Difference-Based Joint Parameter Configuration for MRO and MLB

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Abstract—**Mobility Robustness Optimization (MRO) and Mobility Load Balancing (MLB) are two important functions of Self-Optimized Networks (SON). To improve the Key Performance Indicators (KPIs) of handover and load-balancing, conventional MRO & MLB approaches adjust different handover parameters respectively, based on cell-individual or cell-pairs. However, it is hard for these approaches to control the conflict between MRO and MLB, which results in unnecessary handovers for some users. In this work, a novel parameter configuration method for MRO and MLB is proposed, which jointly optimizes the performances of MRO&MLB by the adjustment of the same handover parameters for individual users. This method enables specific users to be correctly handed over to the neighboring cells. Simulation results show the proposed schemes can achieve better performances than the conventional scheme.**

Keywords-mobility robustness optimization;mobility load balance;joint parameter configuration;self-organized networks

I. INTRODUCTION

To reduce manual operations in wireless communication networks, self-optimized network (SON), which is taken as a promising technology, has attracted much attention in recent years, for example, introduced to 3rd Generation Partnership Project (3GPP) standardization. Mobility Robustness Optimization (MRO) and Mobility Load Balancing (MLB), which are two important functions in SON, have been deeply explored by the industry and academia. MRO aims to minimize handover problems, while MLB tries to balance unequal traffic loads among cells. However, the two functions operate independently in existing implementations, though they both adjust handover (HO) parameters to optimize their objectives.

Incorrect HO parameter configuration can negatively affect user (UE) experience and waste network resources by causing HO problems such as Ping-Pong handover and HO failure, and resulting in higher number of unsatisfactory users. HO-related failures can be categorized as: failures due to too late HO triggering and failures due to too early HO triggering. Signatures of too late HOs are summarized by [1]: (1) Radio link failure (RLF) occurs in the source cell before the HO is initiated or during HO procedure, (2) UE re-establishes the connection in a cell different to the source cell. While signatures of too early HOs are: (1) Radio link failure occurs in a short time after the UE successfully connects to the target cell, (2) UE re-establishes the connection in the source cell. To reduce the HO problems, an algorithm is proposed in [2], which adjusts the handover parameters, i.e. Hysteresis and Time-to-Trigger (TTT). On the other hand, to improve the number of satisfied UEs, load can be shifted from over-loaded cells to low-loaded adjacent cells based on the tuning of HO offsets [3].

Because MLB algorithms may have negative impacts on the performance of MRO, interaction between MLB and MRO was considered in [4]. The MLB function adjusts the handover offsets to adjacent eNB and thus shifts the virtual border and the MRO function tunes the handover hysteresis and Time-To-Trigger parameter pair to shift the virtual border. When there are conflicts between MLB and MRO, an SON coordinator will take corresponding actions, e.g., switching off MLB algorithm. Even adjusting the same handover parameter, the conflict may occur between MRO and MLB when they adjust the handover parameter in opposite directions. In order to prevent the occurrence of the conflict, the authors set an allowed range for MLB in which the handover problems can be prevented [5].

However, the above methods, which both adjust parameters to the same value for all of UEs in the cell, will result in unnecessary handovers for some users that should not be handed over to the neighboring cells, which is different to Ping-Pong handover. Moreover, to simply turn off MLB algorithm still cannot improve users' satisfactions. In order to avoid this problem, we present a difference-based joint parameter configuration method for MRO&MLB, which jointly optimizes the performances of MRO&MLB based on the adjustment of the same handover parameters for individual users. This means each user that should be handed over to the neighboring cells is with individual value of the same HO parameters.

The remainder of this paper is organized as follows. In Section II, we propose the difference-based joint parameters configuration method for MRO&MLB, especially for different MRO&MLB KPI cases. In Section III, the performance of the difference-based joint parameter configuration method is evaluated and conclusions are given in section IV.

II. DIFFERENCE-BASED JOINT PARAMETER CONFIGURATION FOR MRO&MLB

Suppose there are multiple UEs located in the overlap areas between cell 0 and cell i (i is the index of the neighboring cells of cell 0), and k UEs need to be handed over to cell i, as shown in the Figure 1.

A. Identifying UEs for necessary handovers

As described in 3GPP TS 36.331 [6], in LTE network, the UE reports measurement information in accordance with the measurement configuration provided by the Evolved Universal Terrestrial Radio Access Network (E-UTRAN), which can be based on RRC_CONNECTED messages by means of dedicated signaling, i.e. using the RRC Connection Reconfiguration message. Thus, the related measurement information of serving cell and neighboring cells can be acquired. When UEs measure Reference Signal Received Powers (RSRPs) above a threshold from more than one cell, eNodeBs can identify that these UEs are located in the overlap areas.

