A NEW MOBILE VOICE EXPERIENCE
Evolved HD voice enables next-generation mobile voice services for LTE networks. It further enhances the user experience by delivering higher quality voice and music, while leveraging current HD voice services in 2G, 3G and LTE networks.
In the midst of the smartphone era, with ever increasing data traffic usage over different devices, the way people use their phones to communicate is changing. In 2009, data traffic overtook voice as the dominant traffic in mobile networks [1], and there is a stable trend of data traffic growth and almost flat voice traffic development [2]. These trends might seem to suggest that voice is losing significance. However, voice services still play an important role, since by definition they are part of mobile and fixed telephony, and people intuitively expect voice service quality to be as high as possible.

Nowadays operators are exposed to a rapidly changing communication services market; there are many different options on the market for communicating over smartphones, and consumers are also becoming more aware of voice quality aspects. According to an Ericsson ConsumerLab report, some of the most important drivers of user satisfaction with mobile operators are: network speeds, mobile coverage, and clarity of voice calls [3]. This necessitates that operators catch up in terms of service quality and also find new quality differentiation opportunities. With continuous technological advancements within the telecoms sector, voice services can be improved to meet even higher user expectations. As part of evolving their voice services, operators could offer attractive and flexible IP-based communication services, such as video calling, videoconferencing, IP-based messaging and more. There are also new business opportunities within the enterprise segment that operators can support in mobilizing enterprises and providing guaranteed high-quality voice and video communication services seamlessly over any access and device.

Many operators have developed their voice business by improving voice quality in their mobile networks by launching HD voice using AMR-WB (Adaptive Multi-Rate Wideband). With HD voice services, people can communicate more effectively, which has the potential to make them feel closer to the people they are speaking with, even in noisy environments. HD voice is a fully developed and standardized technology that by 2014 has been deployed by well over 100 operators in more than 70 countries [4]. More than 300 HD-enabled devices are currently available on the global market, and the majority of the latest 3G and LTE devices are shipped with HD voice capabilities. It is therefore possible for operators to provide the service to many of their users already at initial service launch [5].

While HD voice is currently being rolled out globally, there is already a next level of further improved HD voice quality for IP-based communications networks on the radar – evolved HD voice for LTE networks. There is a new solution that has just been standardized by 3GPP as the next generation telecom-grade voice codec for VoLTE. In the 3GPP standardization, this new voice codec is called Enhanced Voice Service (EVS). This paper describes the benefits of this new solution and how it relates to today’s voice offerings on the market. With the continued successful proliferation of LTE networks globally, which reached 240 million subscribers in mid-2014 [6], voice services over LTE are becoming increasingly important in the global market.

All mobile phone users, operators and the telecom industry at large would benefit from securing full industry agreement on this new standardized solution for evolving today’s voice service for LTE networks. It is of vital importance to continue building a globally interoperable high-quality voice service for a future all-IP based communications world.
WHAT IS HD VOICE?

HUMAN HEARING
The range of human hearing covers frequencies from 20Hz to 20,000Hz [7], while the human voice spans a frequency range of at least 50Hz to 12,000Hz [8]. However, traditional phone calls (both fixed and mobile) transfer sounds in a smaller spectrum band of roughly 300Hz to 3,400Hz.

Consequently, the voice quality of today’s calls is limited. For example, the auditory information needed to consistently distinguish F sounds from S sounds is contained in frequencies that are higher than conventional calls allow. The potential for misunderstanding is one reason for the development of phonetic alphabets for use in critical telephone or radio communications, such as air-traffic control.

HD voice removes this limitation. It conveys a wideband spectrum from 50Hz to 7,000Hz and uses wideband codecs such as AMR-WB or G.722 that are tailored for this purpose – resulting in better quality, more natural sound, and improved intelligibility and voice recognition.

