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DESIGN OPTIMIZATION OF TRACKING AREA LIST FOR REDUCING TOTAL SIGNALING OVERHEAD IN LTE SYSTEMS

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ABSTRACT

In Long Term Evolution systems (LTE) the perception ofTracking Area List (TAL) is introduced. TAL contains of a group of Tracking Areas (TAs), and it is assigned to a User Equipment (UE), the UE does not requirement to register its position when it moves within TAs of the assigned TAL. If an optimum TAL design is working this may result in the discount of total gesticulating overhead cost introduced by location update and paging procedures. One of the challenges of mobility management in cellular networks is the lessening of overall signaling overhead while maintaining acceptable performance. In this paper we propose a TAL design optimization for reducing overall signaling overhead procedure. To achieve optimal TAL design a cell may change its current TAL, and this may cause a service interruption for active UEs in that cell. A budget pressure parameter is introduced to define the extreme number of cells change TALs while upholding improved performance. For UE mobility modeling the data obligatory can be obtain from the system management system which are cell weight and handover statistical data. Markov model is used for UE flexibility modeling. We present arithmetical results, from which we can say that the optimum TAL design reimbursed from the proposed procedure gave considerable discount of overall signaling upstairs cost compared to the outdated TA design.

Keywords: *LTE, Location Update, Paging, SignalingOverhead, TAL.*

I. INTRODUCTION

In cellular announcement networks, mobility administration contains of location registering (location update) and paging, and it is one of the most essential techniques to provide announcement services to UEs. Mobility administration in Long Term Evolution (LTE) is different from that in the third peer group mobile telecommunication networks. The TA is definite as an area in which the user equipment (UE) may move freely without informing the MME. Tracking Area (TA)is a cluster of evolved Node Bs (eNBs) having the same TA code [9],[10]. In the standard TA scheme, having TA withsmall size (few number of cells) eliminates the paging signaling overhead; on the other hand having TA with a large size removes the location update overhead. When a UE receives a call, the network must page cells within the Location Area (polling) to find that user as rapidly as possible. This process all induces system overhead in both organization signal and wireless bandwidth ingesting. If the wired network knows the exact position of a UE, the paging cost can be condensed to a lowest by polling only the cell in which the UE is situated. On the other dangerous case, if the wired network does not have any material about the location of the UE, cells all over the wireless network have to be questioned. This costs the maximum system upstairs. So the problem is how to find an optimum TA design which gives reduction in signaling overhead and optimal balance amongst Tracking Area Update (TAU) and paging signaling upstairs. Limitations of the tracking Area arrangement can be summarized as follows:

- Ping Pong effect: Here if the UE interchanges back and forth between two or three adjacent TAs and this will cause excessive TAU, because when UE enters a new TA it will perform TAU.
- Massive Mobility Gesturing Congestion: Here If a large number of users immediately move into a hotspot cell, this will cause excessive TAU from the UEs, in a short old-fashioned of time.

In LTE networks Tracking Area List (TAL) scheme has been make known to to solve a problems existing in the ordinary TA scheme such as ping-pong, massive flexibility problems deliberated above and containedprickles in uplink traffic flow problem [1],[5]. The MME delivers the UE with a list of TAs where the UE registration is valid. The network apportions a list with one or more TAs to the UE. The UE may move freely in all TAs of the list without informing the MME. When the MME sheets a UE, a paging communication is sent to all compartments in the TAL.

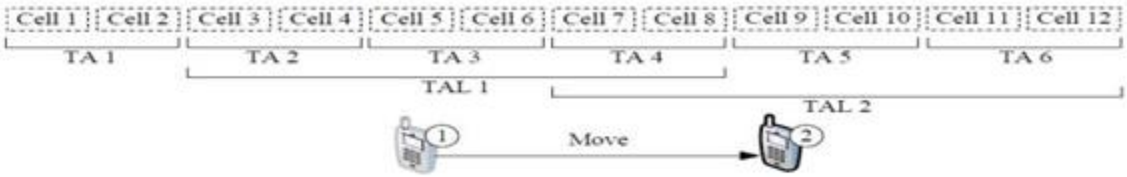

Fig.1 above shows an instance of a TAL scheme.

