

DECT-5G Industry White Paper

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1. EXECUTIVE SUMMARY

In creating this White Paper, the DECT Forum has engaged a diverse set of contributors to give it the perspective and the technological grounding necessary to address new and existing audiences. We hope we have achieved this goal and would like to extend our gratitude to the following contributors: ETSI, ITU-R (Cengiz Evci), Ascom, Robert Bosch GmbH (Dr. Andreas Müller), DECT Forum, Dialog Semiconductor, DSP Group, RTX, NEC Enterprise, Sennheiser and the ULE Alliance.

The 5th generation of mobile communications 5G is a technological quantum leap and one which will leave its mark for many years to come. Indeed, it is not unfair to call it the most important of the mobile generations thus far as it allows for continued enhancements to the standard over time. This White Paper sets out to inform a wider public about 5G and the standard IMT-2020 and why DECT can and should be considered in the context of 5G. It attempts to give the reader an insight into the size of the 5G opportunity, the scope of the technology and how DECT will act as a Radio Interface Technology (RIT) to ensure 5G reaches all of its potential. For anybody interested in mobile technologies and their importance for the internet of things and people, this paper is created to be digestible by technical and non-technical managers, visionaries and professionals alike. We hope you enjoy it.

DECT is one of the Mobile Communications Industry's longest standing and most successful technologies. Standardized by ETSI in 1992 for use in Europe, it has established itself in many global markets far beyond its original regional scope. During this time DECT has become synonymous with reliable robust wireless connectivity. Traditionally this connectivity was understood in the context of cordless telephony and whilst lesser known, was also used in many diverse enterprise applications, including pagers for lone workers, in hospitals for communication devices, in defense for walkie-talkie applications, and in audio for microphones, and headsets. More recently with the introduction of the DECT Ultra Low Energy (ULE) ETSI standard in 2013, other more data centric markets like smart home and building are being successfully engaged. In parallel the technical landscape in which we find ourselves is changing beyond recognition. The so-called Internet of Things (IOT) has become a term describing the online connectivity of all manner of objects. From the Smart Home to the Smart City, the Industrial Internet of things, Automobile connectivity, e-health, no part of our daily lives remains untouched.

Faced by this dynamically changing landscape, the mobile community has created the 5th generation of mobile communications. The ITU-R specification underlying this is called IMT-2020 and promises to shape mobile communications for the foreseeable future. As an existing IMT-2000 Mobile technology(3G), the DECT Industry is also re-shaping itself to become an IMT-2020 technology. DECT-5G is the name given to the specification underlying the next generation of DECT and ULE. This will be aligned with the technical requirements of IMT-2020 but not restricted to them. As a mobile technology DECT has always been and strives to remain unique. Coupled with a radio spectrum that is not regulated by operators, DECT offers significant benefits for industries where reliable service for mission critical processes is a pre-requisite. Industrial (process automation), healthcare (vital signs), and professional audio are examples of industries that place a high premium on these factors and stand to gain from DECT-5G. By its nature, DECT 5G will be of strategic importance for the indoor environment compared to other technologies. This is a critical factor since statistics indicate that around 80% of data traffic is generated via indoor systems, and more than 50% of the world population live in urban areas; such trends are foreseen to continue or even further increase in the future.

This White Paper outlines the technical and market driven parameters that underpin DECT-5G. It describes the technical requirements of IMT-2020 and how DECT-5G will address them as well as exposing how DECT-5G will go beyond the known requirements to enable successful target application markets (eg. Low Power). The paper also exposes some of those potential vertical markets and their requirements for the technology and attempts to bring the applications into focus that will drive the industry in the future.

The 5G market Opportunity

The surge in the number of subscribers is a key factor for the 5th generation of mobile communications. According to some sources*, 1.6 billion 5G subscribers are forecast in 2025; mainly in Asia (58%, 950million) and with 274 million 5G subscriptions, Europe is expected to account for 17% of the world total in 2025, Growth is expected to start from 2022 when 5G subscriptions will head past the 200 million mark [1].

