Guest Editors’ Introduction

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The past two decades have witnessed phenomenal progress in wireless access to the Internet and telecommunication services. Cellular network operators in several countries have already deployed fourth-generation Long-Term Evolution (4G LTE) and LTE-Advanced radio technologies to keep up with the demand from the market, especially for video and social media services. Mobile services are so compelling that the market continues to demand higher bit rates, lower latency, greater reliability, and robust coverage. The explosive growth in data traffic for mobile networks fueled by applications such as ultra-high-definition video, augmented reality (AR), and tactile Internet is driving the industry toward the next, or fifth, generation (5G) of mobile wireless networks.

Apart from supporting these applications, 5G is also expected to enable a host of new categories of applications, such as the Internet of Things (IoT), self-driving cars, industrial automation, eHealth, and AR/VR. As a result, 5G networks are designed from the ground up to target not only traditional key performance indicators (KPIs) such as capacity and coverage, but also new KPIs such as connection density, latency, reliability, and power efficiency. For most operators, 5G is an evolution that will encompass the entire wireless network end to end and provide not only tremendous speeds and capacity, but also open up new business opportunities and revenue potential. While standardization and early trials are underway, 5G’s industry-wide scaled deployment is planned for the 2020 time frame.

The classes of applications enabled by 5G are broadly divided into three different categories, based on their requirements:

- **Enhanced mobile broadband (eMBB).** This encompasses all sorts of ultrabroadband applications, such as 4,000-pixels horizontal resolution (4K) video, AR, and tactile Internet. These applications typically require fairly high bandwidth and reasonably low latency. Throughput in Gbps is targeted.
- **Massive machine-type communication (MTC).** This general category
includes all kinds of connected devices such as meters, sensors, and home security. This enables the IoT with a massive number (it could be tens or hundreds of billion worldwide) of devices connected to the Internet via an umbrella of networks. This requires support for a huge number of attached devices, deep coverage, and long device battery life.

- **Critical MTC.** This category of application includes machine–machine communication that requires ultra-low latency and extreme reliability. Some examples of such applications are vehicle–vehicle communications, industrial automation, and robotics.

As 5G devices and networks are standardized, designed, tested, and deployed, they will provide incremental changes and evolution in some areas, and profound leaps in others. There will be advances in many areas, covering both wireless access as well as network technologies. Wireless access technologies are a critical foundation for mobile services, and are often a constraining factor as users expect mobile services to fully match wired services. Compared to 4G, the targets for 5G radio performance include higher user rates, stringent end-to-end latency, higher spectral efficiency, and greater user density. The need for higher bit rates and capacity requires the use of new spectrum bands such as millimeter wave (mmWave) bands, which will be deployed in small cells with a limited coverage area, in addition to macro cells with larger coverage areas at the lower frequencies, such as those used in existing 4G. It thus will be critical to have user devices that can leverage multiple bands and coverage tiers.

Addressing all the market needs and diversity of network situations with large macro cells and densely deployed small cells in a cost-effective manner will require unprecedented levels of network flexibility and efficiency. The network architectures and technologies are thus going through a major transformation to provide flexibility, scalability, the ability to handle a heterogeneous mix of usage scenarios, and cost-effective deployment and operations. Using network function virtualization (NFV) in edge cloud centers, network functions will be more distributed and close to the network edge in an effort to address the ultra-low latency requirements of the new applications that 5G networks are expected to target. Software-defined mobile network (SDN) architectures and network slicing approaches will be used to support a diverse mix of services and deployment scenarios. As the network complexity increases and functions get decomposed and distributed, security will become ever-more critical and integrated into the design of NFV/SDN approaches.

**In This Issue**

This special issue addresses selected important areas among the many areas involved in 5G. The first article, “TCP and MP-TCP in 5G mmWave Networks” by Michele Polese and colleagues, is highly relevant because mmWave radio bands will be used in mobile cellular systems for the first time in 5G. The article explains how the end-to-end user experience in mobile mmWave networks could be affected by a suboptimal interaction between the most widely used transport protocol, TCP, and mmWave links. It also provides insights on the throughput-latency tradeoff when Multipath TCP (MP-TCP) is used judiciously across various links (such as LTE and mmWave).

The second article, “Network Slicing for 5G: Challenges and Opportunities” by Xin Li and colleagues, discusses network slicing. This is emerging as a possible methodology for allowing network operators to create service instances quickly and flexibly, enabling different services to have their own logical slice instances on a shared infrastructure. The article also proposes a framework for 5G network slicing, discusses the challenges entailed, and considers future research directions.

Finally, the issue addresses the important topic of security. The third article, “Dynamic Reconfiguration in 5G Mobile Networks to Proactively Detect and Mitigate Botnets” by Manuel Gil Pérez and colleagues, discusses a 5G-oriented solution for proactive detection and mitigation of botnets in highly dynamic 5G networks. The article proposes dynamic network reconfiguration provided through the combination of SDN and NFV techniques to adapt detection and reaction functions in 5G networks dynamically.

We hope the readers find the articles informative and interesting, and that they provide some guidance to understand and anticipate the impact of 5G to network designers.
and planners. We thank all of the authors for their submissions, as well as reviewers who have graciously volunteered their time to provide valuable and detailed reviews and comments to improve the articles.

N.K. Shankaranarayanan is a principal member of the technical staff at AT&T Labs. His research interests cover advanced wireless systems and architectures; Open Network Automation Platform/Enhanced Control, Orchestration, Management, and Policy (ONAP/ECOMP)-based control and automation in next-generation wireless networks; model-driven network topology and service path determination; and end-to-end service quality management. Shankaranarayanan has a PhD in electrical engineering from Columbia University. He’s a senior member of IEEE. Contact him at shankar@research.att.com.

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