In Long Term Evolution (LTE), the Mobility Management Entity is associated to a group of progressed Node Bs (eNBs; the LTE term for base postings). The radio treatment of an eNB (or a sector of the eNB) is called a cell (see the dashed squares. Every cell has aexceptional cell identity. The cells are congregated into the Tracking Areas (TAs; e.g., TA 1 contains Cell 1 and Cell 2. Every TA has a unique TA Identity (TAI). The TAs are additional grouped into TA Lists (TALs). In Fig.1 TAL1 consists of TA 2, TA3, and TA4. A UE stores the TAL that comprises the TA where the UE resides. In Fig.1, the UE is covered by Cell 5, and the TAL it stores is TAL1={TA 2, TA 3, TA 4}. If the LTE system attempts to connect to the UE, it asks the cells in the TAL (e.g., Cell 3-Cell 8) to page the UE. Every eNBoccasionally broadcasts its TAI. The UE listens to the transmission TAI and checks if the received TAI is in its TAL. If so, it means that the UE does not change out of the current location. When the UE changes from Cell 5 to Cell 7, it receives the TA4 identity communication from eNB7. Since TA4 is comprised in TAL1, the UE still resides in the same location. When the UE moves to Cell 9 the received TA5 individuality (broadcast from eNB9) but is not found in TAL 1, which means that the UE has moved out of the present location. In this case the UE executes the location inform procedure to inform the MME that it has left TAL1. The MME then allocates a new TAL to the UE. Now the new TAL is TAL2= {TA4, TA5, TA6}. In LTE systems TALs for different UEs may have different sizes, and the newly allocated TAL may be overlapped with the beforehand assigned TAL (as shown in the preceding example) [6].

In this paper we proposed a TAL design optimization for reducing overall gesticulating overhead procedure, this algorithm returns an optimum design of TALs (which gives minimum total signaling overhead) by using the available data obtained from the network administration system which are cell load and handover arithmetical data during a given period of time. The optimum design was obtained by initially chosen random cells and changing the TAL of those cells till we reach the optimal design for all TALs in the network. In overall the TAL of a cell can be adapted at a time by either deleting or adding one of the cells in the TAL. For each cell in the network and if the cell variations its TAL this will causes service intermission, the cell load of the cell (number of active and idle UEs in the cell) is used to amount this service interruption in that cell. When smearing the design to the suggested network it gave considerable reduction of total gesturing overhead.

The rest of this paper is organized as follows: In Section II related works is abridged. Section III descries the proposed algorithm. Mathematical results are presented in Section IV. Finally, Section V concludes the paper.

II. RELATED WORK

In Personal Communication Services Networks (PCS) numerous strategies were projected to reduce the location update cost. In [7] the researchers studied a special case of a location following algorithm called the Alternative Location Algorithm (ALA) . This special case is referred to as the Two Location Algorithm (TLA). An investigative model is proposed to associate the performance of TLA and the IS-41 protocol. The study designates that the performance of TLA is significantly affected by the user moving designs and the call traffic. If the user mobility is higher than the call frequency or the user tends to move back to the previously visited registering areas, then TLA may meaningfully outperform IS-41.

Many researches in the literature aimed to contribute in plummeting total signaling overhead in LTE networks. TAL concept is expecting to reduce the overall signaling overhead when compared to outdated TA concept. In [2] the authors proposed a method for allocating and transmission TALs for LTE networks. This method is called "Rule of thumb". The optimal conventional TA design was associated with the proposed TAL; it found that TAL everything best if a dynamic recurrent reconfiguration is applied for different time intervals. The Rule of thumb technique is simple and cannot guarantee to give an best TAL design because each cell in the network is selfishly optimizing the gesticulating overhead according to their own data and does not measured the impact of the other cells on their modified TAL.

