL (version 3.1.1) and Working Equipment of RNC.

Atoll is a scalable and flexible multi-technology network design and optimisation platform that supports wireless operators throughout the network lifecycle, from initial design to densification and optimisation. It can be used to plan both radio networks and microwave links. Also by using Atoll handover relations between networks of different technologies could be determined.

Data values from Working Equipment of RNC is used to compare the readings of practical experiments that already have been already done with those in this paper.

4. RADIO NETWORK CONTROLLER (RNC)

A Radio Network Controller (RNC) is a governing element that provides interface between wireless devices and network edge. A radio network controller manages hundreds of Node B transceiver stations. It also controls the power of Node Bs through which wireless devices communicate, and acts as a point where encryption is done before sending data from or to the mobile unit. It also controls and manages the radio transceivers that are there in the Node B, and is responsible for management of soft handoffs. The task of RNC in 3G wireless network is same as that performed by the Base Station Controller (BSC) in a 2G or 2.5G network. RNC interfaces with Serving GPRS Support Nodes (SGSNs) that are responsible for mobility management as well as authentication of users and Gateway GPRS Support Nodes (GGSNs) which help in connecting GPRS network with internet.

The Radio Network Controller (RNC) handles functions like:

i. Management of mobility
ii. Supporting various mobile services
iii. Management of radio resources
iv. Processing of calls
v. Maintenance of links
vi. Handoff processing
vii. Management of traffic concentration and traffic flow

The procedure of handoff as studied according to RNC element manager is as follows:

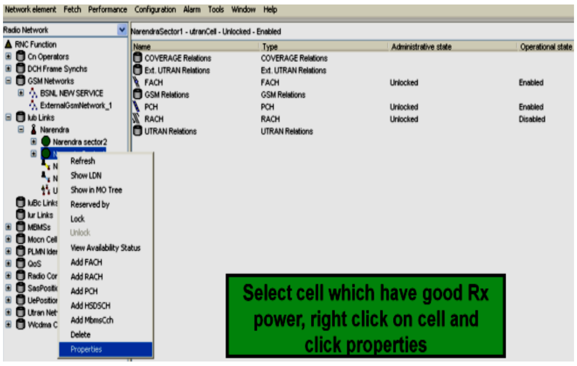

Fig 1: Cell selection on the basis of good receiver power

1) The cell with good receiver power is selected first as mentioned in figure 1.

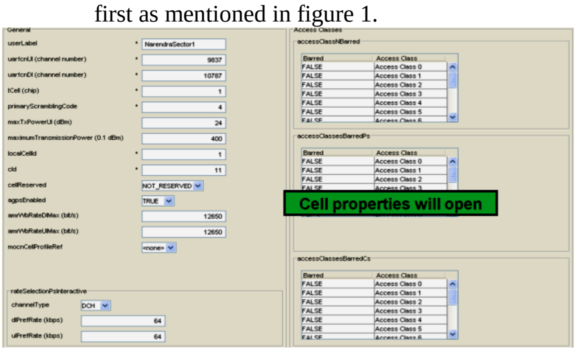

Fig 2: Cell properties

2) If needed, properties of the selected cell could be checked and changed accordingly as mentioned in figure 2.

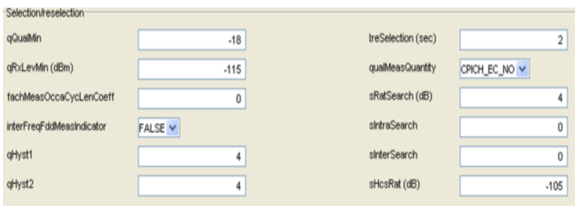

Fig 3: Parameters of handoff in idle mode

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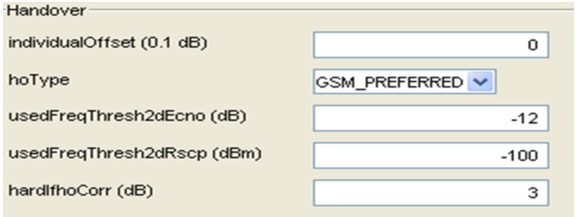

Fig 4: Parameters of handoff when call is under process

3) Mobility selection for parameters of handoff could be done whether the mobile is in idle mode (as in figure 3) or when call is under process (as mentioned in figure 4).

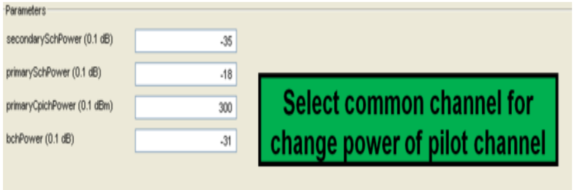

Fig 5: Optimum parameters of pilot channel

Fig 6: Reducing power for bad signal strength

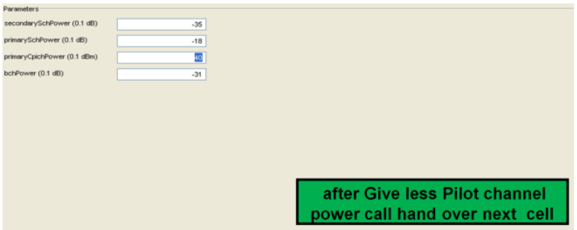

Fig 7: Less pilot channel power causing handoff

4) Initially the power of the channel is 30 dBm as shown in figure 5 which is the appropriate power for proper call processing. To check the conditions of handoff, power of the pilot channel is reduced (as in figure 6) for bad signal strength. As soon as the power is reduced (say 4dBm) handover occurs and this situation is mentioned in figure 7.

5. PROPOSED METHODOLOGY

Basically there are four different handoff events that occur in an active set, they are:

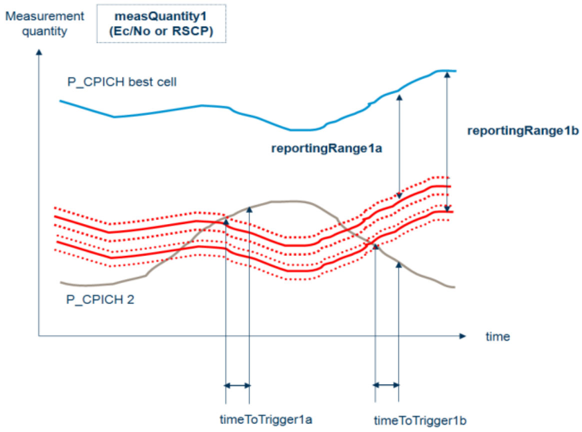

Fig 8: Adding and deleting cells in active set

1. Adding a new cell to an active set is represented in figure 8 by trigger level 1a. In this case the mobile unit (whose signal level is represented by P_CPICH2) compares all the six CPICH (Common Pilot Channel) rake receiver signals (in red) to determine the best possible signal and then handoffs to the best signal available (in blue) in the locality to which it has reached while moving.

