

# Handovers in Hierarchical Multi-tier Systems

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**Abstract.** In hierarchical multi-tier network, preventing unnecessary handover is one of the most important matters to prevent performance degradation. To do this, some recent handover approaches propose to delay the handover from macro to small scale cell. So, in this paper, we introduces a concept of delaying inter-tier handover techniques to prevent temporary visitor being handed over to small cell.

**Keywords:** inter-tier handovers, hierarchical multi-tier network, delaying handover

## 1. Introduction

Currently, many ISPs (Internet Service Providers) are rushing to deploy hierarchical multi-tier networks. In these networks, a macro cell includes multiple small scale cells such as micro, femto cells and Wi-Fi hotspot. The macro-embedded small scale cells provide spatially separated concurrent channel access so that the overall communication capacity can be significantly enhanced compared to traditional macro cell only system [1]. However the signaling overhead also increases with respect to the number of macro-embedded small scale cells. Especially, frequent macro ↔ small scale cell handovers may cause a large burden to the macro cell base station. Therefore, it is more important to reduce unnecessary handovers in hierarchical multi-tier system than in conventional macro cell only system. So, in this paper, we introduce handover techniques to reduce unnecessary handovers.

## 2. Backgrounds and Related Works

Traditionally, the unnecessary handover is referred as ping-pong effect [2]. However, for small scale cellular systems, it is required to use unnecessary handover in the broader definition than before. According to the measurement results in [3], more than 50% and 70% of small scale cellular system user reside in a cell for less than 3

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and 10 seconds respectively. In short, there are many temporary visitors who are connected to small scale cell with short residence time. Based on this observation, we recognize macro to small scale cell handovers made by such temporary visitors also as unnecessary handover.

To handle unnecessary handover problem caused by temporary visitors of small scale cell, recent handover decision schemes propose to delay a handover until pre-determined delay  $d$  [4], [5], [6], [7]. In the delayed handover, when the user comes into the small scale cell, the system does not start macro to small scale cell handover immediately. Rather, it makes a reservation for the handover process at after  $d$ . If the user comes back out of the small scale cell, the reservation is automatically canceled. By this intended hesitation, we can effectively prevent unnecessary handover made by temporary visitors. In the delayed handover policy, one of the most important things is to set delay parameter  $d$  properly. If delay parameter is too short, unnecessary handovers are not avoided well. Conversely, if delay parameter is too long, the system prevents not only unnecessary handover, but also necessary handovers made by long residence time users.

### 3. Description of Delayed Handovers

As we discussed above, we refer temporary visitor as the mobile user who stays in a small scale cell with short residence time. The exact criterion of temporary visitor may be different for administration policy and visiting pattern of system. Here, we use a threshold time  $t_{th}$  as a discriminant of temporary visitor. In our definition, the small scale cell user is temporary visitor if the cell connection time  $t_c$  is shorter than  $t_{th}$ .

From the protocol perspective, delayed handover scheme is a slightly augmented version of conventional handover decision schemes. The conventional schemes decide to conduct handover or not by checking the handover criterion about SINR (Signal-to-Interference-Noise-Ratio) and hysteresis to avoid ping-pong effects [2]. For example, Moon et al uses the following criterion for macro to small scale cell handover [8]:

where  $S_m$  and  $S_s$  are the SINR of the macro and small scale cell respectively,  $\alpha$  is a combination factor, and  $A$  is the hysteresis. Traditional handover decision schemes may immediately start the macro to small scale cell handover when the criterion is satisfied. Unlike them, delayed handover scheme suspends the handover process for until delay time  $d$  is elapsed. This approach is widely adopted by various macro to small scale cell handover decision algorithms for hierarchical macro-femto cell networks [4], [5], [6], [7].

## 5. Conclusion

In this paper, we introduce delayed handover schemes between different scale cells. It prevents unnecessary handovers made by temporary small scale cell visitors. In the delayed handover policy, one of the most important things is to set delay time properly. Therefore, for the future work, we will analyze the effect of delaying time in detail.

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