In [4] the authors familiarized an approach for allocating and transmission TALs, here the impact of national cells was considered, and the data required for TAL allocation is the identical data used of TA design, which are the cell load and handover statistics. These data can be obtained from the mobility management arrangement in the network. In the proposed scheme different users UEs in one cell are holding different TALs according to the original cell they are registered in. The authors aimed to show that even with anunassuming algorithm a TAL design is able to reach a lower complete overhead than the conventional TA design. The proposed algorithm takes into account the impact of neighbor cells in the distribution of TALs. The impact of the neighbor of neighbor cells is not considered, if it was painstaking this will gives more precise design, but the algorithm will be byzantine.

In [1] the local search procedure is introduced for scheming TALs. The input data required for implemented the algorithm was the same data required for designing standard TA (cell load and handover statistics). The basic process of the algorithm was to modify the TAL of a cell at a time by either deleting or adding one of the cells in the TAL, at each trial the general signaling overhead is intended, the algorithm was recurring until lower signaling overhead was touched.

All of the algorithms mentioned above were executed using the available arithmetical data from the network mobility management system and were self-governing of UE traces. The enterprise of TALs based on UEs traces is also imaginable. Here each cell is able to assign dissimilar TALs to different UEs. But if the UEs change their undertaking, which is quite probable the TALs would become incompetent.

III. TAL DESIGN OPTIMIZATION ALGORITHM

From the design of the planned algorithm we tried to find an optimal TALs design, which gives minutest overall signaling overhead. Here a budget limitation is defined because the TAL of a cell can be adapted at a time t by either deleting or adding one of the cells in the TAL. For every cell in the network and if the cell fluctuationsit's TA (change its e nodeB) this will causes service intermission for active UEs on that cell, the cell load (Number of active and idle UEs in the cell at time t) of a cell is used to measure the service interruption in that cell. To find an optimal design of TAL the service intermission is taken into account and the problem can be defined as discovery an optimum design of TAL which gives smallest total signaling overhead and satisfies (1) above. The procedure is examined for different suggested values of parameter B and for the system which descried in Section A below.

A. Network Description

Network explanation is similar to [3]. The network has hexagonal cellular configuration with 61 cells, each cell has a unique cell identity or index (see fig.2 below), and every TA has anexceptional TA identity (TAI). When UE interchanges into cell i it resides in the cell for anaccidental period of time and then moves out in the bearing of one of six neighbor cells. In the proposed algorithm TAL overlapping was well-thought-out whichmeans that one TA can be included in more than one TAL. The UE mobility model used is markov model. We assumed that the TA contains only of one cell, and no constraint on number of TAs within a TAL. A UE stores the TAL that comprises the TA where the UE resides, when the UE moves out from its current TAL in this case it will implements the location update procedure to inform the MME that it has left current TAL. Then the MME allocates a new TAL to the UE. The newly allocated TAL maybe overlapped with the beforehand assigned TAL as deliberated in section I. We assumed that there is no addition between the suggested LTE arrangement and any Radio Access Technology (RAT).

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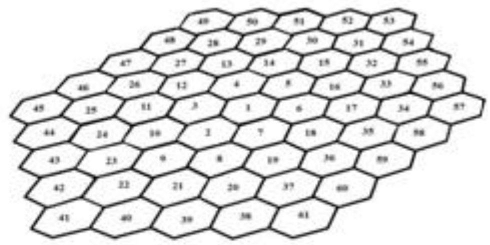

Fig. 2. Network cells

In the projected network the calculation of the complete signaling is depends on the existing statistical data obtained from the network organization system. Here the data used for scheming are the cell load and handover arithmetic data. These data are generated using a UE mobility model. Also the design of TAs and TALs touches the calculation of complete signaling overhead.

