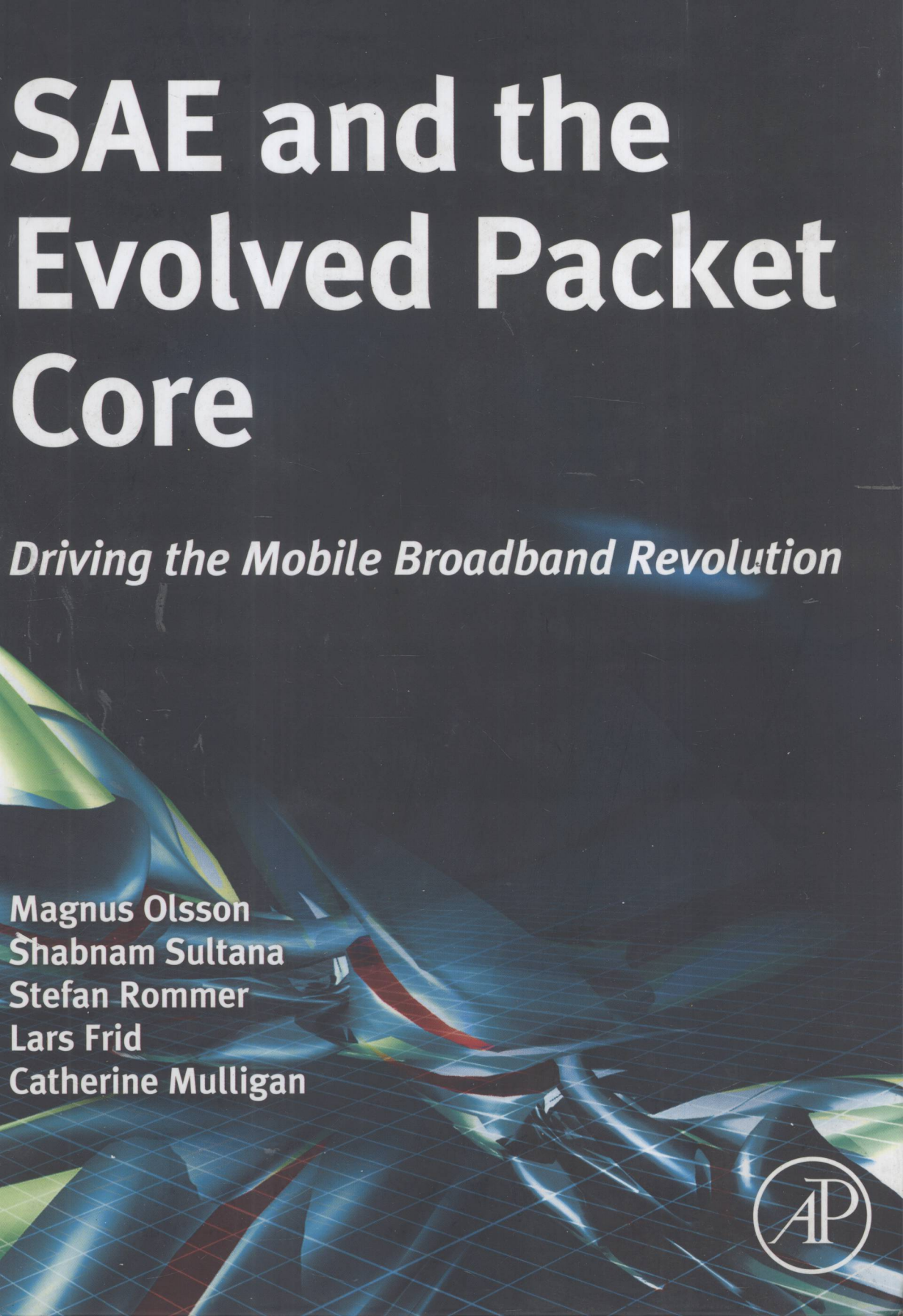
SAE and the Evolved Packet Core

Driving the Mobile Broadband Revolution



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SAE AND THE EVOLVED PACKET CORE: DRIVING THE MOBILE BROADBAND REVOLUTION

