Optimized Adaptive Handover with Based on Type of Service for Densely Femtocell Networks

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Abstract. The limited transmission capacity of traditional cellular networks can not meet the demand of the rapidly growing mobile data traffic. The scheme of intensive deployment of FAP can alleviate network pressure, but it also brings some problems, such as frequent handover, ping-pong effect. This paper proposed an adaptive algorithm based on type of service handover algorithm to solve above problems. This algorithm not only considers the types of service, but also considers the influence of the neighboring list and the SINR value on the RSS value, which greatly reduces the handover times and the rate of handover failure. The simulation results show that it has achieved about 15% in reducing the probability of handover failure and about 13% in improving total system throughput.

1. Introduction
Ultra dense network (UDN) technology can effectively meet the needs of sharply increase 5G capacity. The future wireless communication network is a heterogeneous network with multiple access modes, which can provide different transmission rates, coverage and support for different service levels. Vertical handover technology is the key movement to realize seamless roaming in heterogeneous networks.

Deployment of femtocells with a small coverage range in wireless networks leads to a frequent handover initiation. The problem is more crucial when femtocells operate in an open access mode. Femtocell technology is an important technology for mobile operators to expand the coverage of mobile phones, which provide high-quality and high bit rate services for indoor users, and support the growing demand for data traffic in wireless networks.

UDN utilizes the macro massive deployment of Femto Access Point (FAP) that is low power and low cost, which can achieve great promotion for frequency reuse, thus to realize the local hot spot one thousand times of the ability to improve, but dense deployment of FAP will lead to more frequent handover and ping-pong effects. It is difficult to ensure the continuity of service.

The rest of the paper is organized as follows: Section 2 discusses the related work. Section 3 introduces the system model. Section 4 introduces the details of self-adaptive service-type handover algorithm and Section 5 shows the simulation results. Finally, Section 6 makes a conclusion of the paper.

2. Related Work
Comparing with macrocells [5], femtocells have the characteristic of lower-power, lower-cost and unplanned installations. It proposed a location-fingerprint based handoff decision algorithm so as to
improve the handoff performance and to offload cellular data traffic in densely deployed heterogeneous networks with femtocells. The handoff rate under base stations (BSs) cooperation for the user’s two transitions in ultra-dense network. Frequent handoffs in UDN cause the degradation of user experience[6], which should be considered for UDN deployment. In UDN, the handover rate of two transfer handoff of users based on BSs collaboration is analyzed. In addition, in BSs collaboration, the correlation between the two handover can affect the performance of the handover rate. Femtocell networks deploy large scale FAP nodes, which can meet the requirements of high data rate of wireless communication system and solve indoor coverage problem. The handover from FAP to FAP is very complex, as there can be hundreds of target FAPs as mobile terminals move out of their serving FAP. In [7], it proposes a FAP-FAP handover mechanism that considers factors such as the received signal level, the hidden FAP problem and the FAP access mode. The simulation results show that compared with the traditional scheme based only on the received signal level, the scheme proposed in this paper has lower handover failure rate and smaller neighbor FAP list. Two new methods of FAP handover selection are proposed, one is based on mobile prediction and the other is based on FAP capacity estimation [8][9]. The performance improvement of both methods is different from the traditional RSS-based unit selection method. It also suggests that there is a trade-off between reducing unnecessary handover and avoiding overloaded FAPs.

Base on the discussion above, we observe that the following issues in femtocell networks are not addressed for HO-decision algorithm:

• Indoor environment: Most of the literatures considered marco-femto and femto-marco, and seldom considered the deployment of femto in a large area indoors. In such a scenario, due to the small coverage of the femtocell, users could easily generate handover and ping-pong effects during the mobile process.

• Neighboring femtocell list: In order to reduce the time of target FAP selection, we propose an improved neighboring list of nodes. Different from previous literature, the number of users connected to FAP is also considered.

• New type of communication service: during the mobility process of UE, mobile terminal cannot always keep the same types of business all the time, so the business type might change casually. Given the above, the hysteresis margin value that affects the handover decision should change dynamically in view of the type of business that user is using.

3. System Model

As shown in Fig 1, in the femtocell networks, during the process of mobility users have many femto targets for handover.