B. Ue Mobility Model

UE undertaking and mobility behavior in a cellular network can be labelled by cell residence time and assignment probability calculated for each cell in the system based on the time series of the stayed cells of the UEs [4]. Cell house time and handover statistics can be obtained from the management system of the cellular network. From the literature there are different UE mobility models that can be used to describe UE suppleness behavior [11],[12],[13]. Markov model is widely used for this determination. And in the proposed algorithm it's used for UE flexibility modeling. It's a mathematical model that undergoes transitions from one state to another, between a finite or countable amount of possible states. It is aninadvertent processtypicallyconsidered as memory less and the next state be contingent only on the current state and not on the arrangement of events that preceded it. This specific kind of "memory lessens" is called the Markov possessions. Markov model have many submissions as statistical models of real-world developments.

The Markov model, also known as the random-walk prototypical and it can be applied to cellular systems to pronounce individual responsibility behavior of UEs. In this model, the UE at any specified time slot will either continue within a cell or move to anadjacent cell according to a transition probability distribution, this probability is often adjusted to practical observations of UE performance in cells. In over-all the markov perfect can be described by the following:

- A markov chains with finite set S of m states.

$S = \{s_1, s_2, \ldots\ldots\ldots\ldots\ldots, s_m\}$. And in the estimated algorithm we used 7-state markov model (m = 7) anywhere each state epitomizes a radio cell in the network. For each cell in the system there are 6 neighbors (or less if the cell is incurable cell such as cell with index 57 in Fig. 2 which has only 3 neighbors).

- The State Transition Probability delivery matrix P with size (m×m). Element p_{ij} in this environment represents the likelihood of the undertaking of the UE from cell i to cell j in next time slot. Fig.3 below shows the state sketchand the changeover matrix of 7-state markov model. Cell c illustrate the current cell of the UE, and cell n_z is one of the national cells of cell c, where z=1,2,……,6.

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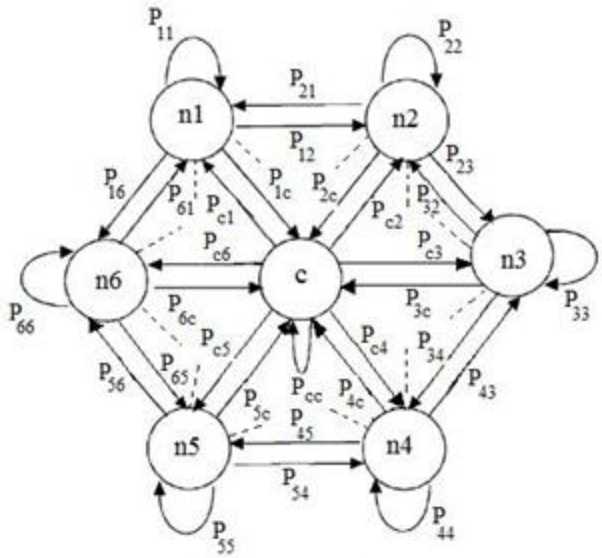

(a) The State Diagram

P =

P_{cc}	P_{1c}	P_{2c}	P_{3c}	P_{4c}	P_{5c}	P_{6c}
P_{c1}	P_{11}	P_{21}	P_{31}	P_{41}	P_{51}	P_{61}
P_{c2}	P_{12}	P_{22}	P_{32}	P_{42}	P_{52}	P_{62}
P_{c3}	P_{13}	P_{23}	P_{33}	P_{43}	P_{53}	P_{63}
P_{c4}	P_{14}	P_{24}	P_{34}	P_{44}	P_{54}	P_{64}
P_{c5}	P_{15}	P_{25}	P_{35}	P_{45}	P_{55}	P_{65}
P_{c6}	P_{16}	P_{26}	P_{36}	P_{46}	P_{56}	P_{66}

(b) The Transition Probability Matrix

Fig.3.The state diagram and the transition probabilitymatrix of a 7-state markov model

Probabilities introduced in the changeover probability matrix shown in Fig.3 above are well-defined as the handover probabilities, and can be intended from UEs handover arithmetical data obtained from the systemorganization system [3]. The UE can be located in 7 different conditions during each time slot contingent on handover likelihood of each neighbor cell.

