Chapter 1

The Evolving Voice Services: From Circuit Switching to Voice-Over LTE/FTTH)

Voice is the most pervasive telecommunication service, particularly mobile voice, with 4.7 billion unique mobile subscribers as of April 2016,[1] out of a total 7.8 billion mobile connections. Legacy circuit switched voice still accounts for majority of world telecom customers; however, voice-over IP is finally starting to replace it. Voice-over IP technologies such as H.323, Session Initiation Protocol (SIP), and voice codecs including wideband, carrier grade infrastructure known as IMS-IP Multimedia Subsystem[2] have been available for more than a decade, but deployment of All-IP access networks (FTTH (Fiber-to-the-Home) and LTE (Long-Term Evolution)) has been the trigger for their adoption. Only in the enterprise segment, the legacy PBX systems have initiated the migration earlier. In fixed networks, initial FTTH deployments maintained simultaneous use of legacy copper for voice. In 4G mobile networks, fallback to 2G/3G for voice has been a temporary patch until VoLTE deployment in the network and progressive availability of enabled devices. HD Voice is included in VoLTE, but is also available in 3G networks without VoIP. Voice-over WiFi is emerging as a complement mainly for zones with poor cellular coverage.

1.1 CUSTOMER NEED: REMOTE COMMUNICATION

Voice has been the dominant, or even only, telecommunications service for decades. The possibility of talking to people in remote places has been, and still is, a killer application. It has substituted more primitive means to communicate, both non-real-time and real-time. Furthermore, the convenience of talking wherever you are, thanks to the more recent mobile telephony that has certainly surpassed the

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success of fixed telephony, allows one to communicate in more remote areas without terrestrial infrastructure.

1.2 FTTH VOICE

The penetration of FTTH subscribers is still nascent; for example, in Europe there were almost 36 million (including Fiber to the Building) in Europe at the end of September 2015.[3] This has triggered the adoption of voice-over IP in fixed lines, although initial FTTH deployments supported simultaneous use of legacy copper for voice. Typically, the FTTH customer premises equipment, Optical Network Terminal (ONT), includes a voice port (RJ-11 connector) that interfaces with the legacy internal copper network or directly with the legacy telephony terminal. The usage is transparent for customers, since they make and receive calls normally with their legacy endpoints. The FTTH device includes a gateway that converts analog telephony into voice-over IP, which in turn is connected to the VoIP infrastructure of the operator.

1.3 VOICE-OVER LTE (VoLTE)

Voice-over LTE is the name given to the technology that provides telephony to 4G customers. It is based on voice-over IP, since LTE gets rid of circuit switched voice. In order to guarantee voice quality, VoLTE traffic is prioritized versus other kinds of traffic, which is also IP. Initial LTE deployments did not include VoLTE support, resorting to Circuit Switched FallBack (CSFB), which is based on disconnecting voice from the 4G network and connecting it to a legacy network (3G or even 2G) to establish the voice call. Once the call is finished, 4G connection can be set up again.

As of the end of the first quarter of 2016, there were 58 operator launches, in 32 countries,[4] with 228 end user devices. This was still a relatively small percentage of the total number of LTE networks: 467 operators in 153 countries, reaching 48% of the population. As could be expected, these countries are mainly in Europe, North America, South East Asia, and Oceania:

- Asia Pacific:
  - Japan by NTT Docomo, KDDI, and Softbank (the "big three")
  - South Korea by Korea Telekom (KT/KT Powertel), SK Telekom, and LG Uplus
  - Hong Kong by China Mobile, 3 (Hutchinson), CSL (HKT), and SmarTone
  - Singapore by SingTel, StarHub, and M1
  - Taiwan by Hon Hai, Asia Pacific Telecom, and Taiwan Mobile
  - Australia by Telstra and Vodafone
  - China by China Unicom and China Mobile (not China Telecom)
  - Others: Indonesia by XL (Axiata) and SmartFren; Thailand by AIS, True-Move, and Telenor (DTAC); Kuwait by KTC; Cambodia by Southeast Asia Telecom, and others