2. Deleting a new cell from an active set is represented in figure 8 by trigger level 1b. When the mobile signal drops even below the worst signal possible from the six rake receiver signal then the connection with initial base station is terminated and the mobile unit connects to the base station with best signal.

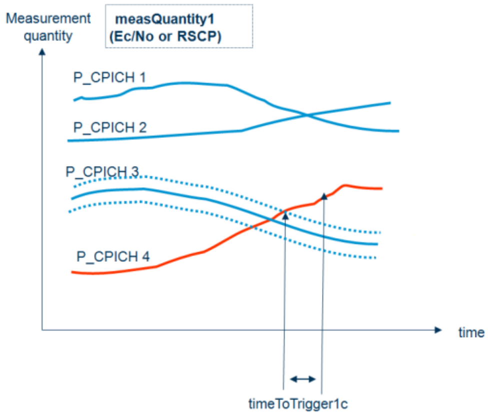

Fig 9: Replacing a cell in active set

3. Replacing a cell in an active set is represented in figure 9 by trigger level 1c. It could be seen from the figure that the signal P_CPICH 4 is continuously increasing and at the point where it crosses the signal P_CPICH 3 is the point where mobile units using signal P_CPICH 3 will replace it with P_CPICH 4.

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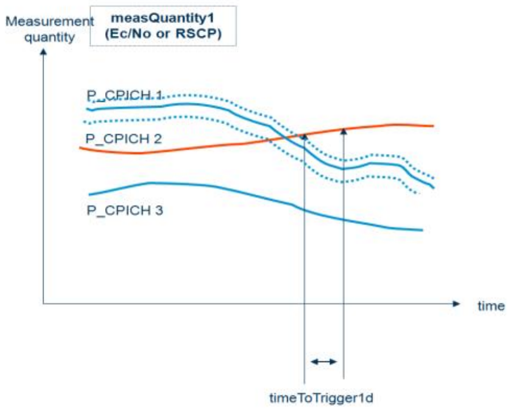

Fig 10: Changing to best cell in active set

4. Change to best available cell in active set is represented in figure 10 by trigger level 1d. According to the figure P_CPICH 2 acts as the best signal with passage of time hence any mobile unit that reaches in its coverage area will opt for it.

These results could be proved with the help of handoffs in different conditions between GSM transmitter and UMTS transmitter using Atoll software considering the parameters like receiver level and receiver quality.

5.1 Handoffs considering receiver level

According to RNC element manager, the minimum acceptable receiver level for a call is -100 dBm as shown in figure 4. Hence when the receiver level drops below

-100 dBm, there is a need of handoff to continue the call. But the criteria for choosing acceptable receiver level for another technology in case of poor receiver level is that there should be a margin value of 3 dB to avoid the occurrence of ping pong effect.

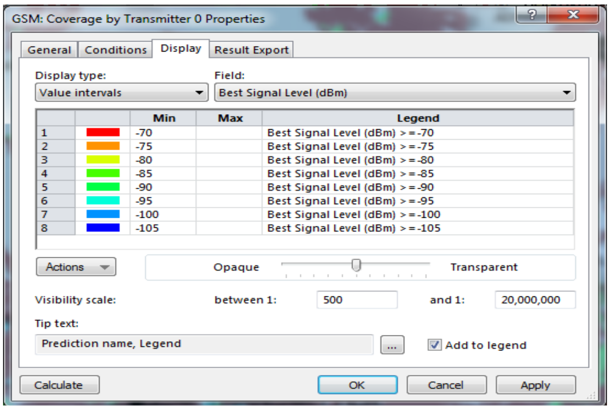

Fig 11: Coverage by receiver level for GSM

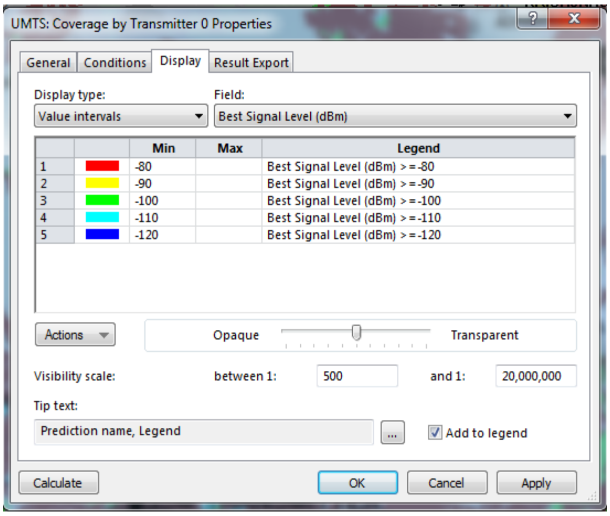

Fig 12: Coverage by receiver level for UMTS

It is depicted from figure 11 that if any mobile unit reaches the blue coloured area (in case of GSM technology), the handoff occurs since the receiver level reaches -100 dBm and then further to -105 dBm which is considered in worst case for the continuation of a call.

Similarly in case of UMTS technology as per figure 12, handoff will be required during and after crossing the green area which shows the receiver level of -100 dBm followed by -110 dBm and -120 dBm represented by areas in different blue shades.