- The steady state likelihood distribution vector in which π_i is the likelihood of a UE being in state i (from which cell residence time can be calculated). We expected that cell house times are Independent Identical Distributed random variables (IID) with average residence time 1/ƛ. The stable state distribution of the cell residence time contents the following equation:

We assumed that at any given time slot in the suggestion matrix and if the UE decided to make anassignment process, it will move to the neighbor cell with high deliverylikelihood. Handover values (number of users making assignment) which are used to calculate the handover probability discussed above are generated arbitrarily but in real world it can be gotten from systemorganizationscheme.

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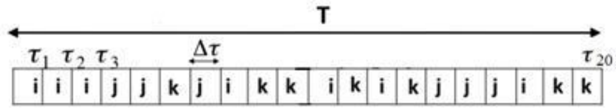

Fig.4. An example of one raw in the trace matrix

In the example shown in Fig.4 the time intermission T is divided into 20 time slots. The compartment load u_i is defined as the total number of UEs in cell i scaled by the time magnitudes that the UEs spend in cell i. Consequently, the load of each cell in the network is aggregated by the ascended values of UEs staying in the cell consuming all the fundamentals of the trace matrix. The combineddelivery value is the number of interchanges from one cell to another [1].

Consider the example above, the aggregated cell load and handover for UE_v are:

$u_i = 0.35$, $u_j = 0.3$, $u_k = 0.35$, and $h_{ij} = 1$, $h_{jk} = 1$,$h_{kj}=2$, $h_{ji}=2$, $h_{ki}=2$, $h_{ik}=3$.Where Equation (7) below is used to calculate the overall signaling overhead for the TA scheme.

$$\sum \qquad \sum \quad (\qquad) \tag{7}$$

Whereh_{ij} is the amount of users performed delivery from cell i to cell j (if i and j are not in the same TA).
c^u is the update cost caused by one UE,
c^p is the amount of above of one contacting.

$\propto$ is the likelihood that a UE has to be paged (also called call intensity factor).

u_i is the total number of UEs in cell I climbed by time quantity each UE spent in cell i. It can be gotten by amassing UE statistics over anassumed time (using the trace matrix).

In (7) the first term represents the upstairs caused by the location apprise process for users affecting from cell i to cell j (if the two cells are not in the same TA), and the second term represents the upstairs caused by the paging progression (if the two cells are in the same TA).

Calculation Of Overall Signalingoverhead
To calculate overall gesturing overhead the cell load and delivery data between each neighbor cells are obligatory. These data are calculated directly from the trace environment discussed in Section *C*, Here the load of each cell was combined by the scaled values of UE staying in the cell using all rudiments in the trace matrix. In the proposed procedure we assumed that the TA contains only of one cell. For the outdated TA scheme handover data was combined from the trace environment as follows, if a UE makes handover from cell i to cell j this income that h_{ij} will increase by one, So the h_{ij} value also intended using all elements in the trace atmosphere.

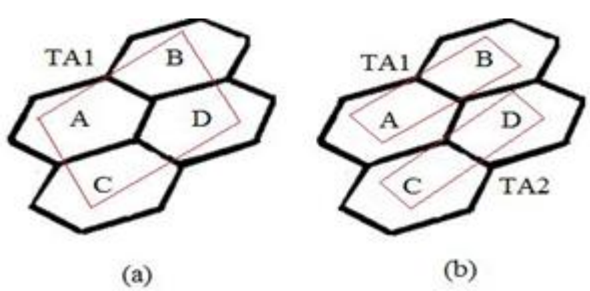

Fig.5. An example of the TA scheme

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Equation (7) is also valid in the scheming of the overall signaling upstairs for TAL scheme. For both outmoded TA and TAL schemes, the calculation of complete signaling directly above requires:

- A well-defined S(t) environment which represents the enterprise of TAs or TALs in the network,
- The cell load u_i for each cell in the system, and it can be obtained from the trace medium. Cell load is combined by the scaled values of UEs staying in the cell using all the rudiments of the trace matrix as deliberated in the example shown in fig3.
- Handover statistics which are the amount of users performed delivery from cell i to cell j. Also it can be found from the trace matrix deliberated in Section C.