![Fig.1 FAP Target Selection Scenario](image)

The total throughput $T$ of the system is denoted:

$$T = \sum_{d} \sum_{u} \beta_{u,d} c_{u,d}$$

(1)

where $\beta_{u,d}$ indicates that UE $u$ is connected to node $i$. And
\[ \beta_{u,i} = \begin{cases} 1, & i \leftrightarrow u \\ 0, & i \leftrightarrow u \end{cases} \]  

\( i \leftrightarrow u \) means user \( u \) connect to node \( i \), \( i \leftrightarrow u \) means there is no connection between the terminal \( u \) and the node \( i \). Also the \( C_{u,i} \) means the estimated throughput of UE \( u \) when user connected to node \( i \). It can be given as the following:

\[ C_{u,i} = \Delta f \log_2(1 + \alpha \delta_u) \]  

where \( \Delta f \) is the subcarrier spacing, \( \alpha \) indicates BER. Also, \( \delta_u \), which represents \( SINR_u \), is given as:

\[ \delta_u = \frac{\sum P_{Fr} G_F}{\sum_{m} P_{Mr} G_M + \sum_{p} P_{p'} G_{p'} + N_0 B} \]  

\( P_{Fr} \) and \( G_F \) are the received power and gain from serving femtocell, respectively. \( P_{Mr} \) and \( G_M \) are the received power and gain from macrocell, respectively. \( P_{p'} \) is the received power from neighbor femtocells.

4. Self-adaptive Service-type Handover Algorithm

In this section, a self-adaptive service-type handover algorithm is introduced. In daily life, people spend a long time in indoor environment, so the proposed algorithm is more suitable for indoor environment situation.

The most basic handover decision, \( RSS_T > RSS_S \), is that the RSS from target base station is greater than the RSS of source service stations. In order to reduce the probability of ping-pong handover, it proposes a concept \([5]\), namely hysteresis margin (HYM). The above formula is changed to:

\[ RSS_T > RSS_S + HYM \]  

The most commonly used algorithm is to set the offset: Threshold which could reduce the influence of macrocell on mobile user. Most of the traditional algorithms directly use the following formula to judge:

\[ RSS_F + \text{Threshold} > RSS_M \]  

So in indoor ultra-densely femtocell deployment scenarios, the value of \( RSS_F \) is far greater than from \( RSS_M \), the algorithm mentioned above do not apply in such situation.

We assume that the same transmit power is taken among all the FAPs with open access mode. the RSS from one femtocell is obtained as:

\[ P_f = P_t - P_{L_{Fr-U}} \]  

\[ P_{L_{Fr-U}} = \max \left\{ \begin{array}{l} 38.46 + 20 \lg D \\ 15.3 + 37.6 \lg D \end{array} \right\} + L_{ow} \]  

the pathloss between the FAPs and the UE, is defined as \( P_{L_{Fr-U}} \). D denotes the separation distance between the FAP and the UE, and \( L_{ow} \) represents the wall penetration loss which is 10 dB or 20 dB.

The need of minimum neighbor femtocell list is essential to make minimum number of scanning and signal flowing during the handover. Large neighbor femtocell list causes many unnecessary scanning for the handover. In \([8]\), users can select node access in the neighborhood list according to the detected RSS value.

\[ NFL = \{ P_t (FAP_i): P_t > P_{th} \} \]  

where \( P_{th} \) is meet the minimum threshold value of neighbor FAP list, and generally set to -55 dB.

**Algorithm 1 :** A self-adaptive service-type handover algorithm

**Initialization:** collects current network status

1. Accept real-time network parameters: \( S_i, RSS_s, RSS_t \)
2. Select network information parameters: \( RSS, FP, P_{th}, HYM_{IB} \)
3. Form NFL by Eq. (7),(8),(9), contains \( n \) FAPs\( (n<N) \)
4. Figure out the number of \( F_c \), users connected to each FAP of NFL
5. Optimize NFL \( \rightarrow NFL' \) \{ \( F_c \leq 5, FP_i \in NFL \} \)
6. Acquire service types \( S = \{ S_1, S_2, S_3 \} \), identity UE’s service \( S_1 \)
7. For any FAP \( FP_i \in NFL' \) do \( j=(1,2,\ldots,k) \)
8. \( HYM_{ij} \leftarrow RSS_S, RSS_T \quad i=(1,2,3) \)
9. While \( HYM_{ij} > HYM_{iB} \) do
10. calculate the \( SINR_j \) according to Eq(4)
11. If \( SINR_j \) less than \( SINR_B \)
12. Return \( FP_j \)
13. Else remain in source FP
14. end if
15. End while
16. End for
17. End
18. Get the optimal result \( FP_j \), and carry out handover