Then among those, UEs that locate in the overlap areas and need to handover can be identified based on statistical KPIs, such as the number of unsatisfied user, call drop ratio, handover failure ratio and ping-pong handover ratio. This procedure involves three main steps:

- Identify cells to be optimized. Each cell periodically accounts the MRO&MLB KPIs, say handover failure ratio, ping-pong handover ratio, unsatisfied users and call dropping ratio based on measurement reports from UEs and the distribution of loads. When KPIs of one cell become worse, e.g., its KPIs are lower than the preset thresholds during m continuous statistical samples; we can take the cell as a problem cell. The cell with the worst KPIs and its neighboring cells are selected to optimize, e.g. cell 0 and cell i mentioned in Figure 1.
- Identify UEs with handover problems. According to the signaling with regard to handover failure, such as radio link failure indication, handover report or RRC connection reestablishment request, UEs that occur too-late handover, too-early handover, ping-pong handover or handover for MLB can be identified in a statistical period n that consists of m statistical samples, say $n+1,\ldots,n+m$.
- Identify UEs to be handed over in overlap area. UEs with handover problem can be compared with UEs in cell overlap areas, thus, we can specify UEs located in cell overlap areas, which need to be handed over.

B. Handover priority computation for UE

In the following, we compute the handover priority of the above UEs. Suppose P_1, P_2 and P_3 represent the priority of UEs for too-late handover, too-early handover and ping-pong handover, respectively, there is

$$P_1 > P_2 > P_3 \tag{1}$$

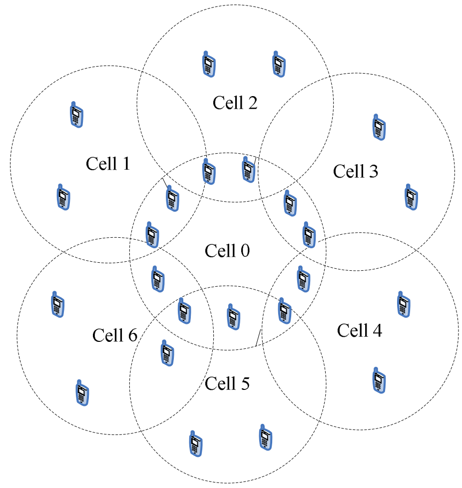

Figure 1 System scenario

- *Case 1: Only MRO KPIs worsen*

For each UE that need to be handed over, there is

$$P_{UE_k}^{MRO} = \alpha l_{UE_k} + (1-\alpha) M'_{i,UE_k} \tag{2}$$

Where $P_{UE_k}^{MRO}$ represents the handover priority of UE_k, and $0 \le \alpha \le 1$ is a coefficient. l_{UE_k} means the normalized number of handover problems occurred for UE_k in one statistical period, it can be written as

$$l_{UE_k} = \frac{w_1 l_{UE_k-1} + w_2 l_{UE_k-2} + w_3 l_{UE_k-3}}{w_1 + w_2 + w_3} \tag{3}$$

Where w_1, w_2 and w_3 are the weight factors of too-late handover, of too-early handover and of ping-pong handover for UE_k respectively. l_{UE_k-1}, l_{UE_k-2} and l_{UE_k-3} mean the normalized numbers of too-late handover, of too-early handover, of ping-pong handover for UE_k in one statistical period, respectively.

$M'_{i,UEk}$, which means the normalized Reference Signal Received Power (RSRP) increment for the reconnected user k from serving cell 0 to neighboring cell i, can be expressed as

$$M'_{UE_k} = \gamma_1 (M_{i,UE_k} - M_{0,UE_k}) + \gamma_2 \tag{4}$$

Where M_{0,UE_k} and M_{i,UE_k} mean the measured RSRP of UE_k for cell 0 and cell i, respectively. γ_1 and γ_2 represent coefficients.

Therefore, we can get $P_{UE_k}^{MRO}$ according to equation (2). Then we sort $P_{UE_k}^{MRO}$ in a descend order, the larger $P_{UE_k}^{MRO}$, the higher handover priority.

- *Case 2: Only MLB KPI Worsen*

The handover priority of UE for MLB is defined by the increment of resources brought by handing over UE to neighboring cell. Thus, the handover priority of UE_k for MLB can be expressed as

$$P_{UE_k}^{MLB} = \zeta_1(N_{0,UE_k} - N_{i,UE_k}) + \xi_2 \quad (5)$$

Where N_{0,UE_k} and N_{i,UE_k} are the used and required number of PRBs for UE_k in cell 0 and cell i, respectively. ξ_1 and ξ_2 represent coefficients.