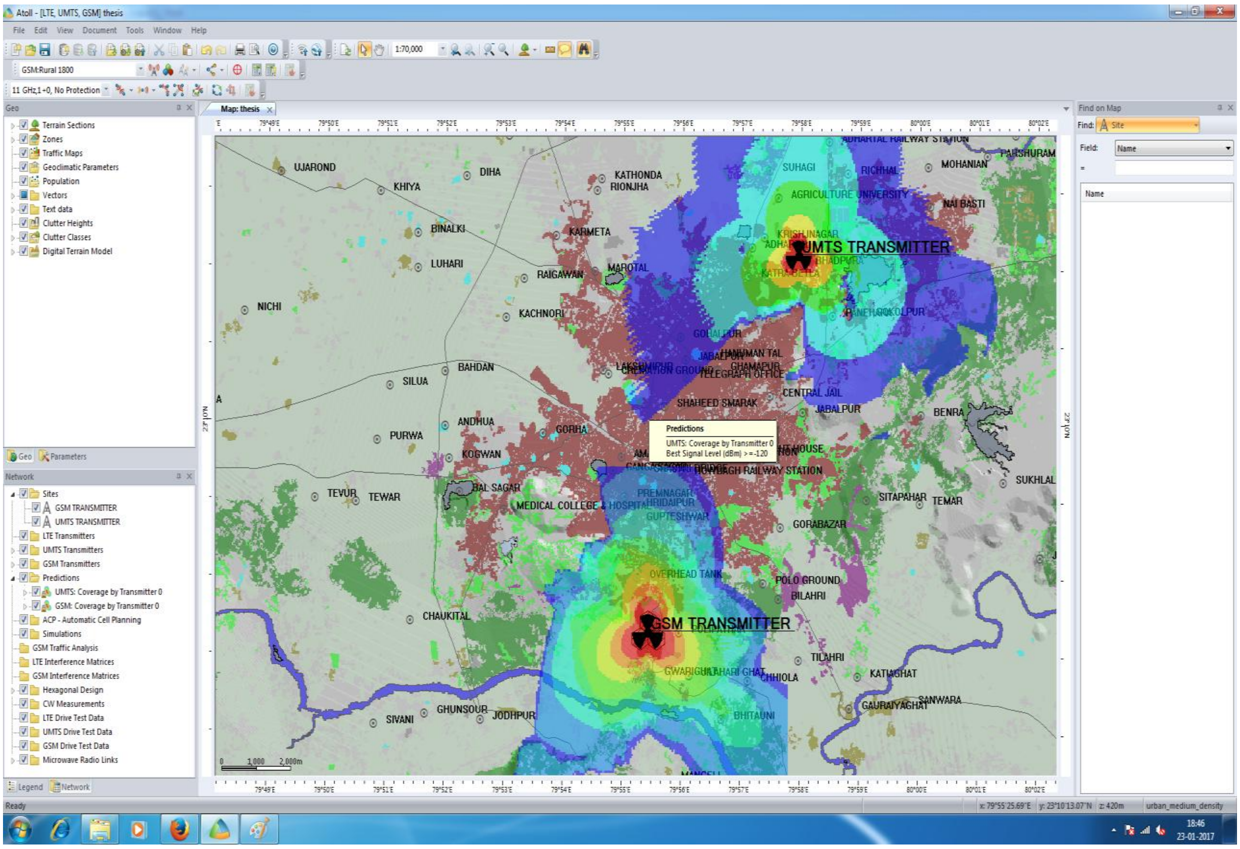

Fig 13: Coverage by receiver level for UMTS (best signal level >= -120 dBm)

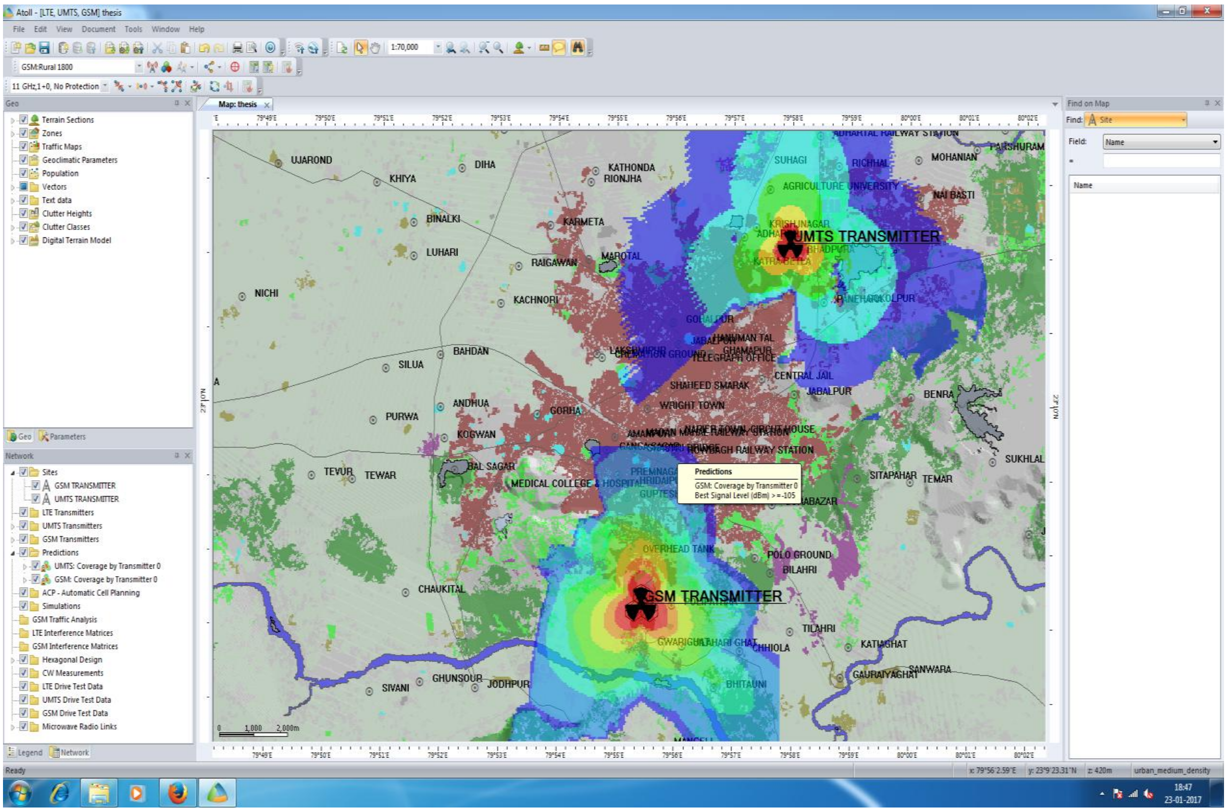

Fig 14: Coverage by receiver level for GSM (best signal level >= -105 dBm)