Algorithm Body

The proposed procedure returns the overall gesticulating overhead cost for an optimal TAL design. First the value of limitation B should be strong-minded (It's the budget constrain stricture), this worth is a percentage of the entire cells load.An imperative variable also distinct which is bl variable. Initial worth of this variable is 0, and it's used to inconsistent whether the movement of cell j from its current TAL to additional TAL is within the budget constrain or not. When cell j variationsits current and preliminary TAL bl value will intensification by u_j (cell load value). And if cell I interchanges back from its current TAL to its opening TAL bl value will diminution by u_j.

Design Optimization of TAL Algorithm:

1- Definition:

2- ST is the initial S(t) matrix.

3- STT is the current S(t) matrix, which describes the current TAL design.

4- ADL is a set contains the indexes of the neighbor cells of TAL_i.

5- CS is the initial overall signaling overhead calculated based on ST matrix.
6- CSO is the minimum overall signaling overhead returned by the algorithm.

7- Construct the trace matrix.

8- Determine the starting TAL for each cell in the network to create the first column in the matrix.

9- Create the ST matrix according to equation ( ). 10- STT=ST; , CS=T_cost(ST);

11- calculate B.

12- bl=0; , l=1;

13- whilebl<B

14- select a random cell i
15- for j=1:61

16- If j is in same TAL with i , remove j from the TAL of i
17- updates$_{ij}$ element in the STT matrix,
18- For all p which is a cell included in TAL_i and TAL_j
update s_{jp} and s_{pj} elements. and ADL set
19- end
20- CSO=T_cost(STT);