USER BENEFITS OF HD VOICE
The voice quality of traditional telephony is perceived to be at its worst when people call while using public transport, such as the subway [9]. An important factor for this is the high background noise of trains, which makes it difficult for both parties of a call to hear each other well. The clarity gained from HD voice allows users to make calls in noisy environments, such as near a busy road, on a construction site or in extreme weather conditions, where normal calls would simply not be feasible. In addition, the technology enables clear voice-mail playback, more effective conference calls and better speech-to-text applications. This reduces stress and offers users a greater voice experience.

HOW TO DEPLOY HD VOICE IN A MOBILE NETWORK
To enable HD voice, operators need to ensure their core and radio networks are capable of providing the service. Both users in a call need to have devices that support the service with the AMR-WB codec and other improved device acoustics suitable for the wideband spectrum, including higher quality microphones and loudspeakers. Many 2G and 3G phones are already HD voice capable. All VoLTE-capable smartphones have HD voice as the default codec, and the service is supported over LTE networks.
THE EVOLUTION OF HD VOICE

MITIGATE MARKET FRAGMENTATION OF VOICE SERVICES

As telecom networks are migrated to all-IP there are possibilities to further enhance voice service quality, with LTE as the starting point. However, in order for users to talk to each other with high-quality voice over different IP-based voice applications, the services have to utilize interoperable voice codecs. There are a variety of different voice codecs being developed and used on the market, which creates a risk of increased market fragmentation for voice services and could lead to increased transcoding costs and quality degradation. Without interoperability and backwards compatibility with existing voice codecs, the benefits of telecom-grade services could be lost, which would be a major drawback for all users of operator-provided mobile voice services.

The industry should hence strive to align and continue building on today’s existing voice technologies and provide users with higher quality voice services that will work across all devices globally.

EVOLVED VOICE SERVICES IN AN ALL-IP COMMUNICATIONS WORLD

Operator-provided voice services will gradually be migrated from today’s circuit-switched (CS) voice networks to packet-switched IP networks, using VoLTE [10] as the foundation to provide telecom-grade telephony services. Additional services like video calling and conferencing can easily be added on top of the voice service to provide more attractive subscription offerings. VoLTE was first deployed in August 2012, and several operators launched it during 2014, with many more launches expected in the coming years. VoLTE uses the HD voice codec as its default in the device, so consumers will immediately be able to experience HD voice when they start using the VoLTE service.

HD voice provides a very high quality experience, as attested to by users trying the service for the first time [11]. With the prospect of migrating voice services onto all-IP networks, there are now greater opportunities to more easily improve voice technologies in order to enhance user experience even further. Efforts to develop the next step after HD voice have already been made. A next generation telecom-grade voice compression technology for VoLTE has been standardized in 3GPP by a number of telecom companies (operators and infrastructure, chipset, device and technology vendors). The 3GPP name for this new technology and voice codec is EVS – see appendix for background info.

The EVS codec provides a new sound experience both for speech and music; evolved HD voice services will gain even crisper and more natural voice quality in any kind of communication environment. It will also provide significantly improved music quality for on-hold messages, music announcements and other similar services. Live music sharing via the mobile phone from, for example, a concert, will give an unprecedented realistic impression. This is achieved through covering an even wider audio band for the complete audible frequency range – see Figure 1 – and new coding strategies originally mainly used by audio codecs.

Evolved HD voice is a fully interoperable extension to HD voice in LTE, WCDMA and GSM, as...
Figure 2 shows. It makes evolved HD voice a complement to HD-voice, rather than a competing solution, and secures investments that have already been made in HD voice enabled networks. It is also designed to provide increased network efficiency for operators. With the EVS codec, operators can reduce the bandwidth required for voice services, while maintaining service quality comparable to today’s narrowband voice or HD voice services. Alternatively, they can substantially increase quality, while maintaining the currently used bandwidth. A third option is to provide a completely unprecedented voice and music service quality at increased bit rates – see Figure 3.