[1] *5G Presentation by B. Barani, EC, DG Connect at Forum Media Mobile, November 2017, Paris)*

In relation to ever-increasing subscriber perspectives, the ITU-R has also investigated the trends in the growth of IMT traffic from 2020 to 2030 by predicting many drivers influencing this growth. E.g. The adoption of devices with enhanced capabilities that will require higher bit-rates and bandwidth. Increased video usage, device proliferation and application uptake will also drive these trends. The adoption of mobile technology in industrial, automotive, smart city and other vertical markets will ensure an application diversity unseen today

Expectation is that these market drivers will evolve over time and will differ between countries due to social and economic differences. The ITU-R Report contains global IMT traffic estimates for the years 2020 to 2030 from several sources. These estimates anticipate that global IMT traffic will grow in the range of 10-100 times over this period. [2] *ITU-R M.2370, July 2015.*

2. THE INFLUENCE OF 5G ON THE TECHNICAL LANDSCAPE

5G (IMT-2020) is a marketing term used to define the next generation of mobile technology and the logical next step following 1G (Analog), 2G (Digital), 3G (IMT-2000) and 4G (IMT-Advanced). These steps are the result of a democratic standardization process driven by national telecommunications administrations and other stakeholders in mobile technology. Like its predecessors, the 5th generation of mobile technology contains lofty goals for the entire industry. Not only will the technology evolve but also the infrastructure, the network, the spectrum, and the challenge of adapting 5G to the requirements of a host of diverse industry verticals that are unrecognizable from older generations. At the start of the standardization process for 5G, the ITU-R produced a graphical representation (Figure 1) of this diversity with a triangle that categorizes major 5G use cases at each of its corners. *Source: (ITU-R M.2083, September 2015) [3]*

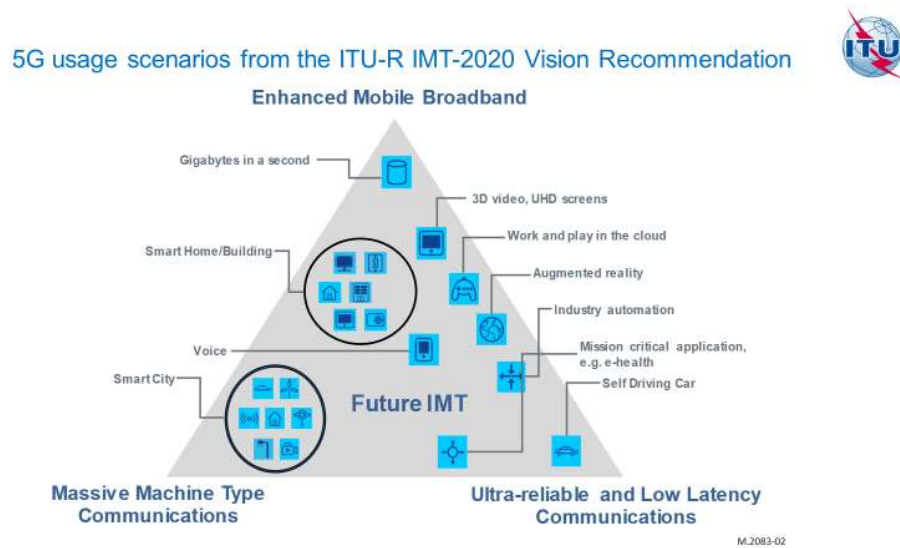


Figure 1: The ITU-R 5G Use Case scenarios[3]

The main difference between 5G and its predecessors is the emphasis in 5G on addressing dedicated application fields, and not only achieving the target technical parameters of high speed and mobility. The use case philosophy is important to help define a standard that addresses the needs of so many diverse verticals, The 3 apexes of the triangle are:

Enhanced Mobile Broadband which essentially deals with high speed data transfer (a factor of 10 higher than 4G-(see Figure 2's spider diagram)) and is one of the requirements driving the standard. For use cases like Video and Augmented reality, this "Fibre-Like" speed is essential.

Ultra Reliable Low Latency Communications however addresses a different set of requirements for applications of a mission critical nature, where reliability and quality of service are of paramount importance. In particular it addresses applications in the area of healthcare, audio and process automation with tough requirements on latency reliability and low power(for battery operated devices) The enhancements, introduced by DECT-5G will enable DECT and ULE to address lower latency applications, and with embedded support for roaming and hand-over, DECT and ULE can even enable the seamless coverage of a campus of buildings making a compelling case for industrial automation.

Massive Machine Type Communication defines a set of uses cases that address Smart City type applications. Mobility is a key attribute in many such applications, delivering a quality user experience in a train at 500 KMH, or to remotely located wind turbines.

