CHAPTER

3

USER ASSOCIATION IN MILLIMETRE WAVE NETWORKS

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3.1 INTRODUCTION

The remarkable evolution of wireless devices along with new content-intensive applications such as virtual reality, autonomous vehicle, holographic projection, and augmented reality, has coincided with the explosive growth of mobile data traffic. According to the recent data traffic forecast by the International Telecommunication Union (ITU) (2015), it is predicted that the global data traffic will continue have an exponential growth, which will reach 5 zettabytes (ZB = 10^{21}) per month by 2030. The upcoming fifth-generation (5G) networks will use numerous technologies, such as massive multiple inputs multiple outputs (MIMO), mm-wave communications, full-duplex communications, energy harvesting, and wireless power transfer. Figure 3.1 depicts an example of technologies in 5G networks. The implementation of these technologies undoubtedly can facilitate the spectrum crunch problem and significantly enhance the network capacity.

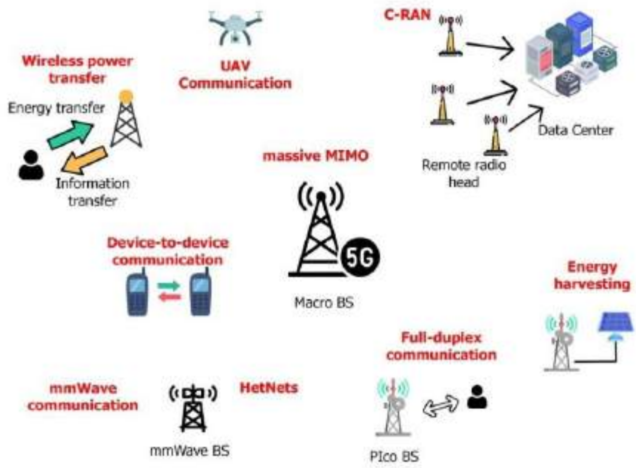

Figure 3.1 An example of technologies in fifth-generation networks

User association is a crucial element in any wireless technology to determine the serving base station of a user for the uplink and downlink transmissions. Compared with conventional microwave communication networks, mm-wave communications have several unique characteristics, which introduce numerous challenges and opportunities for the design of sophisticated user association strategies. Moreover, the overlaid of mm-wave with microwave base station deployment poses a new issue when performing the user association strategies due to such different propagation characteristics and system designs. This chapter presents an overview of the mm-wave propagation characteristics and proposes user association schemes in mm-wave networks.

This chapter is organised by firstly presenting the mm-wave communication characteristics in Section 3.2, Section 3.3 presents the system model and the proposed user association schemes. Next, Section 3.4 provides the stochastic geometry (SG) analysis of the proposed system model, followed by the discussion of results and interesting findings in Section 3.5. Finally, Section 3.6 presents the conclusion of the study.

3.2 MM-WAVE COMMUNICATION CHARACTERISTICS

The current frequency spectrum includes radio frequencies below 6 GHz known as sub-6 GHz and mm-wave bands ranging from 30 GHz to 300 GHz, as illustrated in Figure 3.2. There are many applications in the sub-6 GHz band including cellular networks, TV broadcast, and unlicensed industrial, scientific and medical (ISM) applications. The mm-wave band is a good complement to the sub-6 GHz since it has the capability to provide multi-gigabit communication services, due to large bandwidth of the mm-wave spectrum. Mm-wave communications have various distinct characteristics as compared to the sub-6 GHz band. The following subsections discuss the mm-wave propagation and system characteristics.

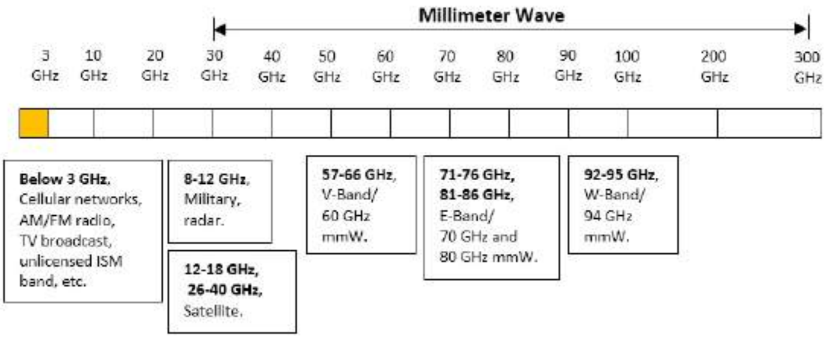

Figure 3.2 Operating frequencies and their applications

3.2.1 Propagation Characteristics

Mm-wave signals are affected by environmental elements such as oxygen molecules, water vapor, and rain. Atmospheric absorption happens when electromagnetic waves are absorbed by oxygen, water vapor, and other gases as they pass through the atmosphere. Figure 3.3 as well as Figure 3.4 show atmospheric (Rappaport et al., 2013) plus rain attenuation (Zhao & Jin, 2006) as a function of operating frequency respectively.