Recent Trend of Hyper-Connected Communication Technologies in 5G and Beyond

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***Abstract*—We are hoping for a new era in which numerous mobile devices, vehicles, and sensors are connected to communicate in real time. It is expected for beyond the fifth generation (5G) networks to realize hyper-connectivity for various highly-demanding applications such as immersive augmented reality (AR) and virtual reality (VR), mobile hologram, and metaverse. In this paper, we first highlight key enabling technologies in realizing a hyper-connected society. We further discuss open issues of hyper-connected technologies in 5G and beyond.**

I. Introduction

Recently, we are witnessing many technological advances brought by a communication infrastructure. However, even after the fifth generation (5G) is commercialized, there are many hurdles in realizing a hyper-connected society where mobile devices, vehicles, and sensors will continuously communication with the nearby environment [1]. It is noting that machines will be the main consumer of the wireless network and there would be a various form-factor devices with diverse hardware capabilities. In this paper, we present key hyper-connected communication technologies and then discuss future research directions.

II. Key Enabling Technologies for Hyper-Connected Society

The primary goal of this section is to address key candidate technologies in realizing the hyper-connected society.

- **Terahertz (THz) communications**: In order to support emerging services which require a rate of up to terabits-per-second (Tbps) [1], it is dispensable to use the THz frequency band. To overcome a significant path loss of the THz band, one can consider the densified network and exploit a pencil beamforming through ultra-massive antenna arrays.
- **Integrated non-terrestrial and terrestrial networks**: Non-terrestrial networks (NTN) terminals are effective to cover remote and rural areas where a terrestrial base station (BS) has no sufficient coverage [2]. To achieve universal global coverage, one should develop multi-layered architecture based on mobility-aware channel modeling and seamless handover techniques.
- **Distributed computing for connected intelligence**: To support computing-intensive applications in various form-factor devices, one can offload computational overhead to surrounding network edges. Considering trade-off between computation and communication, one should investigate both the computational overhead and communication link overhead.
- **Advanced multiple access techniques**: Due to the explosive growth of various form-factor devices, it is required to employ an effective multiple access techniques such as non-orthogonal multiple access (NOMA) and rate-splitting multiple access (RSMA) [3]. It is note worthing that RSMA has emerged recently as a robust multiple access scheme for beyond 5G networks owing to the robustness to imperfect channel state information (CSI).

III. Future Research Directions and Discussions

In this paper, we have highlighted key enabling technologies for the hyper-connected society. On top of these disruptive technologies, there are other remaining major technologies such as free-space optical (FSO) systems, integrated sensing and communication systems, and artificial intelligence (AI) based smart infrastructure.

One example of an important future direction is to apply the advanced multiple access technique in non-terrestrial networks. In the non-terrestrial networks, it is difficult to obtain accurate CSI owing to high mobility of flying/moving objects such as low earth orbit (LEO) satellite and unmanned aerial vehicles (UAVs). We hope that this paper will accelerate the research activities for hyper-connected communication technologies in 5G and beyond.

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References

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