Our self-adaptive service-type handover algorithm consists of three phases: initialization phase (steps 1-2), planning phase (steps 3-7) and handover phase (steps 8-15). In initialization phase, we get network parameters from the network, such as \( S_j, RSS_S, RSS_T \). \( S_j \) is the service-type, which could be estimated by the flow behavior; \( RSS_S, RSS_T \) are the RSS value of source and target cell, respectively. In the planning phase: according to the former results which we could form a neighborhood FAP list (NFL). By using the NFL, the network can reduce the time spent in filtering suitable target nodes, reducing the selection range, and speed up the network response. Moreover, in the NFL, only 0 to 5 users are connected to each node in the list, which ensures that each node has enough resources and does not affect the network status of other users. In the handover phase, according to the front of the RSS values, perform the simplest functions can get HYM value (connect to \( j \)-th node using \( i \)-th business types), compare with the standard of the lowest business handover HYM, and then measure the SINR value. If the SINR values are changing easily, there will be more ping-pong effect (if SINR value is lower than the lowest SINR, mobile terminal can increase the transmission power, which will influence the RSS value, affecting HYM value judgment). So the SINR value has to stay stable within a certain range.

5. Simulation Results

5.1. Experiments Settings
In this section, by simulating the proposed algorithm applied in this situation. Users are uniformly distributed on the coverage area of cells and each user is moving in a random direction. This paper considered a indoor environment which the user moves at medium speed. FAP are randomly deployed by houses or enterprise offices of size 100 × 100 square meters.

To validate the performance of the proposed scheme, comparison was made between the proposed scheme, the basic scheme and then with an existing scheme in terms of number of handover and \( R_{HO_f} \), the rate of handover failure.

| Table 1 SIMULATION PARAMETERS |
|--------------------------------|
| Radius of FAP coverage area   | 10 m          |
| Carrier frequency for FAP     | 1.8 GHz       |
| Transmit signal power by Macro BS | 1.5 W   |
| Transmit signal power by FAP  | 10 mW         |
| Channel bandwidth             | 5 M           |
| Height of FAP                 | 2 m           |
| Path loss of FAP              | 38.46+20lgD  |
|                               | 15.3+37.6lgD |
| Detected value of received signal from original FAP | -90dB |
| Detected value of received signal from a neighbor FAP | -75dB |
5.2. Experiments Results

In Fig. 2, the average \( R_{\text{HO}} = \frac{N_{F}}{N} \), \( N_{F} \) represents the handover failure number, \( N \) denotes the total handover number. In the graph, with increasing number of FAPs, the \( R_{\text{HO}} \) with proposed scheme is lower than the traditional scheme \( R_{\text{HO}} \). The green broken line in the figure above represents the use of the traditional algorithm, namely the RSS-based handover decision algorithm, which also considers the parameter of handover HYM to further reduce the probability of ping-pong handover. The following adaptive algorithm is an improvement based on the above algorithm. The traditional algorithm does not take into account the type of business used by users and only relies on RSS value and HYM value for simple judgment. The traditional handover decision algorithm performs the handover decision as follows: if the source RSS value is less than the target RSS value, and the HYM value is within a certain range (generally 0~10dBm), then the handover operation is performed. In this process, users will not use the same business type all the time, so if the value of the HYM is fixed, it will be difficult to meet the requirements of different handover. Under the same environment, the total \( R_{\text{HO}} \) of the scheme decreased by 11.44%.

![Fig. 2 Average \( R_{\text{HO}} \) (Rate of Handover Failure) of 10 UEs with different Algorithm](image1.png)

![Fig. 3 The whole average handover amount](image2.png)

In Fig. 3, 0~50 FAPs were randomly placed in an environment of 100 × 100 square meters to measure the execution effect of the two algorithms for a single user under different FAP number settings. Along with the increased intensity of FAP deployment, for the cases of 40 and 60 FAPs, it has increased to 11.31% and 17.34% respectively.
In Fig 4, it can be seen that the average network throughput of the whole network obtained by using adaptive dynamic HYM value algorithm and traditional fixed algorithm, respectively. The scheme increases the total throughput in the network by up to 12.95%.

6. Conclusion
This paper simply investigates the performance of handover algorithms in FAP networks. In this article, we considered the huge handover challenges of intensive deployment of FAP in an indoor environment, including a Macrocell and N FAPs, where a FAP has an area of coverage of less than 10 meters. When users move in this environment setting, a large number of handoffs will be generated, which greatly affects the QoE of user. The proposed adaptive handover algorithm reduces unnecessary handoff by considering the service-type of user to carry out the adaptive handover, thus achieving the purpose of reducing handover times and handover time consumption.

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