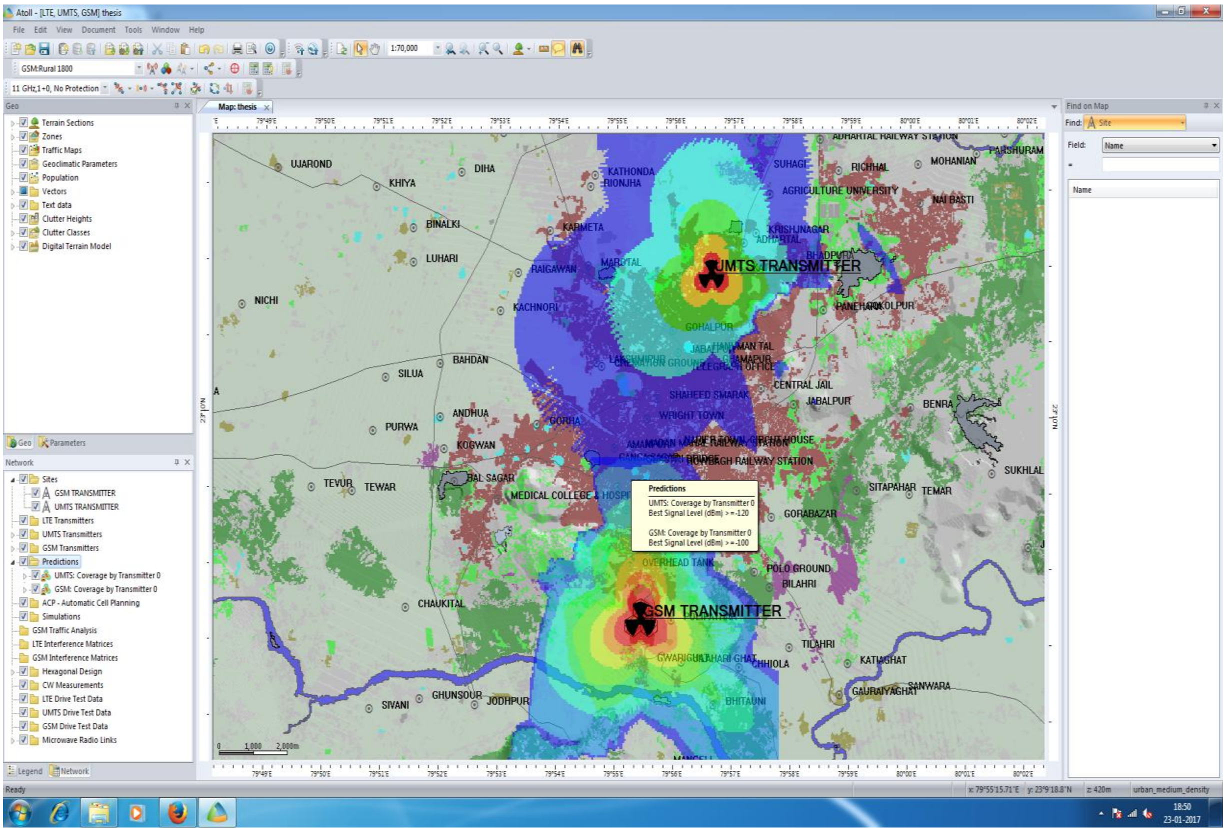

Fig 15: Coverage by receiver level for GSM (best signal level >= -100 dBm) and UMTS (best signal level >= -120 dBm)

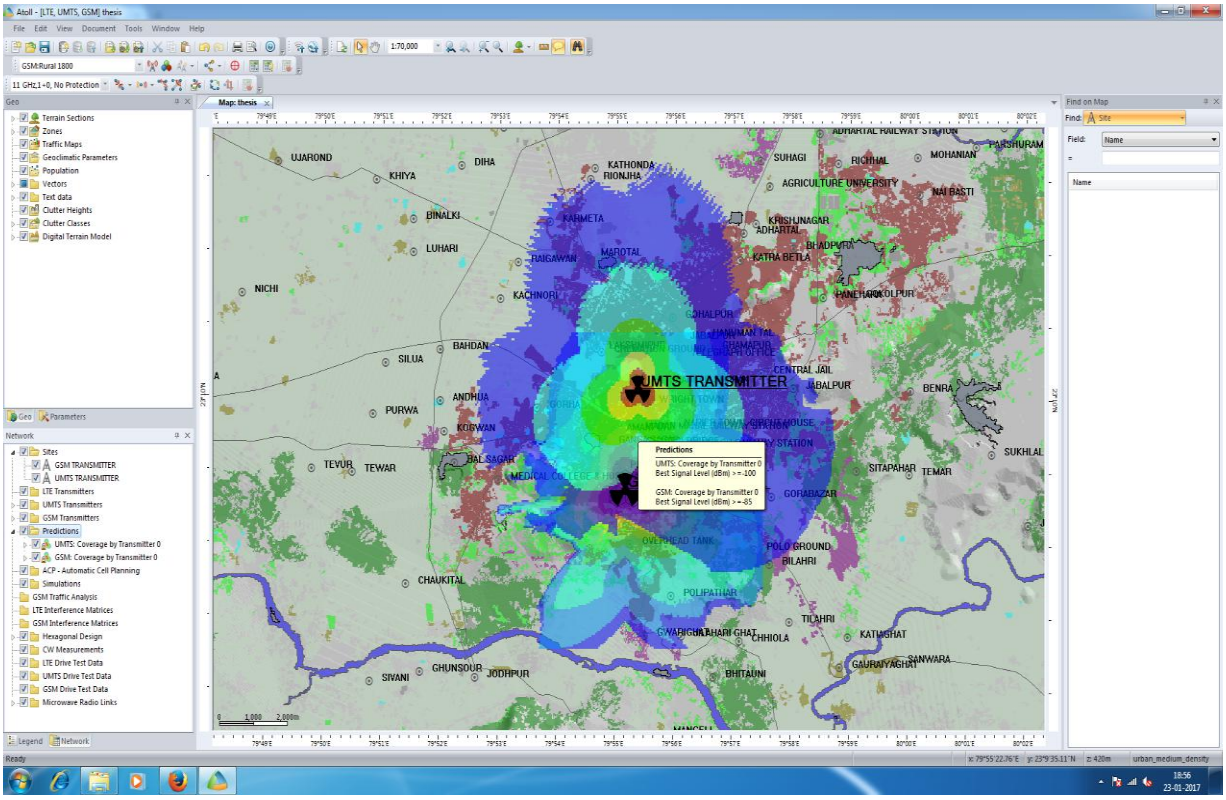

Fig 16: Coverage by receiver level for GSM (best signal level >= -85 dBm) and UMTS (best signal level >= -100 dBm)