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```
if CSO<CS
  ST=STT; CS=CSO; ADL=TN;
  bl=bl+U(j);
else
  STT=ST;  TN=ADL;
end
If j is not included in the list of I, added j to   the
list and then update s_ij element in the STT matrix. 28- For all p which is a cell included in TAL_i and
TAl_j update s_jp and s_pj .and ADL set 29- end
CSO=T_cost(STT);
if CSO<CS
  ST=STT; CS=CSO;, ADL=TN;
  bl=bl+U(j);
else
STT=ST; , TN=ADL;
end
end
end
```

IV. NUMERICAL RESULTS

Given the UE traces background and a TAL design the exact S(t) matrix fundamentals can be calculated and the combined cell load and handover data can be obtained as deliberated in Section C. The state changeover probability matrix publicized in Fib.6 below is used for handover decision in the trace environment. In this matrix probability values are considered using (6).

0.30	0.12	0.05	0.02	0.30	0.28	0.04
0.10	0.36	0.12	0.10	0.02	0.05	0.03
0.25	0.13	0.36	0.18	0.12	0.20	0.10
0.02	0.22	0.22	0.12	0.16	0.02	0.20
0.11	0.02	0.10	0.18	0.21	0.12	0.03
0.04	0.10	0.02	0.30	0.09	0.03	0.40
0.18	0.05	0.13	0.10	0.10	0.30	0.20

Fig.5: State Transition Probability Matrix

The tables below show the general signaling overhead intended from both standard TA optimal design algorithm implemented using the same organization as in [1] and the proposed TAL design optimization algorithm. In individually table the results calculated for ten dissimilar scenarios, each scenario characterizes a cell load and assignment data set. Each table represents the results for anassumed value for both B and $\propto$limits. B value is a fraction of total number of UEs(U) in the network. We predictable that the number of UEs in all UE trace situations is 6000. UEs were outlined for one hour period, this period was divided into 60 equal intermissions and each time intermission is equal to one miniature. We assumed that Cu =1,Cp =1 (common in the literature), Also

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we presumed that the regular value of *γis 0.05.*

In the enterprise of the network we presumed that there are 23 TAs. And each TA contains only one cell (to simplify calculations). Each TAL may cover two or three TAs (depends on the suggested initial TAL design). Tables below show the general signaling overhead calculations for dissimilar scenarios and data sets. For each scenario the location inform cost and paging cost were calculated. The measurement of the trace matrix in all scenarios is 6000×60. Numerical results obtainable in tables below show the location update, summoning cost and total cost for ten dissimilar scenarios.

Table i numerical results for b=15%u &∝=0.01.

Scen-ario	Optimum STA scheme			Optimum TAL scheme		
	TAU	Paging	Overall	TAU	Paging	Overall
1	25011	581	25592	19341	352	19693
2	25623	575	26198	19834	370	20204
3	25412	582	25994	20021	355	20376
4	25838	602	26440	20051	302	20353
5	24321	543	24864	19863	331	20194
6	25452	562	26014	19761	321	20082
7	24998	576	25574	20023	348	20371
8	25902	530	26432	20021	358	20379
9	25645	610	26255	19781	341	20122
10	24984	552	25536	20023	332	20355

Table Ii Numerical Results For B=100%U &□ =0.05

Scen-ario	Optimum STA scheme			Optimum TAL scheme		
	TAU	Paging	Overall	TAU	Paging	Overall
1	27511	931	28442	4226	1798	6024
2	27504	971	28475	4321	1781	6102
3	27555	967	28522	4223	1756	5979
4	26998	943	27941	4651	1795	6446
5	27541	930	28471	4659	1752	6411
6	27510	895	28405	4213	1734	5947
7	27453	984	28437	4551	1722	6273
8	27423	932	28355	4223	1793	6016
9	26978	951	27929	4512	1721	6233
10	27132	940	28072	4224	1790	6014

From tables shown above we may conclude the following:

- The total gesturing overhead calculated and chronicled in table I shows that the optimal design of TAL is 19% to 23% better than standard TA design. The summoning cost is less than the location update cost and it be contingent on the value of parameter ∝ . Results were calculated for B=15% and ∝=0.01 which income that 1% of the UEs will be paged in every cell.

- The overall signaling overhead calculated and shown in table II shows that the optimal design of TAL is 25% to 31% better than standard TA design. The summoning cost is less than the position update cost and better than the summoning cost shown in table I this is since here $\propto = 0.02$.

The overall signaling overhead shown in table III shows that the optimal design of TAL is 77% to 79% better than average TA design. And this because B is 100%U which earnings that there is no restriction in the enterprise of the TALs and we can freely move cells from TAL to another until we reach the optimal design. The table gives best results when compared to other tables, but with no inexpensive constrain the service intermission when changing the TAL of a cell will disturb the presentation of the network in a great method. In the proposed procedure average value of γ was preferred to be 0.05, and it's required to give a respectable estimation of γ because it inspirations the TAL design and the subsequentgesticulating overhead

V. CONCLUSION

In this paper we proposed enterprise optimization of TAL for reducing overall gesticulating overhead algorithm. The proposed algorithm returns the smallest overall signaling overhead intended based on the optimum TAL design. And markovmodel is used as the UE flexibility model. The numerical results gotten from the projected algorithm show that the design of TAL scheme with TAL overlapping decreases the overall signaling above your head compared to the normal TA scheme. And with great value of B we got healthierperformance of the TAL scheme but we should take into account the service interruption caused by cell undertaking from TAL to another to keep the acceptable presentation of the system. For future work we suggest to extend the idea of this paper to include a comparison between different flexibility models to examine their effect on the discount of overall gesturing overhead when applied to the same situation.

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