There may be questions about whether operators should wait with HD voice investments and rather bet on evolved HD voice. However, given that evolved HD voice will be a complement to HD voice, the question should rather be if and when an operator wants to use the additional advantages of evolved HD voice. If the operator decides to go for evolved HD voice, this automatically includes HD voice. The decision to deploy HD voice in 2G or 3G, unless this has already been done, is a separate one. For an operator with installed 2G/3G (CS) legacy networks that plans to invest in VoLTE with evolved HD voice, it would, however, be a logical step in terms of HD voice interconnectivity and service continuity to introduce HD voice in the legacy network at the same time.

**LEVERAGE OPERATOR ASSETS FOR EVOLVED VOICE SERVICES**

With the evolution toward new technology, it is important to continue building on valuable operator assets, specifically guaranteed telecom voice service quality and global interoperability.

The first important asset that operators should leverage is the guaranteed high quality that telecom voice services can provide, not only where there is good mobile broadband coverage. Telecom-grade VoIP services based on VoLTE are always prioritized in the mobile network over any other data traffic by utilizing QoS mechanisms over the core and radio network to ensure guaranteed service quality for these critical real-time services. In contrast, over-the-top (OTT) VoIP services run as best-effort data services over mobile broadband access, meaning there is no guarantee of good voice service quality for users. A notable efficiency benefit of codecs for HD voice ensures that operators can use these without any significant impact on radio frequency (RF) capacity. The new codec for evolved HD VoLTE will – despite improved quality – not require more RF capacity or any upgrades of the VoLTE radio infrastructure.

The second important operator asset to build on is global interoperability. The global E.164 community of billions of phone numbers that form a unique identity for phone users is a major asset for operators. Telephony service providers have over the years managed to build the world’s largest community, in which people can reach, via the phone number, any telephone globally. Operators can maintain a significant advantage over OTT competition by building on this global community and continuing to provide interoperable voice services that can serve billions of users. No other player has managed to build such a high-quality interoperable service. Continuing to build on this successful service and evolving voice quality even further, through support of new interoperable voice technologies such as evolved HD voice, will bring major benefits to the whole industry and its billions of users.
There are several advantages to providing superior voice quality with HD voice, or even more so with evolved HD voice, that can translate into business benefits for operators in both the consumer and the enterprise segments.

**USERS MAKE MORE AND LONGER CALLS**
If operators are using price-per-minute charging, HD voice provides a good business opportunity based on increased minutes of use. The improved user experience encourages subscribers to make more calls, and the average call duration tends to be longer. Making calls in previously inconvenient situations, such as from a busy street, now becomes viable. One study showed 96 percent of HD voice users were either very satisfied or quite satisfied with the commercial service [12]. This type of user satisfaction can turn into revenue, either by direct charging or reduced churn.

**PROVIDE ATTRACTIVE SMARTPHONE BUNDLES**
If operators have moved away from per-minute charging and have instead started offering bundled pricing for data, voice and SMS services, the increased minutes of use within the bundle limits does not provide extra revenue potential. However, voice service quality is still an important aspect to leverage. Users who have experienced the quality improvement provided by HD voice are often willing to change to an HD voice-enabled phone when they experience the quality difference.

Telecom-grade evolved HDVoLTE networks also give operators a further advantage with their ability to enable high-quality voice services in rural areas where OTT services may be unreliable due to limited broadband coverage.

In other words, operators can attract and retain users through compelling smartphone packages that bundle high-quality voice with high-speed broadband, differentiating their offerings with a brand image of quality and reliability.

**ENTERPRISES CAN BENEFIT FROM HIGH-QUALITY VOICE SERVICES**
There is also a significant opportunity for operators to help mobilize enterprises by offering enterprise communication service packages featuring high-quality voice and videoconferencing, voice-recognition services and other similar services. Better voice quality will lead to improved efficiency, reduced costs and a more productive working environment.