- Europe:
  - France by Bouygues and Orange
  - Germany by Deutsche Telekom, Telefonica,[5] and Vodafone (all three mobile network operators)
  - Italy by Telecom Italia and Vodafone
  - The United Kingdom by 3 (Hutchinson) and Everything Everywhere (BT)
  - Spain by Vodafone[6]
  - Others: Austria by Telekom Austria; Czech Republic by Deutsche Telekom; Denmark and Norway by Telenor; Switzerland and Liechtenstein by Swisscom; The Netherlands by Tele2; Portugal by Vodafone; Romania by Orange[7]; Russian Federation by Vimpelcom, and others
- North America
  - The United States by AT&T, Deutsche Telekom, Verizon Wireless, and Evolve Broadband (big four except Sprint-Softbank)
  - Canada by Rogers and Bell
- Africa: Tanzania, Uganda, and Nigeria by Smile; South Africa by Vodacom (Vodafone) . . .

It can be seen that all major mobile telecommunication groups in the world have launched VoLTE in at least one market. Among the exceptions are

- America Movil in Latin America
- Etisalat and Saudi Telecom in Middle East
- China Telecom in China
- Bharti Airtel in India
- Telekomunikasi Indonesia and Chungwa Telecom in Asia
- Telia in Europe
- MTN in Africa
- Telus in Canada
- . . .

However, it has to be noted that as of April 2016, there were already 126 operators investing in VoLTE deployments, trials, or studies in 60 countries.[8]

In terms of adoption, the operator that is most further along is probably AT&T, which launched in mid-2014, and as of the end of 2015, has more than 27 million VoLTE subscribers (the highest in the United States), and has a coverage for 295 million Americans.[9]

In November 2015, South Korea became the very first country to provide commercially interoperable VoLTE service among operators.[10] Before this milestone, customers could only enjoy the superior quality of VoLTE when calling other customers of the same operator. There are three operators (KT, SKT, and LG Uplus) with around 35 million VoLTE-enabled subscribers that are fully commercially interoperable. By that time, South Korea has marketed 90 different models of VoLTE-enabled handsets in the country. It has to be noted that the three operators

were also the first in the world to launch their respective standalone services in December 2012, with the next country launching in May 2014 only.

Also a Korean operator achieved another major world milestone in terms of interoperability—in this case, an international roaming service. At the end of 2015, South Korea's KT and Japan's NTT DOCOMO offered a bilateral VoLTE roaming service. Previous milestones were unilateral (e.g., Korean LG Uplus with Japanese KDDI). Other mobile network operators involved in VoLTE roaming trials include China Mobile, KPN, SK Telecom, and Verizon Wireless.[11]

In terms of end user devices, the number includes carrier and frequency variants. As of June 2015 (219 VoLTE capable out of 3253 LTE devices), 198 smartphones had been announced by all the leading vendors, including Apple, Asus, Fujitsu, HTC, Huawei, LG, Motorola, Pantech, Samsung, Sharp, and Sony Mobile.[12]

1.4 VOICE-OVER WiFi

Voice-over WiFi (VoWiFi) is the term used by operators in order to refer to the provision of telephony services over a WiFi access. From the user perspective, the experience is similar to VoLTE, or traditional voice, that is, just call and answer. However, from the network perspective, it is quite different, since the WiFi network is not an integrated part of the mobile network. And therefore, the quality of the call can be poorer, and in general similar to that of over-the-top (OTT) applications.

Compared to VoLTE, the number of VoWiFi launches is much more limited, just 18 operators in 11 countries, by the end of March 2016. Also, deployments have been much more recent, starting only in September 2014 (in the United States by T-Mobile/Deutsche Telekom). In the United States, all four major operators have launched VoWiFi by now. Other countries with more than one operator include the United Kingdom, Switzerland, Hong Kong, and Canada. The remaining markets are China, Czech Republic, Denmark, Liechtenstein, South Africa, and Thailand. It has to be noted that most operators that have launched VoWiFi in a given market have also launched VoLTE in the same market. An exception is Sprint (Softbank) in the United States.

