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Accumulative distance based Optimization of Handover delay in LTE Femtocell Network

Akkamahadevi.M.B[*1], Arathi R Shankar[2]
[*1,2] Department of Electronics and Communication, BMS College of Engineering, Bangalore, India
akkabgowda@gmail.com

Abstract

LTE stands for Long Term Evolution. Mobility in LTE Femtocell network is an issue when the Mobile Station (MS) moves and has to handover to Femto Base Station (BS). This results in unnecessary Femto BS scanning and handover delay, which may affect real-time applications. In this paper authors have proposed a method of scanning only two Femto BSs depending on the direction of movement of the mobile user. Due to this scanning time will be reduced compared to conventional scanning. Finally, depending on RSS and BW available at the shortlisted Femto BSs the handover decision is made.

Keywords: LTE, Femtocell, Accumulative distance, scanning, delay, throughput handover.

Introduction

LTE stands for Long Term Evolution [1]. It is the successor technology of UMTS and CDMA. It provides up to 50 times performance improvement and much better spectral efficiency compared to other cellular networks. It supports high date rates for the services such as voice over IP (VOIP), streaming multimedia, videoconferencing, etc and uses both Time Division Duplex (TDD) and Frequency Division Duplex (FDD) mode. In FDD uplink and downlink transmission use different frequency, while in TDD both uplink and downlink use the same carrier and are separated in time.

LTE uses OFDMA as the radio access method [2]. OFDMA helps in transmission of high quality signals in multipath mobile communication environments. OFDM and MIMO are two key technologies featured in LTE [3].WiMAX signals can reach up to 50 km but with very high degradation in signal quality [4]. WiMAX is much optimized for shorter distances like 1.5 to 5 km. On the other hand, LTE can cover up to100 km, which is twice as much as of WiMAX's coverage. LTE is different from other technologies of 4G [5] because it is completely integrated into the existing cellular infrastructure for 2G and 3G. This allows seamless handoff and backward compatibility with previous standards.

Femtocells are also known as HeNB (Home Evolved Node B) [6], [7]. The figure 1 indicates the coverage range of Macrocell (in this case LTE cell) and Femto cell. Femtocells are used in LTE network to satisfy the demand of high data rates [6]. Their coverage area is very small and deployed randomly. Efficient and cost-effective way of reducing the macro network's traffic is to deploy Femtocells [7].LTE Femtocells provide cost-effective solutions mainly for indoor applications [7], [9].

Figure 1: Macro cell and Femtocell coverage [8].

Mobility in LTE Femtocell network is an issue when the Mobile Station (MS) moves and has to handover to Femto Base Station (BS) [10]. This can cause unnecessary Femto BS scanning and handover delay, which may affect real-time applications [11]. In the proposed Accumulative distance based scanning method, only two Femto BSs are shortlisted for scanning depending on the direction of movement of the mobile user. Due to this scanning time will be reduced compared to conventional scanning. Finally, depending on RSS and BW available at the shortlisted Femto BSs the handover decision is made.

The rest of this paper is organized as follows: Section II introduces the conventional handover process in LTE Femtocell network. Section III presents the proposed Accumulative distance based

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handover scanning method. The simulation scenario and results are discussed in Section IV. This paper is concluded in Section V.

Conventional Handover Process in LTE Femtocell Network

Handover is a procedure to maintain the mobile user communication when MS moves from one location to another between the coverage areas of the BSs [10]. Handover have two phases namely the pre-handover phase and the actual handover phase. The first phase includes network topology advertisement and Femto BS scanning. The second phase includes handover decision and initiation. Due to the redundant scanning activities in this phase, all the data transmission will be paused, and it may cause handover delay and throughput degradation. This will affect the real-time continuity of multimedia data such VoIP and video conferencing.

Proposed method of Accumulative distance based handover scanning method

In this paper, Accumulative distance is used to determine the direction of MS movement and shortlist the Femto BSs in that direction. The Serving BS determines the locations of MS and Femto BSs by the LTE network's backbone. Depending on the past and present MS position, the Serving BS predicts the direction of MS movement which will be described in detail below. In this method the MS will scan only the shortlisted Femto BSs. In the case of conventional handover scanning mechanism in LTE, the MS performs redundant scanning of all the Femto BSs. The unnecessary scanning activities may cause delay and throughput degradation. This in turn affects the system performance. The proposed scheme reduces the number of scanning activities and the scanning duration. Thus overhead reduces and the overall system performance increases.