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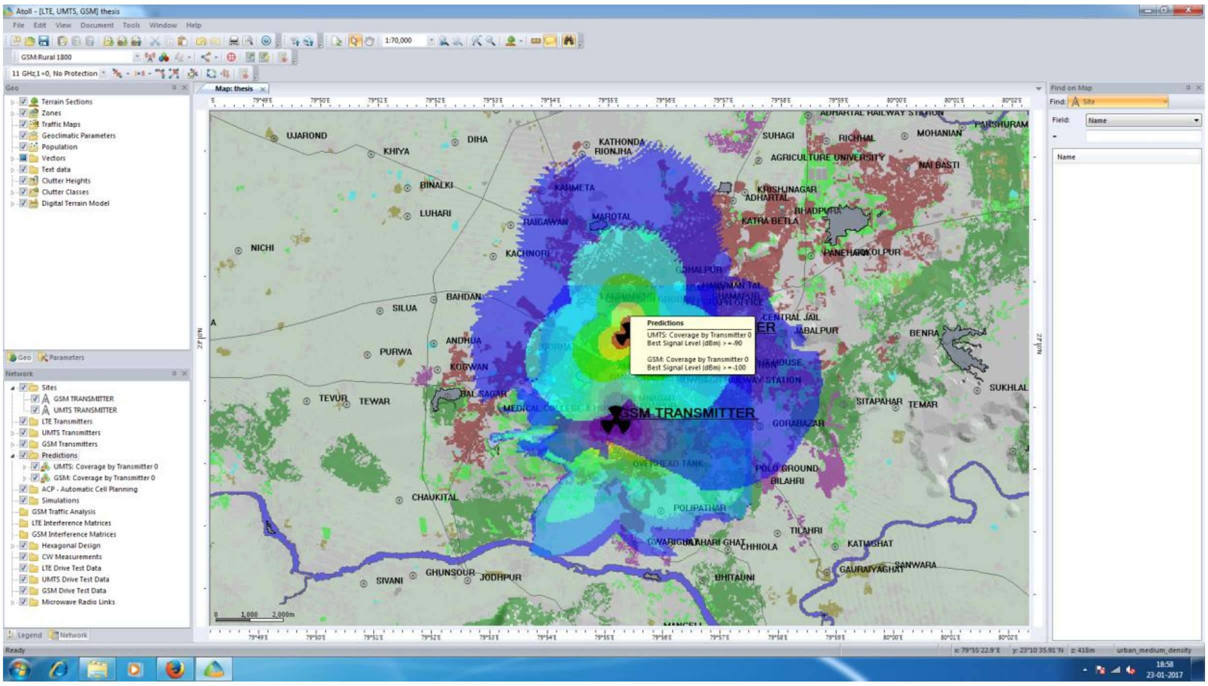

Fig 17: Coverage by receiver level for GSM (best signal level >= -100 dBm) and UMTS (best signal level >= -90 dBm)

According to figure 13 and 14 there is no scope for handoff in either case i.e., whether the mobile unit travels from UMTS coverage area to GSM coverage area or vice versa. Even after the mobile unit reaches its minimum receiver level no handoff will occur since the coverage areas of the two transmitters viz. the GSM transmitter and the UMTS transmitter are much far apart. Hence the call will be dropped.

In figure 15, the two coverage areas are coinciding with each other unlike as shown in figure 13 and 14 but still handoff will not occur. As it could be observed that the receiver level for GSM transmitter has reached its minimum value and a handoff is required, but handoff will occur only when the mobile unit will receive the signal level of -97 dBm or better considering the margin value of 3 dB as given in figure 4.

In figure 16, the call which is in process in UMTS coverage area undergoes handoff to the GSM coverage as the receiver level for UMTS transmitter drops and has reached -100 dBm while the receiver level for GSM is -85 dBm which is suitable for call to carry on.

The case in figure 17 is just opposite to that in figure 16. In this figure, it could be seen that GSM receiver level has dropped to -100 dBm while UMTS receiver level at the same region is -90 dBm, hence handoff could occur from GSM to UMTS.

5.2 Handoff considering receiver quality

Considering receiver quality in RNC element manager, minimum acceptable level is -12 dB with a margin value of 3 dB as per mentioned in figure 4. That implies handoff will be required if the receiver quality deteriorates beyond -12 dB.

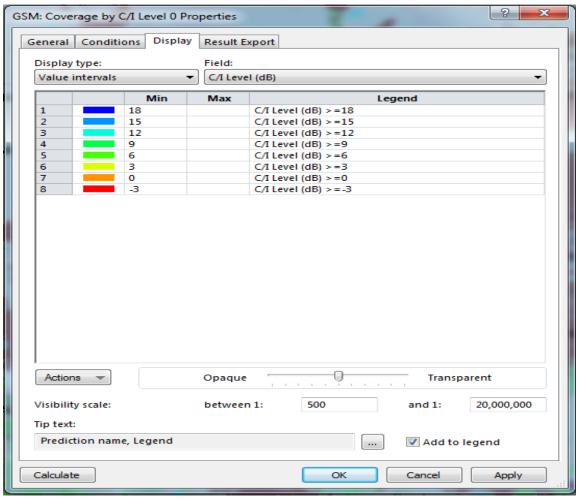

Fig 18: Coverage by receiver quality for GSM

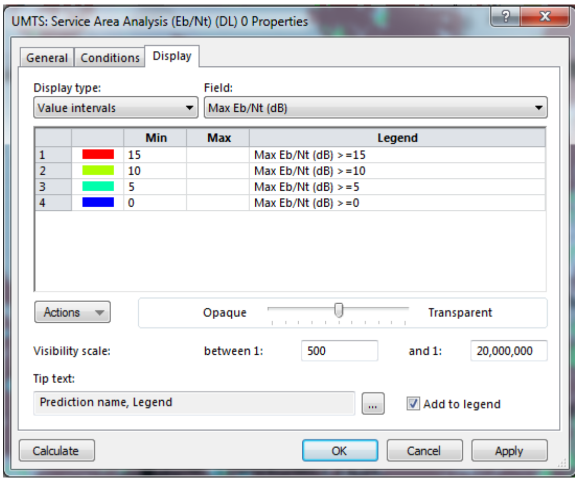

Fig 19: Coverage by receiver quality for UMTS

The measurement range for Carrier to Interference (C/I) ratio in GSM technology extends from 0 dB to 35 dB. If C/I is below 0 dB, it can be regarded as highly unlikely. Therefore, only the positive values are considered and not negative values. C/I values below this limit would normally result in a dropped call. To provide mobile users with best C/I ratio, the area with the blue shades (C/I level > 12 dB) will only be considered good for call processing (as per figure 18) and the area afterwards will be considered responsible for handoff.

