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Open RAN EXPLAINED

THE NEW ERA OF RADIO NETWORKS

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Author Biographies

Jyrki T.J. Penttinen has worked on mobile telecommunications in Finland, Spain, Mexico, and the United States since 1994. His past employers include Telia Sonera, Nokia, G+D Mobile Security Americas, and Syniverse, and he is with GSMA North America Technology Team at present. He is experienced in research and operational activities such as planning, optimization, measurements, system architectures, and services. Dr. Penttinen is also an active lecturer and has authored various books on telecommunication technologies.

Michele Zarri is an independent management consultant. He started his career in Fujitsu R&D working on layer 1 of WCDMA before moving to Deutsche Telekom representing the company in 3GPP. Michele served two terms as 3GPP TSG SA WG1 chairman and has been rapporteur of several specifications and work items. In 2015, Michele joined the GSMA as technical director of the 5G projects.

Dongwook Kim is Specifications Manager of the 3GPP, the secretary of 3GPP CT3 working group, and the work plan coordinator of 3GPP TSG CT. He has worked in the industry for 11 years and his past employers include Korea Telecom (KT), GSM Association (GSMA), and Telecom Infra Project (TIP). His career has focused on promoting latest telecom technologies and serving as the industry think tank.

Preface

The primary intention of the standardization of the mobile communications systems is to ensure as good interoperability between the system components as practically feasible. This principle has provided the mobile network operators with means to design and deploy their networks relying upon different equipment vendor solutions for the radio and core segments. Nevertheless, in practice, the network components within the radio access network (RAN) have been typically so tightly integrated by each vendor that it has been all but impossible to mix and match different radio network equipment providers' solutions within the same RAN.

Industry has thus decided to put further efforts, building upon the 3GPP specifications, to extend the current architectures to cover more standardized interfaces also within the RAN itself. This allows operators to disaggregate the RAN into a set of interoperable components. Such disaggregation has in turn facilitated the emergence of totally new stakeholders that are no longer required to be able to provide the full RAN stack but can instead focus on some of its components. The abstraction of these contact points makes the new RAN environment more transparent and interoperable and can have a positive impact on the business of all the involved parties in terms of increased number of available solutions as well as potentially bring more innovation. Operators are provided with more options to choose from to evolve their radio access segment as well as deploy bespoke solutions for some specific scenarios.

The new environment is still in relatively initial phase regardless of the very active efforts the telco industry has invested to evolve the concept, but the Open RAN is getting increasingly real now. There are already several examples of practical deployments, while the standardization efforts continue detailing adequate solutions. The effort is not, however, completely straightforward, and some challenges will require more time to be successfully addressed. For example, new RAN component concepts such as Radio Intelligent Controller (RIC) is not expected to reach its full potential initially, while operators learn how to leverage the underlying machine learning models and various use cases that artificial intelligence solutions can bring. Moreover, the move toward virtualization of the RAN will require operators to become familiar with orchestration strategies.

Evolved measurement techniques, testing, and processes are needed to ensure the new concept works adequately prior to production and deployment while ensuring adequate performance through the rest of the lifetime of the networks. It is important to note that RAN often accounts for around 70% of the CAPEX of a typical operator.

Yet another challenge, regardless of the increasing number of references becoming public, has been the lack of concrete publications detailing the concept, its more concrete possibilities and challenges, and the ways to deploy the Open RAN in practice.

This book answers to the need by presenting the Open RAN concept based on the latest specifications and information sources and walks the readers through some of the very key aspects that the ecosystem needs to understand in the functioning, deployment, and operation of the Open RAN-based networks.

This effort to summarize sufficiently and concretely the essential between single covers has been challenging due to such fast pace of the development and the lack of adequate references. Our author team is extremely happy to share the result in a form of this book which we hope to serve the ecosystem in our efforts to make sense out of the complex and oftentimes rather fragmented public information sources.

This book is thus a result of rather long exploration of the environment and root sources such as key specifications of the 3GPP and Open RAN Alliance. We hope this effort benefits the mobile communications ecosystem to learn more about the Open RAN, the topic that has rather realistic prospects to become a highly significant – perhaps even elemental – part of the modern telecom systems, and that is expected to work as important driver for generating new business through evolving ecosystem and new stakeholders.

“Mobile telecommunication systems have been an integral part of people’s lives for such a long time that only few of us would really like to return to the era of sole fixed telephony. Having seen the development of the wireless industry from many points of view since 1980s through technical engineering career, starting off with radio network measurements of the very first generation, and working posteriorly with operators, manufacturers, security and roaming providers, and membership organizations, I have been fortunate to witness some of the key breakthrough moments of the wireless industry. Some examples include the commercialization of the 2G in Finland back in 1991, the standardization of the first truly IP-based mobile data service, General Packet Radio Service (GPRS), the pre-commercial field testing of the 3rd Generation UMTS (Universal Mobile Telecommunications System), and the takeover of the 4G LTE that currently represents the dominating radio technology. This journey is becoming increasingly interesting as the 5G, which I started to research from the specifications prior to its commercial readiness, is maturing firmly and starts offering advanced features and functions such as network slicing and other 5G SA capabilities also in practice.