Foreword by Dr. Ulf Nilsson

The history of modern mobile telephony, which is about 30 years by now, has certainly been fascinating. The first analogue systems deployed in the early 1980s followed by GSM in the early 1990s provided users a basic voice service with mobility support. The addition of GPRS subsequently introduced support for packet-oriented mobile services. After about another 10 years or so, the third generation mobile system UMTS appeared with better capacity and higher throughput for packet services. For a long time, however, voice services dominated the operators' service offerings and the mobile network traffic. But just as the Internet changed the nature of fixed-access networks, it finally changed the usage of the mobile networks as well. In front of their computers at home, more and more users were realizing what a great source for information, entertainment, interactivity and productivity the Internet was. They also discovered new ways of communicating with others through, for example, chat. The wish, or in many cases probably the need, to bring the Internet along to wherever you happened to go, led to the mobile broadband revolution of recent years. In many markets, the best selling mobile device is no longer a phone but rather a mobile broadband modem for laptops and computers. This is a paradigm change that the whole mobile industry needs to understand and come to grips with.

For a mobile operator, the mobile broadband revolution with its rapidly increasing traffic volumes has resulted in a number of challenges. Our customers want ubiquitous network coverage, high bandwidths and reliable services for reasonable price, while investors and owners require constant efficiency improvements, reduced operational costs and higher profits. In order to cope with such diverse requirements, operators rely as always on the mobile communications industry to continuously improve already deployed networks but also, when the evolutionary tracks finally come to an end, to define new network solutions.

Currently we clearly see that if we rely on only enhancements to the GSM/GPRS/UMTS core and access networks, it will be impossible to cope with the foreseen future demands. In fact, they might not be enough even in the near-time. Therefore the SAE/LTE network developed by 3GPP is extremely important, not only for an operator like TeliaSonera, but also for the whole mobile industry. It is what we shall deploy and live with for a number of years in the new mobile broadband-dominated market place.

As the SAE/LTE network is important for the mobile industry, it will be absolutely necessary for everybody working in the area, or aiming to work in the area, to have a solid understanding of what the new network is capable of and what possibilities it provides. There is no doubt that this book, which appears just when the mobile industry starts its transition away from legacy GSM/GPRS and UMTS networks into the future, will become the reference work on SAE/LTE. There are no better-qualified persons than the authors of this book to provide both communication professionals and an interested general public with insights into the inner workings of SAE/LTE. Not only are they associated with one of the largest mobile network equipment vendors in the world, they have all actively contributed to and, in some cases, been the driving forces behind the development of SAE/LTE within 3GPP.

Dr. Ulf Nilsson
TeliaSonera R&D
Mobility Core and Connectivity

Foreword by Dr. Kalyani Bogineni

There are billions of mobile devices operating on various types of 2G and 3G wireless networks. Projections are for several billion more devices in the next few years on newer technologies with expectations of simultaneous services with high throughput and low-latency requirements. There will be multiple wireless devices for each user and there will be wireless devices embedded in machines supporting automation of many functions. In short, the users will be 'any-where any-time on any-device'. This is heralding an era of communication and information exchange that will test the limits of many existing telecommunications and data technologies. Hence there is a need for implementing concepts born out of disruptive thinking combined with pragmatic application of innovations.

From a service provider point of view, this is a time for laying the foundation for many of the features needed in future generation networks in order to meet the above expectations. For example, the networks need to enable signalling and low-latency media paths across segments of different technologies to support real-time applications like voice and gaming. Fundamentals like mobility and roaming, the pillars of global cellular technologies, need services management based on availability of resources, offered via policy-peering mechanisms between the home and visited networks. Simplicity and ease of using devices and services is enabled through unified authentication and subscription validation mechanisms across various access networks and application platforms. Coexistence and cooperation is needed between end-user-driven intelligent devices and intelligent network elements.