While an optimal user experience is no longer exclusive to fixed networks, they continue to be important, and high-quality voice is relevant to any fixed offering, especially as part of HD videoconferencing solutions. Offering operator interconnect of high-quality communication services between all enterprises will obviously increase the market size significantly, with even larger benefits for all enterprises within a country or globally.
HOW TO INTRODUCE EVOLVED HD VOICE IN THE NETWORK

Evolved HD voice will be an IMS-based telecom-grade VoIP service available in 3GPP systems with LTE access. The direct system requirement is therefore LTE support and a 3GPP Evolved Packet Core network. This means that there are essentially no other requirements than the use of current IMS-based 3GPP VoLTE, which is profiled by GSMA under PRD IR.92 [13]. This means that except for evolved HD voice clients, the network entities that may be impacted and may require (software) upgrades are those that perform media conversions with associated control functions at IP network borders or execute centralized media processing functions; that is, typically Session Border Gateway (SBG)/Border Gateway Function (BGF) and Media Resource Function (MRF).

If the system already supports VoLTE according to IR.92 is based on AMR-WB (HD voice), no major upgrades other than adding EVS codec support to the control plane are necessary, since the network already meets the architectural prerequisites. Further upgrades of SBG/BGF will enable transcoder-free interworking with CS 2G/3G HD voice deployments and transcoding to other HD voice codecs in, for example, the fixed network or internet realms.

For supplementary services like multiparty conferencing or voice mail to benefit from all the potential enhancements of evolved HD voice, it is recommended to upgrade the MRF with full EVS codec support. The direct benefits will, for example, include a new level of enhanced audio conferencing experience and high-quality music announcements. Such an upgrade is, however, not time critical and can be made at any time according to the operator’s strategy. Without the upgrade and in cases where the operator network already supports HD voice, the operation of supplementary services may only rely on the AMR-WB interoperable mode of the EVS codec.

To take advantage of evolved HD voice, the clients, or user equipment (UE), in the phones must support the new EVS codec. This poses certain requirements on the clients with regards to processing power and terminal acoustics. In order to fully benefit from the new quality dimension enabled by evolved HD voice, the client device acoustics have to be properly designed to support super wideband (SWB, up to 14kHz) or even fullband (FB, up to 20kHz) audio frequency range. Corresponding requirements on device acoustics are currently being specified by 3GPP. SWB and FB operation will also require that the UE’s speech enhancements functions, such as noise suppression and echo cancellation, support the enlarged audio bandwidth. An overview of the system impact of evolved HD voice is shown in Figure 4.

HOW TO SUPPORT HIGH-QUALITY VOICE SERVICES EVERYWHERE

With the vision of a high-quality, voice-connected world in which all users are able to use HD voice with all of their friends, colleagues and business partners across the globe, operators would have to ensure the interconnection of all their HD voice-enabled mobile networks. Twenty-nine countries have at least two mobile operators offering HD voice [14], and operators have
started interconnecting multinational networks. Interconnectivity takeoff is expected to continue even with the adoption of evolved HD voice, during which today’s HD voice will remain the fallback. Mobility cases with roaming between LTE/VoLTE and 2G/3G networks will be handled efficiently and without impacts on voice quality through seamless HD voice handover from LTE to 2G/3G networks [15]. Fixed VoIP networks with HD voice codec support and HD-enabled devices can also be interconnected to mobile networks.

HD voice and evolved HD voice can therefore be valuable solutions for all networks, with the potential to develop into a global ecosystem in which users make high-quality voice calls from wherever they are, over any device, to any other location – see Figure 5. Operators need to invest in interconnectivity in order to leverage the full HD voice and evolved HD voice potential.
Across the globe, voice is valued as a personal way of communicating, and for operators, an attractive voice offering will continue to be an important component of successfully combined data and voice bundles. The operator business case for high-quality voice services centers around the following: increased revenues from existing customers, reduced churn, and attracting new customers. With high-quality voice services, users make more and longer calls, and operators gain the ability to improve subscriber loyalty and brand perception by offering attractive high-quality service bundles for consumers and enterprises.

