1

Introduction

In modern, complex telecommunications systems, quality is not something that can be added at the end of the development. Neither can quality be ensured just by design. Of course, designing for quality is very important, but no design process is good enough to guarantee that everything works correctly first time. The fact is that complex devices need extensive testing to make sure that they work reliably. Coupled with this, the limited selling window of consumer-oriented user equipment (UE) means that for high-quality products, this testing starts early in the development cycle and continues through to product deployment.

This gives rise to a wide variety of different tests and testing methodologies, applied at various stages in the development cycle. This book aims to provide an insight into achieving high-quality through testing, by providing the reader with both an appreciation of the various testing methodologies, and an understanding of how they fit together to make a complete approach to quality.

Modern networks are indeed very complex, and testing plays an important role in the development of all parts of the network. However, there are special considerations for the testing of the mobile terminals. These are deployed in large numbers; popular handsets can sell in the millions and are in the hands of users who are neither equipped for nor interested in their service and maintenance. This book is concerned mainly with the testing of these devices.

1.1 Important Definitions

The telecommunications industry, like many areas steeped in technology, tends to have a bewildering array of terminology specific to the industry. The Glossary covers the common acronyms and specialist technical terms used within the book, but there are a few key terms where a deeper explanation will assist understanding from the outset.

Testing UMTS: Assuring Conformance and Quality of UMTS User Equipment Dan Fox

1.1.1 3rd-Generation Partnership Project

3GPP is the abbreviation for the 3rd-generation partnership project, an alliance of national and regional telecommunications standards organizations (the partners). The 3GPP is largely built on the foundations of the European Telecommunications Standards Institute (ETSI), based in Sophia Antipolis, France. ETSI takes care of administration and management of 3GPP, and the standardization very closely follows the principles and methodologies set by ETSI during the standardization of Group System Mobile (GSM) and other major European telecommunications standards.

While the term 3GPP strictly applies to the standardization body, it is also widely used to refer to the standard itself and is often used interchangeably with other terminology [e.g. Universal Mobile Telecommunications System (UMTS) or wideband code division multiple access (WCDMA)]. In this book, the term 3GPP will be used to refer to the standards body.

1.1.2 UMTS, UTRAN and GERAN

Conceptually, the UMTS originated as the European extension to the GSM system and was put forward under the IMT-2000 initiative of the International Telecommunications Union (ITU) as one of the converged family of standards for third-generation mobile communications. UMTS and 3GPP are often used interchangeably to refer to the standard, but in this book, UMTS will refer to the overall mobile telecommunications system as defined and standardized by the 3GPP. The UMTS system was designed to integrate with existing GSM networks. The network was split into two parts: a core network (CN) and a radio access network. The network architecture is described in more detail in Chapter 10. The CN from GSM was left essentially unchanged, and the standard defined a new radio access network to complement the existing one. This is known as the UMTS Radio Access Network, or UTRAN.

In parallel with the development of UMTS, the GSM network has also evolved to some extent. In part, it has evolved to provide more efficient use of the existing GSM spectrum, through the development of enhanced data rates for GSM evolution (EDGE) and Enhanced General Packet Radio System (EGPRS) which provide higher data rates and, in part, it has evolved in synergy with UMTS to allow operators with dual networks to offer new services more seamlessly. This evolved GSM radio access network is now referred to as GERAN–GSM/EDGE Radio Access Network.

1.1.3 User Equipment

UE is the official term for a device capable of interfacing to the UMTS network. In GSM, this was referred to as the mobile station (MS), and this term is still widely used in much of the documentation that is shared between GSM and UMTS. The term UE was selected mainly because UMTS was expected to include new classes of device beyond the mobile phones and hand-held computers of 2G technologies. It is intended to imply the broader span of devices that are expected to operate on a UMTS network.

1.2 Scope

Mobile communications is a very diverse field, with many different standards and standards bodies. Even within UMTS, there are variants of the standard. This book is intended to be practical in nature, and hence, I have chosen to focus only on the widely deployed frequency division duplex (FDD) mode of operation. All of the descriptions of functionality, the examples, the test requirements and so on are specifically only covered from the FDD perspective.

The purpose of this book is to provide an introduction to the complexities of testing a UMTS UE through its design cycle. Unless specifically stated, all the examples and descriptions represent the view from the terminal side. This includes testing done during the product development phase, conformance certification and gaining acceptance by operators for deployment on their networks.

The book is divided into three sections. Part I provides an overview of the following:

- Mandatory processes the UE has to go through
- Expectations of operators and end-users
- Typical testing done to ensure a high-quality product.

Where possible, I have also tried to cover some of the practical issues, such as how to go about testing, what equipment is typically needed and some of the common problems encountered during testing.

Part II provides a more detailed look at the testing of the main layers of the air interface protocols of the UE, starting with the physical layer and working up to the signalling and some of the system testing required. The chapters in this section are structured to provide:

- A basic introduction to the technology and protocol behind each layer
- An explanation of the test requirements associated with that layer.

Testing the higher layers is a very substantial subject in its own right, and looking at each of the signalling protocols in isolation does not help the reader to understand how the system works as a whole. Chapter 12 explains a number of complete signalling procedures, showing how the individual protocols work together in a structured way. These procedures are explained from the perspective of a test system and are intended to help the reader understand the conformance test cases and gain a starting point for writing test cases.

The book concludes with a brief section looking at some of the trends shaping the future of testing mobile UE.

