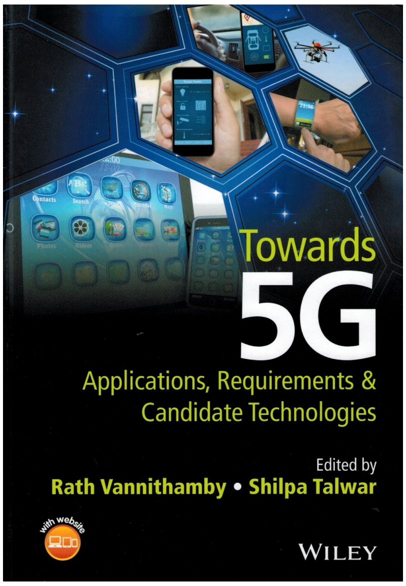
[5G book gets into the technology details]

Martin Rowe - August 30, 2017



Toward 5G: Applications, Requirements & Candidate Technologies, edited by Rath Vannithamby and Shilpa Talwar. ISBN: 978-1-1-8-97983-9, John Wiley & Sons, 2017. Price: $125. www.wiley.com/go/vannithamby/towards5g.

5G is huge, and I'm not talking about the marketing hype that will come in the next few years. Instead, I'm referring to the technological challenge of increasing data rates, reducing latency, and increasing the number of users—all of which must occur with better use of spectrum and with lower energy consumption. From a consumer perspective, we also want it all at no additional cost.

The technologies proposed for 5G—from beamforming to network slicing to mmWave signals—is enough to make your head spin just trying to understand the concepts, let alone make it all work. *Towards 5G* attempts to clarify these concepts. It's a compilation of papers, mostly written by researchers and edited by two Intel engineers who cover the problems and possible technologies to solve them.

The book is organized into three parts.

- *Part I* looks at the requirements for 5G, which include a 1000x increase in network capacity by 2020, billions of connected devices, and lower network latency.
- *Part II* looks at "evolutional" candidate technologies such as distributed resource allocation, device-to-device (D2D) communications, small cells, and energy efficiency.
- *Part III* covers "revolutionary" technologies such as Massive multiple input, multiple output (MIMO), backhaul networks, and full-duplex radios.

One significant problem is spectral efficiency. There's just not enough spectrum below 6 GHz to go around and most of it is licensed. Plus, these frequencies limit bandwidth. Thus, we're seeing mmWave frequencies starting at 28 GHz and going up to 73 GHz. Chapter 14, "New Physical-layer Waveforms for 5G," delves into the radio technologies of transmitters, receivers, modulation, handshaking, etc. needed to take advantage of higher frequencies.

There are many ways to approach the issue of spectral efficiency, some of which I hadn't considered prior to reading this book. For example, the book covers device-to-device communication (chapter 9) to minimize data traveling over the cellular network. Think of D2D as a superset of machine-t--machine (M2M) communication. Indeed, D2D is already in place, think Apple's iMessage where when both devices are connected to Wi-Fi. Of course, that breaks down when connected to cellular data. Another approach makes the network content aware so that users might share content. For example, teenagers wanting to see the latest Katy Perry video might get it from each other rather than each device needing to download it. Imagine that, maybe someone will develop an app for music sharing.

5G is more than radio, for it will impact network infrastructure through a concept called network slicing. That is, the network will consist of several virtual networks that handle different forms of traffic, say content versus control. Having a separate network slice for control signals could improve network latency. Chapter 12 covers M2M communications.

Why is latency so important? Because of the needs for automotive Radar (mmWave) and IoT, which often need priority over, say, e-mail because data arriving too late can result in a loss of money or worse. Chapter 13 covers those topics, looking at timing and radio interfaces.

While chapter 5 covers energy efficiency and why it's important, Chapter 10, "Energy-efficient Wireless OFDMA Networks," gets down to the details. Why has energy efficiency taken center stage? The tremendous amounts of energy consumed by datacenters, wireless transmitters, and the Internet, according to the chapter authors, account for over 3% of total electric energy consumption and that's expected to rapidly rise. Unfortunately, there's a tradeoff between energy efficiency and spectral efficiency. The authors take you through the math behind the tradeoff, where energy efficiency doesn’t need a transmitter's maximum power, but spectral efficiency does.

The impact of higher wireless data rates and many more connected devices has significant impacts on the backhaul. Chapter 17 looks at the issues that 5G will create in the wireless and wired backhaul. The chapter looks at a concept called *in-band backhaul* where access links and backhaul links are multiplexed into the same frequency band. "The resources used for backhaul are taken from the access-link resources regardless of the multiplexing method used," note the chapter authors. They also look at new ways to schedule messages in the backhaul network.

If you're truly interested in 5G, then this book will help you understand the enormous undertaking needed to achieve it. I would, however, recommend that you get and read this book quickly. The book's publication data is January 2017, meaning much of the work was likely written as much as a year prior, given book publishing schedules. With 5G technology still in development, you don't want to spend time reading about technologies that won't bear fruit.

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