For each connected user k, the used number of PRBs in cell 0 can be expressed as

$$N_{0,UE_k} = \frac{D_{UE_k}}{R(SINR_{0,UE_k})} \quad (6)$$

Where D_{UE_k} represents the demanded data rate of UE_k, $R\left(SINR_{0,UE_k}\right)$ represents the data rate per PRB given $SINR_{0,UE_k}$.

The SINR of user k after handover to neighboring cell i can be obtained using prediction scheme [7], thus required number of PRBs in cell i can be expressed as

$$N_{i,UE_k} = \frac{D_{UE_k}}{R(SINR_{i,UE_k})} \quad (7)$$

Therefore, we can get $P_{UE_k}^{MLB}$ according to equation (5). Then we sort $P_{UE_k}^{MLB}$ in a descend order, the larger $P_{UE_k}^{MLB}$, the higher handover priority.

- *Case 3: MRO&MLB KPI Worsen*

We define P_{UE_k} as the priority of MRO&MLB for UE_k,

$$P_{UE_k} = \frac{(\lambda_1+\lambda_2)P_{UE_k}^{MRO} + (\lambda_3+\lambda_4)P_{UE_k}^{MLB}}{\lambda_1+\lambda_2+\lambda_3+\lambda_4} \quad (8)$$

Where $\lambda_1, \lambda_2, \lambda_3, \lambda_4$ represent the weight factors of handover failure ratio, ping-pong handover ratio, the number of unsatisfied users and call dropping ratio, respectively, which depend on the policies of operators.

We sort P_{UE_k} in a descend order, and then UE with the highest P_{UE_k} is the first one to be handed over, while that with the lowest P_{UE_k} is the last one to be handed over.

C. *Parameter configuration and adjustment*

Generally, the adjustable parameters for MRO&MLB consists of cell individual offset (CIO) and time to trigger (TTT). In this work, we propose two schemes for the joint parameter configuration for MRO&MLB. One is Diff-MROMLB that adjusts only cell individual offset (CIO) parameter and another is Diff1-MROMLB that jointly adjusts CIO and TTT parameters. Thus, we can calculate the required CIO or jointly adjust CIO and TTT parameters for each UE to be handed over, and then send the configuration to it. According to Event A3, there is

$$\begin{cases} M_{i,UE1} > M_{0,UE1} + Oc_{0,UE1} - Oc_{i,UE1} + Hysteresis + HOoffset \\ M_{i,UE2} > M_{0,UE2} + Oc_{0,UE2} - Oc_{i,UE2} + Hysteresis + HOoffset \\ \cdots \\ M_{i,UEk} > M_{0,UEk} + Oc_{0,UEk} - Oc_{i,UEk} + Hysteresis + HOoffset \end{cases} \quad (9)$$

Where $M_{i,UEk}$ and $M_{0,UEk}$ represent the measured RSRPs of UE_k for cell i and cell 0 respectively. Oc_{0,UE_k} and Oc_{i,UE_k} are the cell specific offsets of the serving cell and the neighboring cell for UE_k, respectively. *Hysteresis* and *HOoffset* represent the hysteresis parameter and the offset parameter of Event A3 respectively.

Setting $CIO_{UE_k} = Oc_{0,UE_k} - Oc_{i,UE_k}$, the above inequation can be rewritten as

$$\begin{cases} M_{i,UE1} > M_{0,UE1} + CIO_{UE1} + Hysteresis + HOoffset \\ M_{i,UE2} > M_{0,UE2} + CIO_{UE2} + Hysteresis + HOoffset \\ \cdots \\ M_{i,UEk} > M_{0,UEk} + CIO_{UEk} + Hysteresis + HOoffset \end{cases} \quad (10)$$

Thus, we can get the required CIO for each UE to be handed over.

Additionally, we can jointly adjust CIO and TTT parameter to observe the effect of faster handover of high priority users on KPIs of networks.

III. PERFORMANCE EVALUATION

A. *Simulation Scenario*

We consider Manhattan simulation scenario. In the simulation topology, there are 61 cells placed in regular hexagonal grids. Radius of each cell is 250 m. Red lines on the Figure 2 denote streets. From 550 to 875 users move along the streets with constant velocity and turn probability in crossings is 0.5. User's velocity distribution is shown in Figure 3.