HD voice-capable networks and devices are already widely spread across the globe and continue to proliferate. The service can be further improved for both voice and music by utilizing evolved HD voice in LTE networks. However, delivering the best possible user experience and establishing superior voice quality on a mass-market scale requires interconnection of these services across all networks.

HD voice in GSM, WCDMA, CDMA, LTE and fixed networks, together with evolved HD voice for LTE networks, can provide an improved user experience in combination with new IP-based communication services. For example, voice-mail playback can be clearer, eliminating the need for a user to listen multiple times to a message in order to understand it. The number of inaccurate translations in speech-to-text applications can be reduced, and conference calls can also be more effective with the addition of HD videoconferencing. There is also great potential to make live broadcasting more reliable, as reporters could call studios directly, knowing that their voices would be heard clearly.

Real performance matters: this is why improved voice quality makes a difference to people, business and society and will continue to provide value to both operators and users. With HD voice and evolved HD voice, people will continue to enjoy superior quality voice communication via their operator service to anyone who has a phone number.

The telecom industry and its users would benefit from securing full industry agreement on this suggested evolution of today’s voice service for LTE networks based on evolved HD voice, so that operators can continue building globally interoperable high-quality voice offerings for an all-IP based communications world.
BACKGROUND ON STANDARDIZATION

In 2010, 3GPP launched a work item \cite{16} targeting the standardization of a new voice codec EVS suitable for migrating HD voice to the next level – evolved HD voice. This continues to build on the globally deployed 3GPP-based voice services yet maintains interoperability with today’s AMR-WB-based HD voice. While 3GPP has just approved the main EVS codec specifications \cite{17}, it is expected that the standardization work to support evolved HD voice in 3GPP systems will be completed shortly as part of 3GPP Release 12.

The targeted vision is that the EVS codec will lead to clear benefits in terms of overall service quality and service deployment costs in 3GPP LTE networks. This would make evolved HD voice based on the EVS codec the dominant voice service in 3GPP LTE networks. It is further likely that evolved HD voice will see extensions beyond the 3GPP LTE system scope, ranging from possible deployments in CS networks \cite{18} to other mobile and wireless networks (such as Wi-Fi), fixed networks and the internet, including uses involving WebRTC.

The envisioned evolved HD voice use cases often go beyond classical telco-grade telephony and include high-quality, multiparty conferencing or audiovisual communication, which will offer a “being-there” QoE. Even streaming voice and audio, as well as offline voice and audio delivery, may not be too far-fetched application scenarios of the EVS codec.

AVAILABILITY OF EVOLVED HD VOICE

Implementation and deployment of evolved HD voice can now start directly after the 3GPP approved EVS codec selection and the EVS standard specifications. Commercial launches could be expected in 2015.
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18. 3GPP Support of EVS in 3G Circuit-Switched Networks, 3GPP work item description, available at: http://www.3gpp.org/ftp/tsg_sa/WG4_CODEC/TSGS4_80/Docs/S4-141034.zip
FURTHER READING


> 3GPP TR 22.813, Study of use cases and requirements for enhanced voice codecs for the Evolved Packet System (EPS), available at: http://www.3gpp.org/ftp/Specs/archive/22_series/22.813/22813-a00.zip

GLOSSARY

AMR-WB  Adaptive Multi Rate Wideband
BGF    Border Gateway Function
CS     circuit-switched
DECT   Digital Enhanced Cordless Telecommunications
EVS    Enhanced Voice Service
FB     fullband
MGCF   Media Gateway Control Function
MGW    Media Gateway
MRF    Media Resource Function
MRFP   Multimedia Resource Function Processor
MSC-S  Mobile Switching Center Server
OTT    over-the-top
PSTN   public switched telephone network
RF     radio frequency
SBG    Session Border Gateway
SWB    super wideband
UE     user equipment

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