There have been operators that have launched VoWiFi service, without integrating it tightly with the VoLTE/IMS infrastructure and devices. One example is Telefonica in the United Kingdom and Latin America, with its service TU (formerly TU Go) that can be considered a pioneer in the world (perhaps together with Rogers in Canada), since it was launched in the United Kingdom in March 2013 (and afterward in Argentina, Peru, Brazil, and Colombia).[13] In the first quarter of 2016, it announced the integration with iPhone's native WiFi calling feature in Brazil.

Another announcement worth mentioning is the collaboration between Google and mobile network operators (19 major ones) in the field of Rich Communications Suite (RCS). Google will provide the user experience for Android devices (including an open-source version of the client), initially for messaging, but with support

for advanced calling features, which among other things also include calling over WiFi, in the future.[14]

1.5 HIGH-DEFINITION (HD) VOICE

High-Definition voice provides superior voice quality based on wideband codecs, which (as opposed to legacy telephony) include more frequencies (bandwidth) of the analog sound (legacy narrowband reaches 3 kHz, whereas human voice reaches 14 kHz). HD voice has been available for quite long time, for both voice-over IP applications and circuit switched telephony (particularly mobile, even before 4G, with 3G and even 2G[15]). Therefore, the number of commercial services is more widespread, with 162 operator launches in 89 countries as of the end of the first quarter of 2016, including VoLTE deployments.

1.6 OVER-THE-TOP SUBSTITUTES

The term "over-the-top" refers to services that are offered independent of the underlying network. One of the most prominent consumer over-the-top applications for PC has been Skype, which is now part of Microsoft. In January 2016, the company reported that Skype has over 900 million downloads on iOS and Android.[16] It also has an enterprise counterpart, called Skype for Business, with a major update released in December 2015, including voice telephony without PBX, and online meetings for up to 10,000 participants.

Perhaps the most prevalent over-the-top application for mobile is WhatsApp,[17] which was started in 2009. In early 2014, WhatsApp was acquired by Facebook for $16 billion ($4 billion in cash, and around $12 billion in shares).[18] In February 2016, it reached the astonishing milestone of 1 billion monthly active users, although it has to be noted that its predominant usage is for messaging. It is worth mentioning that WhatsApp was an inexpensive app, but in early 2016 the company announced that it was becoming free, that is, no longer charging any subscription fees; its usage is also free in free WiFi networks, but of course it consumes data allowance if used with mobile broadband. The company also confirmed that it will not include advertising to subsidize its costs, but rather test business models around commercial messages (communications with businesses). In April 2016, it included end-to-end encryption for all the information exchanges, including voice. The app is available for iOS, Android, and Windows Phone. By the end of 2016, it will end its support to minority or legacy operating systems like BlackBerry, Nokia S40/Symbian S60, as well as older versions of Android 2.1 and 2.2 and Windows Phone7.1. In the first quarter of 2015, WhatsApp started rolling out voice-over IP calls, progressively in different operating systems; this feature was already available in Facebook Messenger application, which by then accounted for more than 10% of mobile VoIP calls globally according to the company.[19] By mid-2016, 100 million voice calls per day were made through WhatsApp.[20]

ACRONYMS

2G	2nd Generation
3G	3rd Generation
4G	4th Generation
CSFB	Circuit Switched FallBack
FTTH	Fiber-to-the-Home
HD	High Definition
IMS	IP Multimedia Subsystem
IP	Internet Protocol
LTE	Long-Term Evolution
ONT	Optical Network Terminal
OS	Operating System
OTT	over-the-top
PBX	Private Branch Exchange
RCS	Rich Communications Suite
RJ	Registered Jack
SIP	Session Initiation Protocol
VoIP	voice-over IP
VoLTE	voice-over LTE
VoWiFi	voice-over WiFi
WiFi	Wireless Fidelity

NOTES

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