Based on these personal experiences, I realize the development of mobile communication systems is a constant effort that materializes in cycles of each decade as completely new generation becomes commercially available. Each new generation tackle important lessons learned that the ecosystem has gained through the previous ones. I also reckon that – apart from the actual deployment and commercial start of the new generation – it is hard to think of much more significant and groundbreaking moments than the gradual availability of the Open RAN concept. This new concept has also provided a fantastic opportunity to learn and share latest knowledge, including the security and testing specifications of the Open RAN Alliance.”

Jyrki T. J. Penttinen, Atlanta, Georgia, USA, 2023

"I have been involved in mobile standardization for more than 20 years and I am sure that the rise of the Open RAN "movement" will be remembered as a major milestone along with the creation of 3GPP, the selection of WCDMA as radio technology for 3G, the battle between LTE and WiMAX during the design of 4G and the introduction of service based architecture in 5G.

Besides addressing well-known shortcomings of the existing RAN architecture, Open RAN drive to transfer to tangible benefits of virtualization, separation of hardware and software and disaggregation that have proven their worth in the IT world, creates the premises for establishing a healthier supply chain, foster innovation and ultimately make the RAN more affordable. A cheaper, better RAN will bring societal benefits such as reducing the digital divide as well as economic benefits by unlocking new commercial opportunity.

While the jury is still out as to whether all these promises will materialize and challenges will be overcome, it is clear that the efforts of TIP and O-RAN Alliance have not gone unnoticed and acted as a wake-up call for the established vendors who might have been too slow in adopting new technologies and paradigms.

Moving forward, the most desirable outcome from my point of view is that the principles, components and specifications developed in Open RAN converge in 3GPP avoiding a divergence of mobile communication system standards that may damage in the long run the economies of scale and pace of innovation. Precedents exist of ideas generated outside the "mainstream" that were contributed to and implemented in 3GPP: the IP Multimedia Subsystem initially devised by 3G. IP and the RAN split first introduced by X-RAN being notable examples. Such convergence of Open RAN and 3GPP would also create the best premises for the development of a successful, global, open 6G."

Michele Zarri, London, UK, 2023

"Modular architecture and separation of integrated layers is already prevalent in our lives. From Lego in toys to our personal computers, we often mix and match components to build what we want when we want it and how we want it to be. It is no surprise that I witnessed, in the start of my career, similar work in the core network side starting with Network Function Virtualization (NFV), leading to a great success that is still on-going within the Industry Specification Group NFV at ETSI. This shows that the principles and the trend of Open RAN is not as complicated and strange as it initially seems, it is the quest of the network operator (whether it be traditional network operators or emerging alternative network models in the 5G era) to flexibly and optimally deploy and operate its network.

However, openness can be tricky in that the user/customer needs a degree of knowledge to fully exploit the potential. Taking the Lego example, an average child playing with the toy will not be able to build a gigantic and magnificent masterpiece that you would find in Lego Land, let alone the Lego toy series that manias display in their glass cupboards. In this respect, I believe that this book will set a stepping stone for you to be able to play with Open RAN like the Lego manias do with their Lego toys. Of course, you should not limit yourself to Open RAN per se as mobile networks is a much more complex topic and should be aware of the relevant 3GPP work that Open RAN is based on."

Dongwook Kim, Sophia Antipolis, France, 2023

Acknowledgments

This book is a result of countless hours of exploration of mobile communications resources through specifications and other available information sources, discussions with our peers, as well as ideation and manuscript drafting, that all were essential steps for us to be able to write down the contents of this book. It has been a challenging task, yet highly rewarding as we wrote this book to provide ecosystem with concrete ways to learn more on the subject.

Our author team would like to acknowledge all the ones we had possibility to discuss the topic throughout this effort, including our colleagues and peers at GSMA and 3GPP. We also appreciate all the support and patience of our close families during this work.

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Abbreviations

1G	first generation of mobile communications
2G	second generation of mobile communications
3G	third generation of mobile communications
3GPP	third generation partnership project
4G	fourth generation of mobile communications
5G	fifth generation of mobile communications
5GS	5G system
6G	sixth generation of mobile communications
A/V	audio/video
AAL	accelerator abstraction layer
AAL	ATM adaptation layer
ACPI	advanced configuration and power interface
ADC	analogue to digital conversion
AI	artificial intelligence
AICPA	American Institute of Certified Public Accountants
ALD	antenna line device
AMF	access and mobility management function (5G)
ANR	automatic neighbor relation
AP	application plane
API	application programming interface
AR	augmented reality
ARIB	Association of Radio Industries and Businesses, Japan
ASIC	application-specific integrated circuit
ATIS	Alliance for Telecommunications Industry Solutions (North America)
BBU	baseband unit
BoM	bill of material
BSS	business support system
BVLOS	beyond visual LOS
CA	carrier aggregation
CA	certificate authority
CAGR	cumulative annual growth rate
CAPEX	capital expenditure
CCSA	China Communications Standards Association