In a very similar manner if negative values of Energy per bit per carrier to Noise per carrier in traffic mode (Eb/Nt) ratio in UMTS technology are considered then it means that energy is below the noise. Hence, to provide with good signal quality only positive values are being considered. According to figure 19, the area in red colour (Max Eb/Nt >= 15 dB) will only be considered for call processing and rest of the area will be liable to handoff to provide the best receiver signal quality.

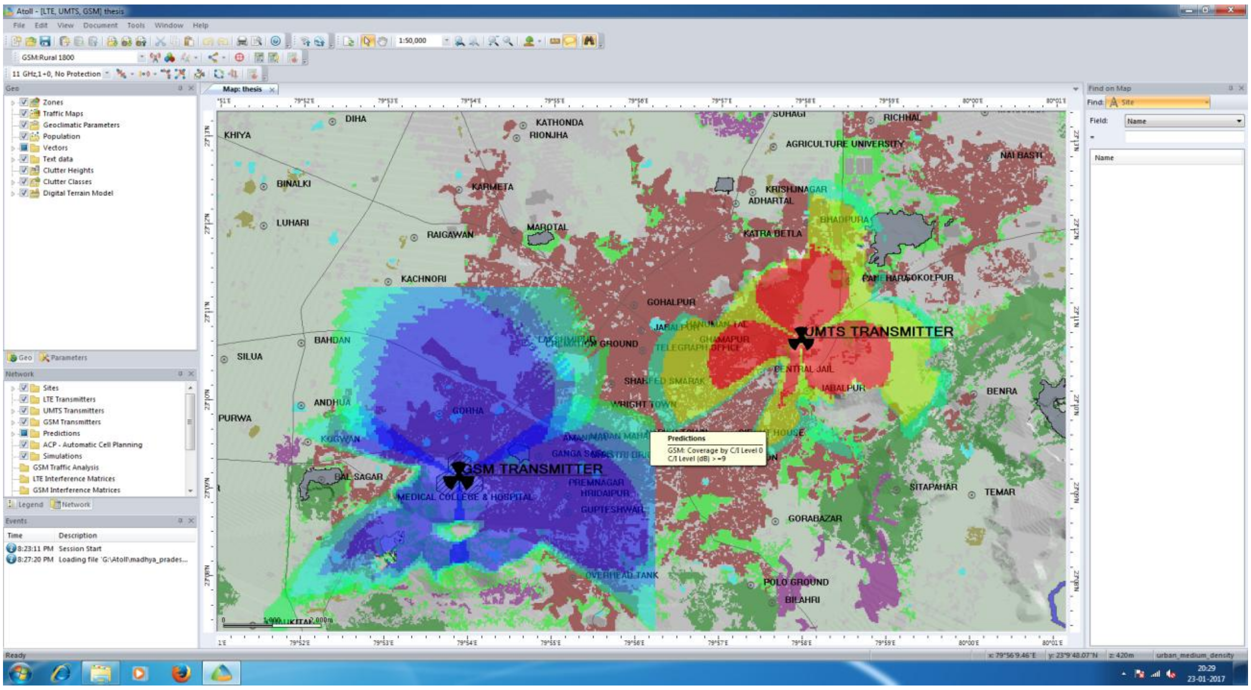

Fig 20: Coverage by receiver quality for GSM (C/I level >= 9 dB)

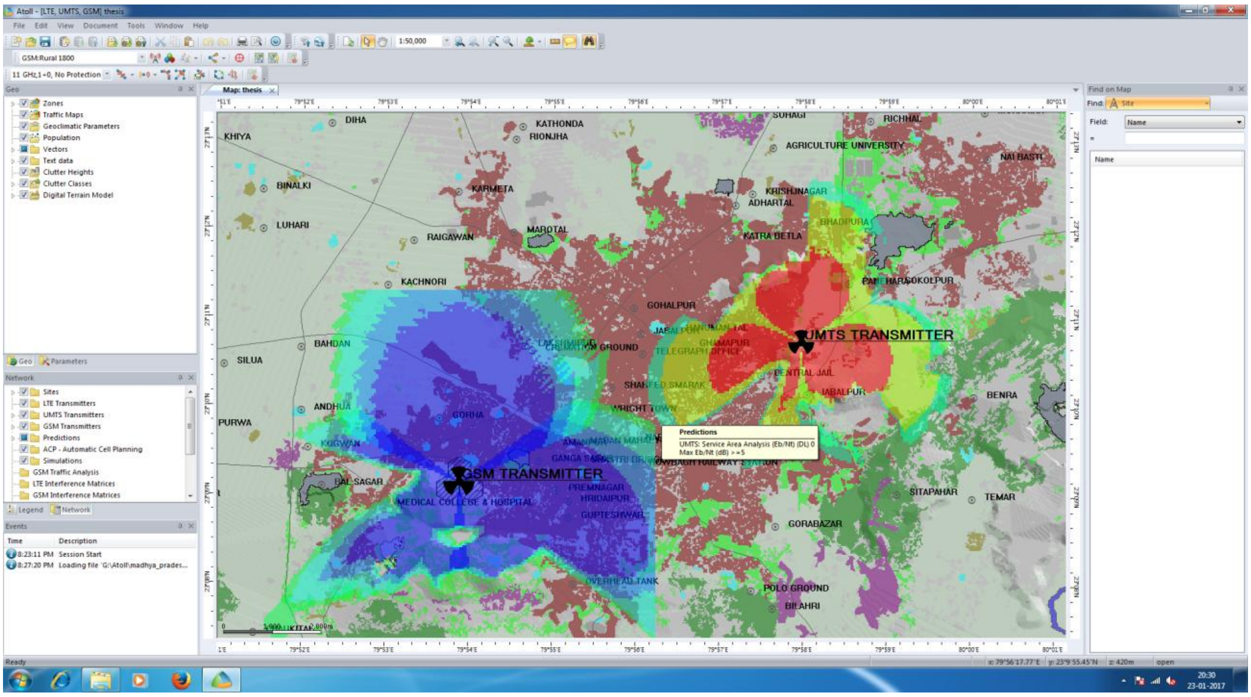

Fig 21: Coverage by receiver quality for UMTS (Max E_b/N_t >= 5 dB)

