mobile communications series

Zerihun Abate

WiMAX RF SYSTEMS ENGINEERING

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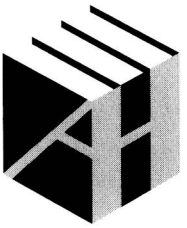

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WiMAX RF Systems Engineering

For a list of titles in the
Artech House Mobile Communications Series,
turn to the back of this book.

To my mother, Gete Ayele,
whose love and prayers sustained me through the years,
and to my late father, Abate Negatu,
who brought me up with love and instilled confidence in me.

Preface

We have heard the adage, "Need taught him wit," and others similar to it such as, "Necessity is the mother of invention." The saying is no more true anywhere else than in telecommunications.

As societal needs and demands change, they fuel technology to rise and meet those needs. (It can be argued that sometimes the antithesis is true, as advances in technology can create "unnecessary" needs.) Largely, though, needs give a strong impetus to technology to innovate. As society becomes more complex, problems abound, food becomes scarcer, health issues arise, people spread out in space and time, and innovation and efficiency requirements take center stage.

Communication as a crucial part of technology has evolved very rapidly as a result. The wireless communication technology, namely, wireless mobile communication in particular, has evolved over a few generational changes in a short period that represent applications from the crude to the advanced.

Here is a summary of the wireless mobile communication generational changes:

- *0G:* Prior to first generation (1G), mobile phone was limited to two-way radios such as in police cruisers, taxicabs, and ambulances. In the early 1940s Motorola developed backpacked two-way radio and a walkie-talkie and later developed a large, handheld two-way radio for the military.

- *1G:* Mobile communication based on analog cellular technology was first launched in 1979 (in Japan) and 1981 (in the Scandinavian countries). An example of 1G system in the United States is the Advanced Mobile Phone Systems (AMPS).
- *2G:* A digital version of mobile communication came to the fore in the 1990s. The 1G system includes: GSM, IS-136 (TDMA), iDEN,[1] and IS-95 (CDMA). The various improvements and evolutions in each of these systems gave rise to a change of name to distinguish them from the basic 2G as in 2.5G, 2.75G, and just short of 3G.
- *3G:* 3G services are designed to offer broadband cellular access at speeds of 2 Mbps, which will allow multimedia services. In 1998 the International Telecommunication Union (ITU) called for and accepted a proposal for IMT-2000[2] (3G) from different entities based on TDMA and CDMA technologies. The European Telecommunication Standards Institute (ETSI) and Global System for Mobile Communication (GSMC) with infrastructure vendors such as Nokia and Ericsson backed WCDMA, while the U.S. vendors, Qualcomm and Lucent Technologies, backed CDMA2000. Improvements to accommodate a higher data rate over the basic 3G has taken place, and 3G currently includes 1x, EVDO; WCDMA, and HSPA. In this evolution, at the time of this writing, we are now in transition between 3G and 4G. Incidentally, this is where WiMAX injects itself in that continuance.
- *4G:* 4G is a convergence point for various CDMA technology flavors, at least in terms of access technology, to OFDMA, and as such these latest and up-and-coming technologies include: IEEE 802.16e (WiMAX), IEEE 802.16m, long-term evolution (LTE), and LTE-Advanced.

While the definition for fourth generation (4G) is somewhat imprecise, it can include many of the following features:

- Services include interactive, multimedia, voice, and video stream;

1. Operating in 800 MHz and 900 MHz using a 25-kHz channel bandwidth on TDMA/GSM architecture, iDEN (Integrated Digital Enhanced Network) combines the capabilities of a digital cellular telephone, a two-way radio, an alphanumeric pager, and a data/fax modem in a single network while giving the end user access to information without having to carry around several devices.
2. IMT-2000 (International Mobile Telecommunications) is the term used by the ITU for a set of globally harmonized standards for 3G mobile telecom services and equipment that provide higher data speed between mobile phones and base antennas. IMT-Advanced is for the generation beyond 3G.

- Replaces the core network (CN) with 100% IP-based network;
- Much higher throughput and data rate than 3G (100 Mbps to 1 Gbps);
- Higher spectrum efficiency (8 bits/sec/Hz);
- OFDMA technology for higher data rate and immunity to ISI;
- Mobility services;
- Lower latency;
- Better security
- Enhanced QoS;
- Usage of MIMO antenna technology for capacity and throughput;
- Usage of multiple or concatenated coding which improves bit error rate in FEC and multiple QoS capability by adding redundancy (over and above, say, convolutional coding).

Book Organization

In the pages of this book, you will find fundamental WiMAX RF network planning principles laid out step by step and supported by concrete examples. Without getting bogged down with too much detail and unnecessary mathematical rigor, the essentials are presented in a straightforward manner. Not only the whys, but also the hows are explained.

Even though this book is titled *WiMAX RF Systems Engineering,* the engineering principles and methods explained extend to most other similar wireless technology fields.

As a more hands-on than a theoretical text, this book is suitable for design engineers, experienced technicians, or communications students. It begins with a general historical background and introductory information on WiMAX technology. A case is made why WiMAX is a compelling technology, and the book covers spectrum definition; channel characterization; WiMAX modulation and antenna techniques; link budgets; coverage, capacity, and frequency planning; service delays; interference; intermodulation and noise description; illustrations; and supporting examples.

The book is divided into five major parts, as shown in Figure P.1. It begins with the historical and technical background of WiMAX, which makes up Parts I and II. Part III relays the core message of the book, dealing with network radio design and covering such topics as link design, link budget, point-to-point link design, network planning steps, WiMAX capacity, frequency plan, antennas, oversubscription, delay characterization, case study, and benchmarking.

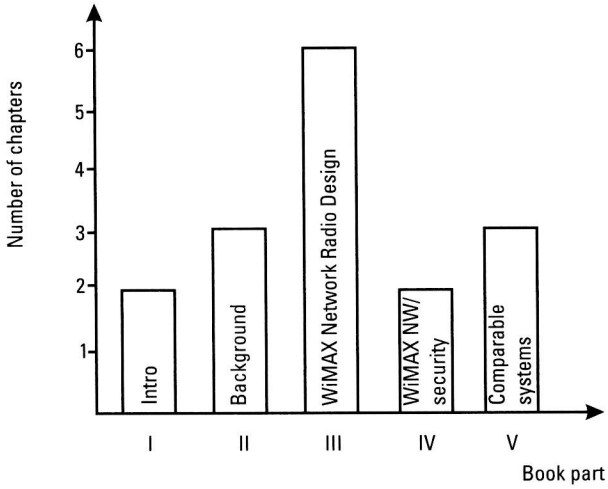

Figure P.1 Book organization.

Part IV covers network and security aspects of WiMAX, while Part V deals with systems comparable to WiMAX, such as WiFi radio design and UMTS.

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