The 3GPP has specified a core network based on the Internet Protocol (IP) that provides numerous operational benefits in addition to meeting the above-mentioned expectations. The specification

- Allows evolution of any deployed wireless or wired access technology network towards a common architecture with benefits of seamless mobility between various generations of access networks and global roaming capabilities on different technologies.

- Enables network designs based on high availability, reliability, scalability and manageability paradigms as well as efficient bandwidth usage on access, backhaul and core networks.
- Supports delivery of combinations of advanced telephony and Internet services that can be hosted by any access network or application provider.
- Provides the user security functions like privacy and confidentiality while protecting the network through functions like mutual authentication, firewalls, etc.
- Minimizes the number of services databases and the number of services controllers which reduces the number of provisioning points in the network.
- Provides an efficient charging architecture that reduces the number of network elements sending billing records and minimizes the number of billing records formats.

The scope of the 3GPP specifications is ambitious but essential. The authors have done an excellent job in writing this book. Their familiarity with the requirements, concepts and solution alternatives, as well as the standardization work allows them to present the material in a way that provides easy communication between Architecture and Standards groups and Planning/Operational groups within service provider organizations.

Dr. Kalyani Bogineni
Principal Architect, Verizon

Preface

The outcome of the 3GPP SAE (system architecture evolution) technical study and specification work is a set of standards that specifies the evolution of the packet core network for GSM/GPRS and WCDMA/HSPA to an all-IP architecture and enables a feature-rich 'common packet core' for radio accesses developed within 3GPP and also by other standardization fora. This common core is referred to as EPC (evolved packet core) and the full system is known as EPS (evolved packet system) which includes support for 3GPP radio access technologies (LTE, GSM and WCDMA/HSPA) as well as support for non-3GPP access technologies. Unlike its predecessor, EPC provides support for multiple access technologies and provides for mobility between them, allowing end-users to move between, for example LTE, WLAN and other 3GPP and non-3GPP accesses. The architecture, in comparison to the one used for 2G/3G packet core is also optimized for efficient payload handling; a so-called 'flatter' architecture. In addition to these benefits, EPC provides updates to all of the already established parts of the 2G/3G packet core network, for example security, connectivity management and so on. In short, the SAE work has prepared the core network for the mobile broadband revolution, through the specification of EPC.

The standards produced by the SAE work item can be perceived as complex, as they span several thousands of pages. This makes it difficult for any individual not involved in the development of the standard to find time to examine these specifications in detail. Many people in the industry have often mentioned to us that the system spans a multitude of specifications and it would be beneficial for the readers within the telecom industry to have a single source description of the new packet core. This book is an answer to this demand; a concise and comprehensive description of the different aspects of the SAE standards for several different reader groups with interests for mobile communications industry.

Our goal is that reading this book will improve the overall understanding of the network architecture and protocols included in the EPC system. It is, however, significantly more than just annotated 3GPP specifications. It provides a detailed analysis of the network architecture, nodes and protocols involved in EPC. In addition we have described the main reasons why certain decisions were taken in the standards bodies; the context of many of these technical decisions is often imperative to a full understanding of how the architecture fits together. This is

extra knowledge that we have tried to capture for the reader through our experiences in the standardization process of the SAE work item.

This book provides a thorough grounding for anyone wishing to learn about how operators and other actors in the industry may implement the EPS and also the different migration paths that may be taken. It also provides an overview of the services that will be utilizing LTE and EPC.