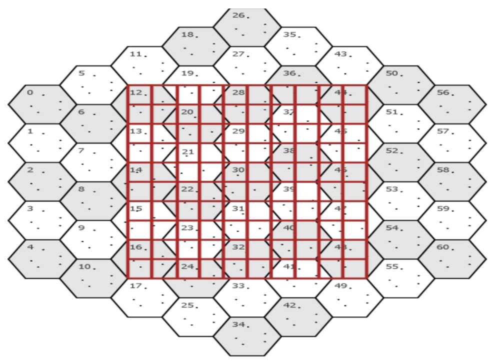

Figure 2 Simulation Scenario

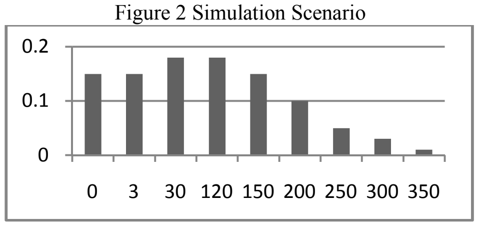

Figure 3 User's velocity distribution

All the users have 170 kbps Constant Bit-Rate (CBR) application. Iterative solution [8] for calculating $SINR_{UE_k}$ and $\hat{\rho}_c$ with exit condition based on converge accuracy and number of iterations are used.

The simulation parameters settings can be found in the following table I.

Each cell executes the algorithm that has two parts. One is event-driven and performs registration of "ping-pong", "early incoming" and "lately outgoing" problems in history windows. Another periodically computes CIO parameter of A3 event for all users connected to the cell. Periodically executed part of algorithm of cell 0 is described below, as shown in Figure 4.

TABLE I. SIMULATION PARAMETERS

Parameters	Assumption
M_{PRB_i}	50
BW	180kHz
$R(SINR_{UE_k})$	$R(SINR_{UE_k}) = 0.6\log_2(1+SINR_{UE_k})BW$
D_{UE_k}	170kbps
N_{UE_k}	$N_{UE_k} = \frac{D_{UE_k}}{R(SINR_{UE_k})}$
$\hat{\rho}_c$	$\hat{\rho}_c = \frac{1}{M_{PRB}} \sum_{u \in c} N_{UE_k}$
z	$\sum_{\forall c} \max\left[0, M_c(1-\frac{1}{\hat{\rho}_c})\right]$
HOF	$\frac{N_{HOfail}}{N_{HOsucc}+N_{HOfail}}$
HPP	$\frac{N_{HPP}}{N_{no-HPP}+N_{HPP}+N_{HOfail}}$
CDR	$\frac{N_{dropped}}{N_{accepted}}$
Hysteresis	3 dB
CIO_{UE_k}	[-24,-22,-20,-18,-16,-14, -12,-10,-8,-6,-5,-4,-3,-2,-1, 0,1,2,3,4,5,6,8,10,12, 14,16,18,20,22,24] dB
α	0.6

Notes: reference to [6] and [7].

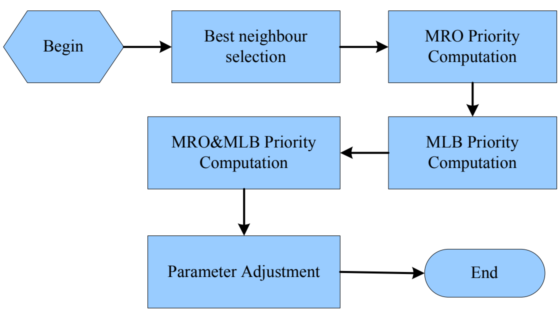

Figure 4 Simulation Procedure

B. Simulation results

This section presents a comparison between the reference scheme and the proposed schemes. In the reference scheme, the adjusted parameters for each UE, such as CIO and TTT, are the same, which means it is based on the adjustment of cell-individual parameters. While in the proposed schemes, the adjusted parameters for each UE are different. *Diff-MROMLB* scheme adjusts only CIO parameter and *Diff1-MROMLB* scheme jointly adjusts CIO and TTT parameters.

Figure 5 shows the handover failure ratio varying with the number of UEs. The blue curve refers to the reference scheme, while the red and green curve refers to the difference-MROMLB scheme and difference 1-MROMLB scheme, respectively. It is obvious that the handover failure ratio of the proposed schemes are better than that of the reference scheme because the proposed schemes reduce the cell load by handing out users which may have better signal or load in the neighboring cells which in turn allow other users hand in. Moreover, Diff1-MROMLB performs better than Diff-MROMLB because it handovers such users with higher handover priorities faster. Figure 6 shows the ping-pong handover ratio varying with the number of UEs. However, it can be seen that the performance of the reference scheme is better than those of the two proposed schemes. This is due to the fact that ping-pong handover does not have effect on user experience, and ping-pong handover problem is not taken as the important improving performance in these two proposed schemes (i.e. the weight of ping-pong handover, λ_2 is small).