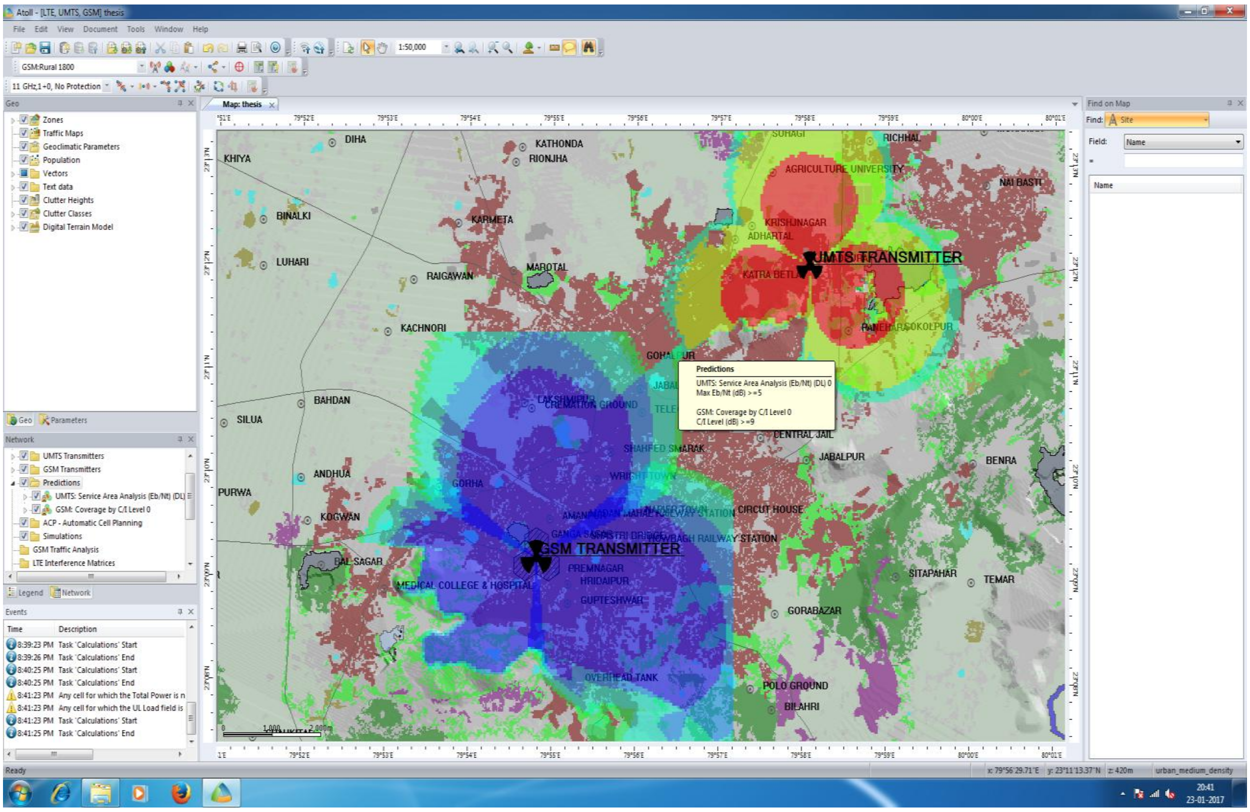

Fig 22: Coverage by receiver quality for UMTS (Max E_b/N_t >= 5 dB) and GSM (C/I level >= 9 dB)

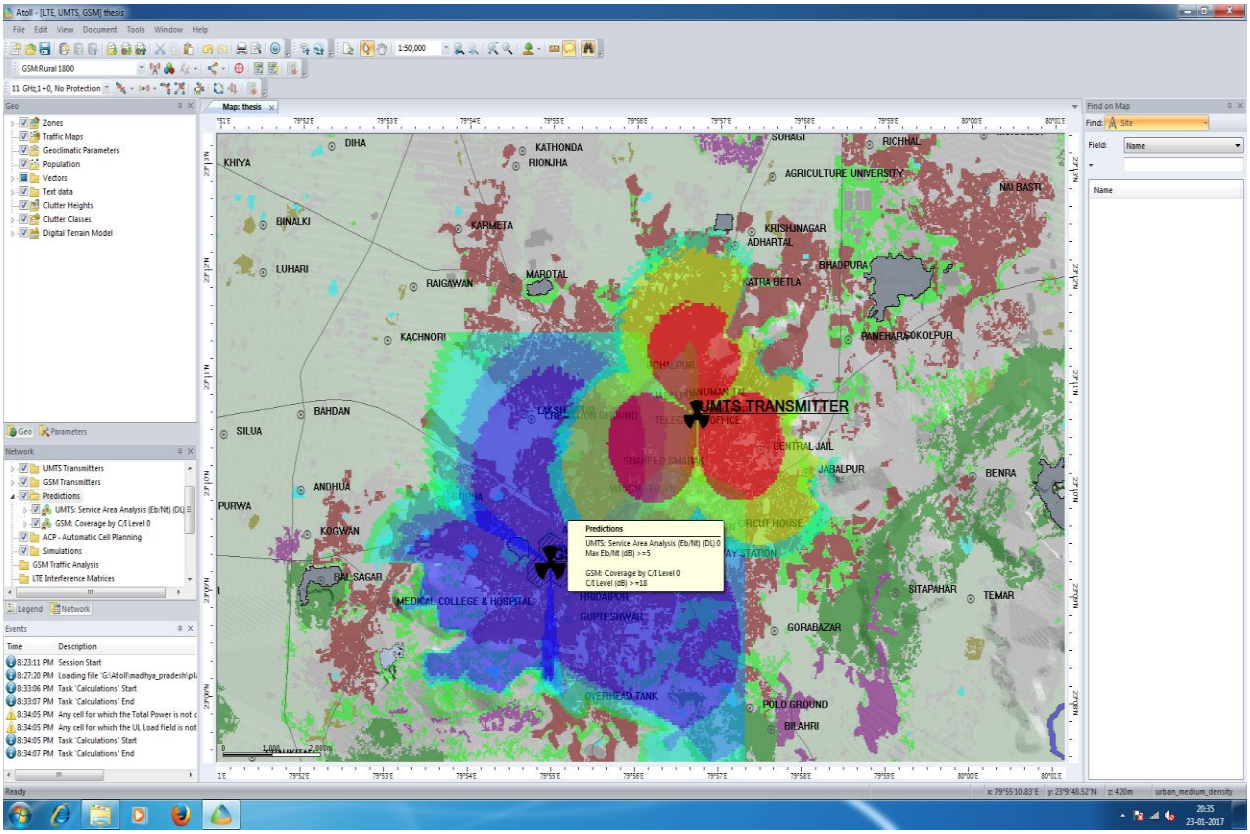

Fig 23: Coverage by receiver quality for UMTS (Max E_b/N_t >= 5 dB) and GSM (C/I level >= 18 dB)