Readers who are already familiar with EPC, LTE or IMS will hopefully also benefit substantially from this book as it identifies how these concepts fit together in order to deliver the promise of mobile broadband. For example, readers familiar with IMS will gain a new depth of insight into how voice services will fit together with the new network architecture and protocols. Appendix A covers the different specifications that are relevant for SAE. It should be noted, however, that this book is not just for readers interested in 3GPP specifications, but it also covers the implementation scenarios for 3GPP2 and also interconnection with non-3GPP accesses such as WLAN, WiMAX or fixed access. Readers interested in only one access technology, or indeed interested in only one protocol, will also gain a good depth of understanding of how their part fits in with the overall network architecture.

We have divided this book into five different parts, each of which contains several chapters.

Part I: Introduction – Background and Vision of EPC

These chapters put SAE and EPC in the correct context with regard to other technologies that affect the evolution of telecommunications networks, specifically mobile broadband and non-3GPP access technologies. These chapters also give a description of the history behind SAE and why the core network needed to be evolved.

Chapter 1

This chapter provides the 'outside view' of telecommunications networks as they stand today and where EPC sits in relation to this, covering the following points:

- Why evolve the core network?
- Technologies connected to EPC.
- Standards bodies involved in SAE work.

Chapter 2

This chapter provides the reasoning within the industry for evolving the core network and the role of different players in the standards bodies.

- Why SAE was started and what the initial targets were
- How did these initial targets evolve during the process?
- Description of the different aspects of the standardization process and the impact they had on the architecture.

Part II: Overview of EPS

This section provides technical descriptions of EPS, including functional descriptions of the different components of EPC. This section also covers different migration and introduction scenarios as well as illustrates how the concepts and standards described in previous chapters are connected together to create services in an operator's network.

Chapter 3

Chapter 3 provides a high-level introduction to the main concepts of the EPS system designed to give a basic understanding of SAE/LTE services.

- A brief description of the EPS services.
- Simplified network diagrams to give the reader an initial understanding of the EPS network and where EPC is placed in the overall network.
- Introductory information on the fundamental choices in LTE.
- Terminal perspective.
- Short LTE overview and its relation to EPC.

Chapter 4

Chapter 4 provides descriptions of how EPC may be deployed based on the situation of the market where it is being deployed as well as its relation to LTE deployment.

- Brief description of the overall NW when deploying EPC/LTE in different operator configurations.

Chapter 5

This chapter provides a description of the data and voice services that will be used on an EPC network, aiming to bring the whole EPS and its concepts together, analysing it from several different potential evolution paths for the services.

- Description of the predicted target services:
  - Data services and applications
  - Voice services
  - Messaging services

Part III: Key Concepts

Chapter 6

This chapter provides a description of key concepts within EPS. Owing to the nature of EPC compared with previous core network architectures, this chapter will provide a clear description of these new concepts and compare them to the previous core networks. This aims to provide readers with a clear point of reference for the key concepts after the evolution of the core network.

Chapter 7

This chapter provides details on security including user authentication/authorization as well as network security mechanism for both 3GPP and non-3GPP accesses connecting to EPS.

Chapter 8

This chapter provides readers with in-depth view of quality of service and policies to control and manage services and to differentiate charging. This chapter also includes a high-level overview of the 3GPP charging models and mechanisms.

Chapter 9

This chapter provides an in-depth view of the usage of DNS as well as 3GPP developed mechanisms as tools for the operations of the EPS network efficiently by selecting the 'right entity' for the right user in an operator's network.

Part IV: The Nuts and Bolts of EPC

Chapters 10, 11 and 12 together illustrate in detail how the EPS system is built end-to-end by using the network entities, the interfaces connecting them together and protocols that provide the 'meat' for the 'backbone' of the system carrying the information between these entities and then some high-level procedures illustrating key scenarios such as attaching to the EPC, detaching from the EPC,

handover of various kinds between 3GPP and non-3GPP access technologies as well as between 3GPP access technologies.

Part V: Conclusion and Future of EPS

Chapter 13

This chapter includes observations and conclusions regarding the EPC and some discussion on what may lie ahead for the future evolution.

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