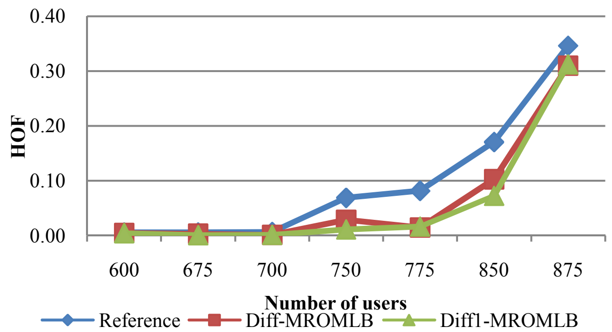

Figure 5 the performance of Handover failure ratio

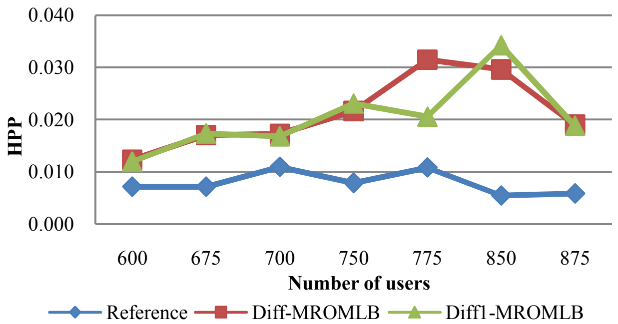

Figure 6 the performance of Ping-pong handover ratio

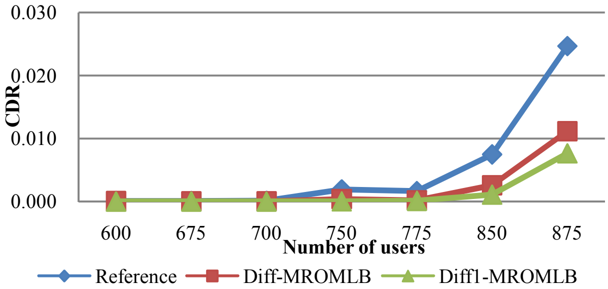

Figure 7 the performance of call dropping ratio

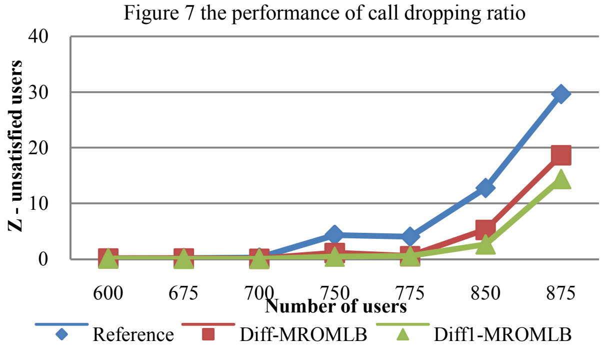

Figure 8 the performance of unsatisfied users

As shown in Figure 7, the call dropping ratio varies with the number of UEs. It can be seen that the proposed schemes are better than the reference scheme because the proposed schemes avoid the unnecessary handovers for some UEs by selecting suitable UEs to be handed over, and setting different parameters value for each UE. Moreover, the proposed schemes reduce the cell load by selecting suitable UEs to be handed over to neighboring cells which in turn allows other users to hand in before RLF may happen. Additionally, it can also be seen that KPIs improvement becomes more obvious with the increase of number of users because the difference of environment where users located is more evident. Furthermore, Diff1-MROMLB performs better than Diff-MROMLB because it handovers such users faster.

Finally, the number of unsatisfied users varying with the number of UEs is shown in Figure 8. It can be seen that the proposed schemes outperform the reference scheme because the proposed schemes do not waste resource by selecting suitable handover UEs so as to assure enough resource for normal operation. Additionally, Diff1-MROMLB still performs better than Diff-MROMLB because handovers for necessary handover users are faster.

Therefore, in contrast with the reference scheme, the proposed schemes can achieve better performances KPIs.

IV. CONCLUSION

In this paper, we develop a difference-base joint parameter configuration method to avoid unnecessary handovers for MRO&MLB, which selects suitable UEs to be handed over to the neighboring cell based on their handover priorities for MRO&MLB. MRO and MLB both adjust the same HO parameters (e.g. CIO and TTT) for individual UEs under the context of multi-KPIs optimization, which is easy to control the conflict between MRO and MLB, and gets better trade-off of MRO KPI and MLB KPI. Simulation results show that the proposed schemes can achieve better performances for most of KPIs due to reducing unnecessary handover for some UEs, compared to the conventional scheme.

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