The flow of Accumulative distance based scanning mechanism is as shown in figure 2.

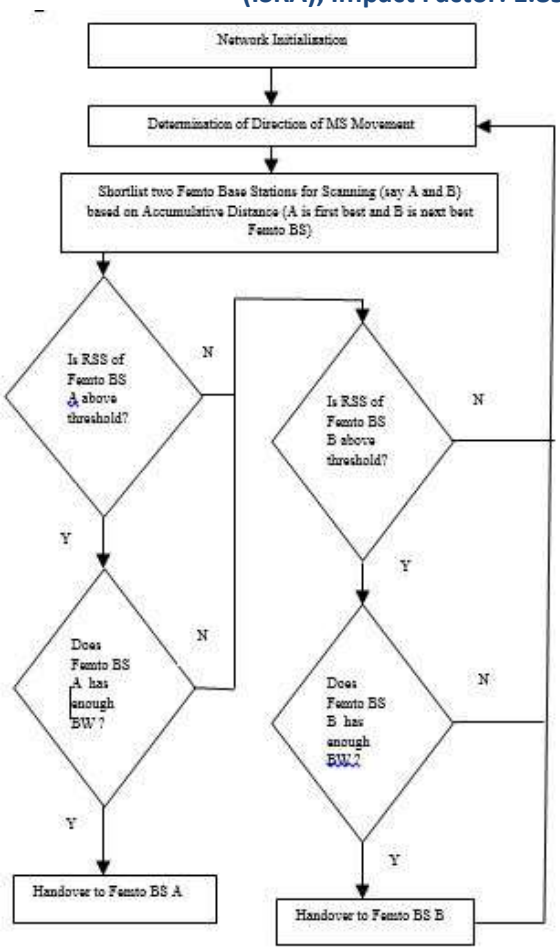

Figure 2: Flow of the Accumulative distance based scanning mechanism.

The network initialization phase consists of initializing the network with main LTE BS, Femto BSs and Mobile Stations as shown in figure4. The Serving BS tracks the direction of the MS movement. The BS coverage area is divided into zones and sectors as in figure 3. The BS coverage area is divided into three zones no handover (No-HO) zone, low handover (Lo-HO) zone and high handover (High-HO) zone based on signal quality. The handover probability of MS in No-HO zone is zero. Whereas, handover probability of MS in Lo-HO zone is low and handover probability of MS in High-HO zone is high. In the figure 3, Mobile Station (MS) moves from position 'i' to 'j' then to 'k'& finally to 'l' [10.]

The distance between MS at position 'i' (x_2, y2) and Femto BS1(x_1, y1) is calculated using equation1.

$$D1_i = \sqrt{\left((x_2 - x_1)2 + (y_2 - y_1)2\right)} \ldots . (1)$$

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Similarly, the distance between MS at position 'i' and other Femto BSs is calculated. Using the same equation the distance between MS at position 'j' and Femto BS is calculated. The difference in distance (DD) with respect to Femto BS 1 is computed using equation2.

$$DD1_{ji} = D1_j - D1_i \text{..... (2)}$$

The accumulative distance (AD) of the active MS (MS whose movement is tracked)with respect to Femto BS1 is calculated using equation3.

$$AD1 = DD1_{ji} + DD1_{kj} + DD1_{lk} \text{..... (3)}$$

Similarly AD is calculated with respect to remaining Femto BSs. The Accumulative distance(AD) is calculated at each position of MS. The two Femto BSs which have low value of AD are shortlisted. Suppose MS moves towards any Femto BS, the AD of that MS with respect to that particular Femto BS will be very less compared to all other Femto BSs. So, the Femto BS with least value of AD is considered as first best Femto BS. The Femto BS with next lesser value of AD is considered as next best Femto BS. If the Receive Signal Strength (RSS) of first best Femto BS is above the threshold and the number of users it is serving is lesser than the upper bound of users it is capable of serving, then handover to first best Femto BS takes place. Otherwise, if Receive Signal Strength (RSS) of next best Femto BS is above the threshold and the number of users it is serving is lesser than the upper bound of users it is capable of serving, then handover to next best Femto BS takes place. If both the above conditions are not satisfied then again the AD of MS with respect to all Femto BSs are calculated and entire process is repeated again.

