CHAPTER

4

HANDOVER IN HIGH-SPEED RAILWAY COMMUNICATION SYSTEMS

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4.1 INTRODUCTION

Today's ever-increasing individual traffic, as well as the prospect of traffic collapse and climate change, are prompting governments to seek other modes of transportation. Choosing trains over roads is the best option since rail transportation systems are by far the most ecologically friendly mode of transportation. The high-speed train (HST) plays a vital role in mass transit because of its dependability, heterogeneity, autonomy, real-time performance, green energy, big capacity, and safety. The advancement of HST simplifies people's lives and it is critical to ensure the quality of services (QoS) for all users. First and foremost, the underlying technologies must be dependable and real-time to assure the system's reliability, which is mostly decided by handover performance.

Handover is the process of switching an ongoing call or data session from a current serving cell to a new target cell in the network (Yang et al., 2019). Handover failure is a situation when the UE fails to connect to the target cell. This is one of the most critical issues in radio, more so with real-time services, since handover failures increase with increasing speed (Lin et al., 2014). Because of the necessity and frequent handovers in high-speed railway broadband wireless connections, a communication breakdown may take place and greatly degrade the train passenger experience. It is therefore indispensable for handover process to provide necessary QoS to high-speed users in wireless cellular networks. According to future consumers' needs, broadband high-speed mobile communication is an unavoidable trend, as discussed in (Gavrilovich, 2001), (Kastell, 2011) and (Zhou et al., 2011). To keep up with this unprecedented demand growth, innovative technological solutions are required.

This chapter is organised by firstly the introduction of High-Speed Railways and discussing the handover issues in Section 4.2. Section 4.3 describes the handover scheme and finally, Section 4.4 of this chapter provides the conclusion drawn from the study.

4.2 HANDOVER ISSUES IN HIGH-SPEED RAILWAY

Consumer experiences including infotainment as well as access to dependable communication systems are also necessary in-train. As HSR becomes faster and more widespread, wireless communication service's quality to train passengers pertaining to its reliability and low latency are critical. The key challenge, as described in (Pang et al., 2010) and (Jiang et al., 2011), is to identify what are the obstacles that may hinder quality access to the train passengers, primarily the connection between high-speed train (HST) and ground network.

The following are the wireless access issues in high-speed mobile scenarios: (1) Frequent and quick handover, which results in repeated cell re-selection, service unavailability and degradation of call quality; (2) Doppler frequency shift issue, which results in an unacceptably poor rate of communication link, challenge in triggering handovers and many handover crashes and (3) Penetration loss, resulting in an intra-train signal weak field. These effects will be discussed in depth in this section.

4.2.1 Frequent and Quick Handover

The frequent and quick handover is an important factor affecting broadband wireless access for HSTs. The high-speed mobility of mobile terminals causes frequent handover. The higher the HST speed for given cell size, the less time it takes to pass through the overlapping region. If the length of time the HST is passing through the overlap cells area is less than the minimal handover processing delay, then a handoff will not be successful, and a call will be dropped. For example, a remote antenna unit (RAU)'s cell normally has a diameter of 100 m; in this case, the HST will receive a handover once a second at a speed of 100 m/s. This means traditional handover periods of 0.1–1 second are now unacceptable (Zhou et al., 2011). Frequent handover introduces the issue of packet loss and reordering (De Greve et al., 2005). Hence, one of the main challenges that HST broadband wireless access faces is achieving fast handovers.

On the one hand, increasing cell radius can reduce the handover rate to meet the requirement of fast handovers (i.e. the number of handover events per unit time). Expanding cell coverage, however, will result in a reduction in system capacity, according to (Veeravalli & Sendonaris, 1999). Handover times for unique HST scenarios can be reduced by strengthening handover protocols and streamlining decision-making processes. This will ensure uniform and reliable performance on the network. On the other hand, reducing the cell radius, for example, to 100–500 m, and utilising optical switching and millimetre wave technologies can realize rapid handovers. For instance, the 60 GHz RF signal exhibits good line of sight (LOS) characteristics in open space and can thus provide a transmission range of around 100 meters. All these qualities will help reduce the multipath effect. However, this technique results in more handover events. In a high-speed mobile environment, the handover rate will be excessive.