While the text will hopefully provide useful background information on UMTS, the behaviour of the UE is specified over hundreds of thousands of pages of detailed specifications. In a book of this type, it is not possible to provide detail on every aspect of the UE specifications. Instead, the explanations are intended as an introduction only. They are incomplete in that they explain only at a high level, and many detailed points are omitted for clarity. The reader is recommended to refer to the full 3GPP specifications to understand the full detail of any individual function.

1.3 Overview of the Industry

The mobile communications industry has experienced one of the fastest growths in history. Since the introduction in 1981 of the Nordic Mobile Telephone system, the world's first fully automatic cellular system, the industry has grown to service over 2.6 billion subscribers in 2006; more than one third of the Earth's population. The industry inherits much of its DNA from the fixed telecommunications industry, and this has important consequences when considering testing. Considerable attention is paid to creating and adhering to open standards. Equipment suppliers are expected to prove conformance to these standards as well as their ability to interoperate with other suppliers. Equipment is expected to operate reliably and continuously for long periods of time.

These requirements combine to create some tough challenges for manufacturers. The need for open standards and close adherence creates a relatively slow evolution path for new technology compared to, for example, the computer industry. The effort and time needed to define these standards give rise to periods of slow evolution interrupted by large technology steps to 'catch up' with the latest advances. The evolution from GSM to UMTS is an example of such a step.

The problem for the industry is that the average user already has an expectation of performance and reliability set by the preceding technology. The new technology has to equal this expectation, even from the early days of introduction, otherwise it quickly gets a reputation for being unreliable, and this can act as a significant brake against uptake. This is a tough challenge indeed, as the comparison is generally being made against a technology that has had years of gradual evolution to become stable and robust. Against this backdrop, testing takes on a higher degree of significance.

Most organizations and businesses involved in the mobile communications industry are connected in some way with testing of UEs, either indirectly or directly as a key requirement, or even as their primary business focus. The next few paragraphs look at the impact of testing on the main parties associated with mobile communications.

1.3.1 Network Operators

Network operators provide a variety of wireless services based on a cellular wireless infrastructure coupled with a license to operate that infrastructure. The license usually comes from the national government and lays down conditions or regulatory requirements that the operator must meet, such as operating frequency bands and the radio technology of the network (although more recently the latter is changing). Originally, the network operators set up, operated and maintained the physical network themselves. However, more recently, some operators have been externally sourcing these, often from the network infrastructure suppliers.

In many areas, the network operator supplies a complete service to end-users, including the phone or other UE, creating a direct relationship between the operator and the end-user. This places the operator as the first point of call if the UE does not operate correctly. As well as loss of revenue from dropped or missed connections, the operator also has to deal with the consequences of problems, which may often result in end-users calling the operator's support call centre to complain. Consequently, operators have a strong interest in testing UEs, and many operate fairly extensive acceptance testing to try to catch problems before phones are supplied to subscribers. This is covered in Chapter 6.

1.3.2 UE Manufacturers

These are the companies that either undertake or commission the manufacturing of mobile phones, PDAs, data cards and various other mobile communications devices and market them to network operators and in some cases directly to end-users. The UE manufacturer is ultimately responsible for the quality of the device and therefore has the greatest interest in its testing. Even if the UE is made from components that have themselves been extensively tested, some level of testing is still required when integrating to a complete product, and some types of testing, such as conformance and acceptance testing, have to be carried out on the final device.

1.3.3 Component Suppliers

For all but the largest manufacturers, developing a mobile phone entirely through one's own resources is not practical. Many manufacturers rely nowadays on third parties to supply key components of the phone. This has created a competitive market for chipsets and protocol stacks, and competition has resulted in pressure for greater integration. Nowadays, apart from vendors supplying specialized components, suppliers of UE chipsets are expected to supply a complete solution, including a reference design capable of passing certification and accompanying protocol stack software. Whilst the final integrator of the end product still needs to perform a certain amount of testing, there is an expectation that this testing will be minimal or perfunctory, with main design verification being done by the component supplier. This means that component suppliers will also have an interest in carrying out development, conformance and interoperability testing.

1.3.4 Testing Services

A number of specialist companies provide testing services to the industry. Mainly, these are targeted towards the UE manufacturers and component suppliers although increasingly they are also supplying the network operators. In particular, certification of UEs requires specialized test laboratories that meet certain quality standards, usually assured through a system of accreditation. These laboratories, also often called 'test houses' in many cases, are starting to expand their business by offering a wider range of test services. Traditionally, these companies have focused on offering conformance testing. However, there has been a steady trend for them to become more involved in operator acceptance testing and other forms of interoperability testing.

1.3.5 Standards Bodies and Certification Bodies

Standards bodies define the behaviour and operation of the network technology at least to the point where independent implementers should be able to develop devices that work with each other. This usually includes providing a test specification that sets out what tests need to be performed to ensure that a device meets their specification. A certification body is one empowered with the authority to decide whether a device meets a minimum level of compliance with the standard. Their authority can come from national government or it can come from the industry itself, through self-regulation. Standards bodies can sometimes be

separate from certification bodies, such as is the case for UMTS – where the standards body is 3GPP and for Europe, the certification body is the Global Certification Forum (GCF). There are many reasons for this independence; for example, deciding the minimum acceptable level of compliance is often a local or regional affair, whereas defining the standard may be a global one.

In the past, standards bodies have only been concerned with conformance testing, but there has been a trend more recently for an informal involvement in interoperability testing through the hosting of interoperability test events. Certification bodies by contrast have some history in both conformance and interoperability, particularly in areas where the industry considers that conformance testing on its own is not enough to ensure adequate quality.