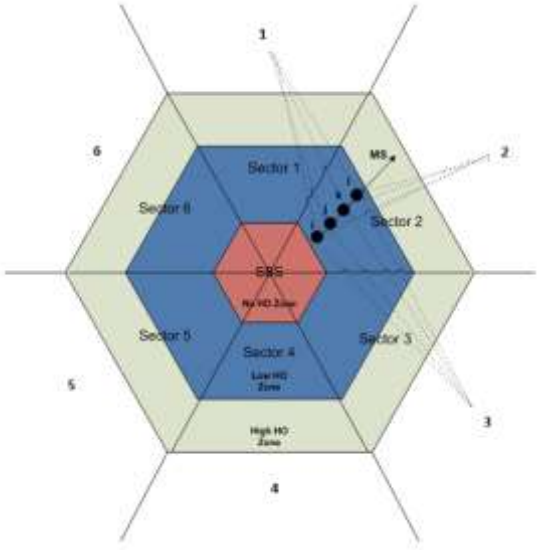

Figure 3: Scenario to explain the determination of direction of movement of MS.

Simulation scenario and results

The simulation is carried out in Matlab. The simulation scenario is indicated in figure 4. A cellular region of 120x120 square meters area is considered. It consists of one main LTE BS, four Femto BSs and sixty Mobile nodes. In the simulation scenario, the main LTE BS is represented as red star and its coverage range is depicted with large blue circle. The Femto BSs are indicated as green star. The Mobile Stations whose movement is not tracked are indicated as filled blue circles. The Mobile Station (MS) whose movement is tracked is indicated as black circle. The filled black circle indicates the first position of the MS whose movement is tracked whereas the other unfilled black circles indicates its subsequent positions. The femtocells' coverage area is divided into three zones as explained in the previous section. The Accumulative distance(AD) is calculed at each position of MS. The two Femto BSs which have low value of AD are shortlisted. Finally, depending on RSS and BW available at the shortlisted Femto BSs the handover decision is made.

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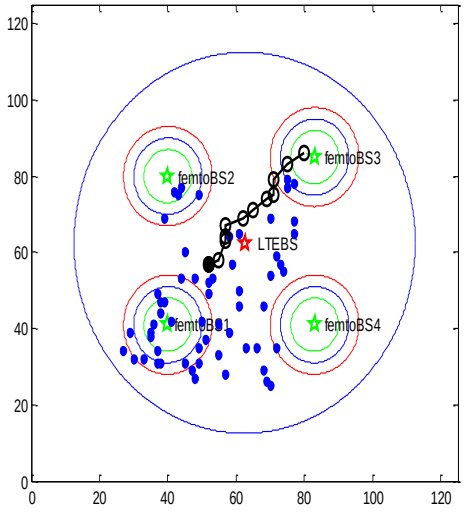

Figure 4: Simulation scenario

The comparison of handover methods is given in table 1.The scanning duration of AD based handover scanning mechanism is reduced by 20% compared to conventional scanning mechanism. The Comparison graph of handover scanning delay is indicated in figure 5.

Table1: Comparison table of handover methods

Handover methods	**Network initialization time (sec)**	**scanning time(sec)**	**Handover decision time(sec)**	**Total time(sec)**
Conventional method	7.239049	0.002551	0.000167	7.241767
Accumulative distance method	7.239049	0.002029	0.000003	7.241081
Reduction in time (sec)	0%	20%	82%	0.01 %

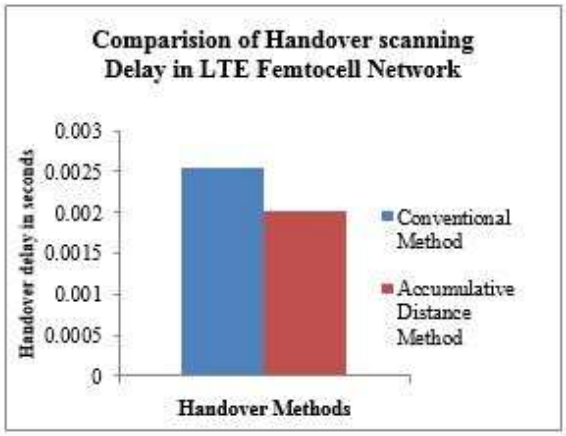

Figure 5: Comparison graph of handover scanning delay

Conclusion

In case of conventional handover scanning mechanism in LTE, the MS performs redundant scanning of all the Femto BSs. The unnecessary scanning activities may cause delay and throughput degradation. This in turn affects the system performance. The accumulative distance based handover scanning mechanism reduces the number of scanning activities and reduces the overall scanning duration. Thus overhead reduces and the overall system performance increases.

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