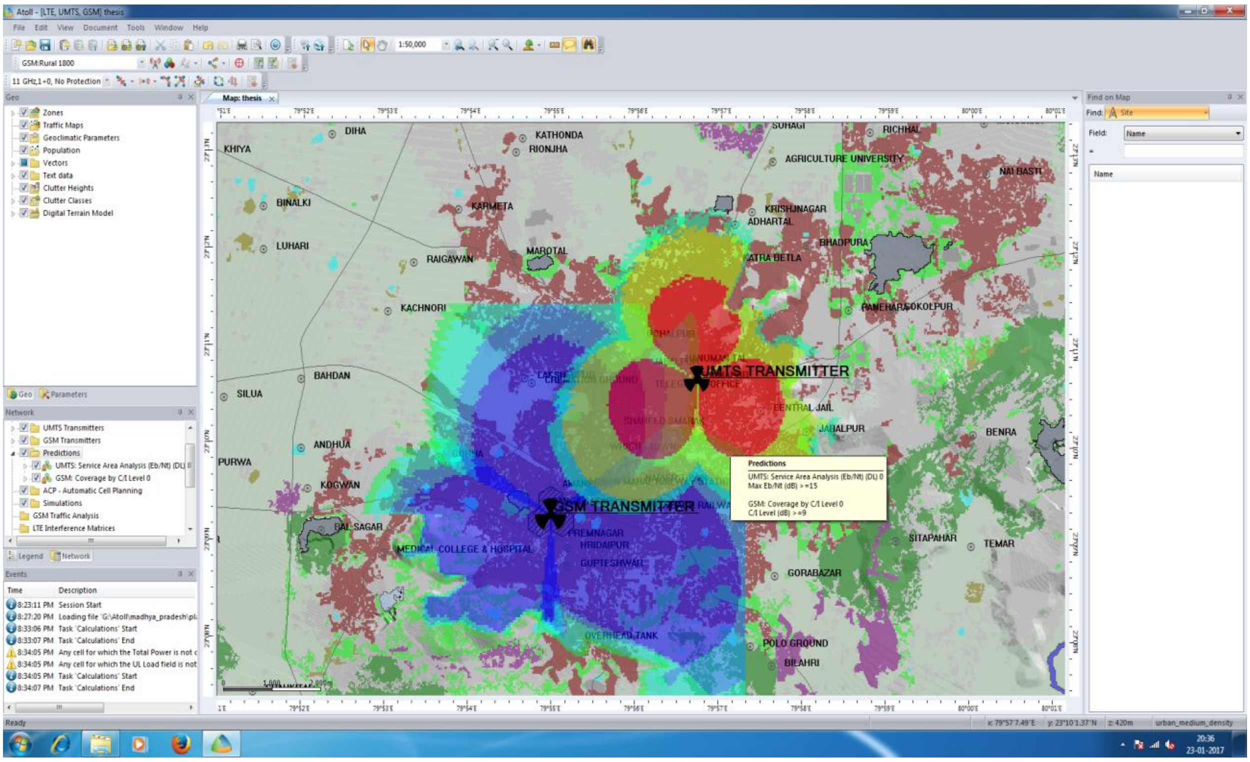

Fig 24: Coverage by receiver quality for UMTS (Max E_b/N_t >= 15 dB) and GSM (C/I level >= 9 dB)

According to figures 20 and 21 handoff will not occur either going from GSM coverage area to UMTS coverage area or vice versa as the C/I ratio in case of GSM is 9 dB and the Eb/Nt ratio for UMTS is 5 dB while the best receiver quality considered is above 12 dB with a margin of 3 dB in either case.

According to figure 22, inspite of coinciding coverage areas of the two technologies, there are no chances for handoff as the values of both the ratios viz. C/I ratio as well as Eb/Nt ratio are below 12 dB.

In figure 23, any mobile unit travelling from UMTS coverage area will receive poor Eb/Nt ratio and hence handoff will occur to the GSM coverage with C/I ratio of 18 dB as the condition for handoff is 12 dB with margin of 3 dB. Hence, whenever the receiver quality will be less than or equal to 12 dB for any technology and the receiver quality is greater than or equal to 15 dB for the other technology, the mobile unit will opt for handoff to the technology providing better receiver quality.

Now according to figure 24, the C/I level has been dropped below 12 dB therefore any mobile unit in that particular area will go for handoff to UMTS coverage area since it has favorable call processing conditions of Eb/Nt ratio being 15 dB.

The conditions when handoff is a failure to complete an ongoing call is summarized in table 1. According to table 1, either when Ec/No is less than or equal to 12dB or RSCP (Received Signal Code Power) is less than or equal to -100dBm or when both situations apply simultaneously, the mobile unit with call under process will suffer from sudden call termination due to poor receiver signal level and quality. Also keeping margin at 3 dB in case of traffic mode will cause unnecessary handoffs.

Table 2 indicates the values of different parameters which are suitable for making a successful and imperceptible handoff. For successful handoff Ec/No of the target cell must be more than or equal to 15 dB and RSCP should be more than or equal to -97 dBm. Also the margin for traffic mode is taken to be as 2 dB and that for idle mode it is taken as 3 dB.

Table 1. Data values when handoff was a failure

Name of Parameter	Value
Primary CPICH power (dBm)	40
Used Frequency Threshold E_c/N_o (dB)	12
Used Frequency Threshold RSCP(dBm)	-100
Handoff margin (dB)	3

Table 2. Data values changed for successful handoff

Name of Parameter	Value
Primary CPICH power (dBm)	40
Used Frequency Threshold E_c/N_o (dB)	15
Used Frequency Threshold RSCP (dBm)	-97
Handoff margin (dB)	2

Hence using the Atoll software, the different technologies can be compared when a particular cell has different types of technologies working together and the mobile receiver can opt for the best one in different scenarios. It will help to avoid unnecessary handoffs that can cause ping pong effects. Also the lower limits and marginal values for the handoff are set so as to provide users with best quality signal for call processing.

6. CONCLUSION

This paper has used the predefined results of a radio network controller element manager to perform handoffs in various situations to express the various conditions required for a fruitful and successful handoff without causing ping pong effect which occurs due to frequent handoffs and burdens the MSC. It also deals with the problems of unnecessary handoffs. In this paper, handoff decisions are made on the basis of parameters like receiver level and receiver quality of the two technologies (GSM and UMTS) used. In future, evaluation of vertical handoff could also be done using different network technologies.

7. ACKNOWLEDGMENTS

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