Densely populated cities will pose the challenge of delivering both high throughput to multiple devices in multiple homes. Conversely the same customer will require low data, low power and low latency services with mission critical reliability. There is no "One Size Fits All" solution that can also achieve the price points to make it a compelling prospect for a large scale roll out. Such diversity will require optimised solutions for each market segment

Within this context, DECT-5G addresses a subset of the 5G use cases. By complementing other 5G mobile technologies within a Set of Radio Interface Technologies(SRIT) like 3G PP and LTE, DECT-5G will address the market and business-case needs of applications like voice and data in smart homes and buildings, as well as mission critical URLLC applications like Industrial Automation, Healthcare, Audio and more.

The number of use cases for IoT in general, and smart buildings in particular, is very broad and diverse. There isn't a single wireless technology that can efficiently and effectively support all of them. Considering its unique performance characteristics, ULE supports a significant portion of these as well as effectively addressing use cases beyond smart homes and buildings.

Complementary Technologies

To fulfill the promise of IMT-2020, candidate Radio Interface Technologies (RITs) are being developed to satisfy the minimum technical performance requirements and evaluation criteria of IMT-2020 and are combining to complement each other within a Set of RITs (SRITs) to fulfill *all* of the requirements.

As mentioned above, Indoor coverage is an important factor for the success of 5G with 80% of data traffic generated via indoor systems, and with more than 50% of the world's population living in urban areas. For 5G to meet the challenges of so many diverse

applications, proponent technologies will have to be complementary. DECT and ULE have built their success on addressing indoor applications.

Cellular (mobile) systems on the other hand are designed for a similar set of services and requirements in outdoor and indoor areas. However, this is expected to change in the future. Indoor environments, where people spend most of their time (work and home), are expected to be much more heterogeneous than outdoor in terms of access technologies and services. The requirements for technologies and services will span several orders of magnitude, in terms of data rates and (low) latency. (from multiGb/s video and Virtual Reality applications, to low data rate sensor devices).

This underpins the need for 5G technologies such as DECT-5G and 3GPP to complement each other to fulfill all of the requirements of a diverse set of applications that cannot be fulfilled by just one technology.

3. SETTING THE SCENE: DECT FROM IMT-2000 TO IMT-2020

To understand DECT becoming an IMT-2020 technology, it is wise to reflect on how this came about. Standardization of DECT started in the CEPT committee Radio-Equipment-and-Systems (RES) and ECTEL Task-Group-Cordless-Services (TCS) in the mid-80s. The work transferred to ETSI in the year 1989. Within two years with the help of Project Team 10, the ETSI Sub-Technical-Committee RES-3 produced the first version of the DECT base standard EN 300 175, which was published 1992.

That year, the World Administrative Radio Conference (WARC-92) identified spectrum for the Future-Public-Land-Mobile-Telecommunications-System (FPLMTS) which then was renamed to International-Mobile-Telecommunications-2000 (IMT-2000). This initial spectrum allocation for IMT-2000 included the band 1710 - 2025 MHz.

ITU-R defined the requirements for IMT-2000 systems, which include the capability for multimedia applications and a wide range of services and terminals. To fulfill the IMT-2000 requirements a new release of the DECT standard was generated, which included high-level modulation modes for supporting higher bitrates. DECT passed all the evaluation criteria and was included in the IMT-2000 Recommendation ITU-R M.1457[4].

Since the publication of the first version of the Recommendation, the IMT-2000 specification has been continually enhanced. ETSI TC DECT regularly provides input to the revisions of the IMT-2000 Recommendations, improving the existing services and adding new features and capabilities.

After the completion of the first version of the IMT-2000 Recommendation, ITU-R started with the definition of the IMT-Advanced system. Key features were increased spectrum efficiency, a higher peak data rate and a higher user experienced data rate of 10 Mbit/s. The first version of the IMT-Advanced Recommendation was completed 2010 and the main proposal came from 3GPP.

The next step was the definition of the IMT-2020 Recommendation, which has identified three usage scenarios:

- Enhanced Mobile Broadband (eMBB)
- Massive Machine Type Communications (mMTC)
- Ultra-reliable and Low Latency Communications (URLLC)

All requirements (See Figure 2) have increased compared with the earlier IMT-systems (*ITU-R M.2083, September 2015*). Relative to IMT-Advanced most of the key-parameters have increased by a factor of 10 or more (Figure 2). Two groups announced they plan to provide candidate proposals for IMT-2020, these being 3GPP and ETSI TC DECT.

In many countries, eMBB is under consideration as the first service for deployment. In a European context, both The European political goals for the Digital Single Market (DSM) and the Digitizing European Industry (DEI) indicate that mMTC and URLLC have equal importance to eMBB and are applicable in vertical sectors such as health, transport and manufacturing.

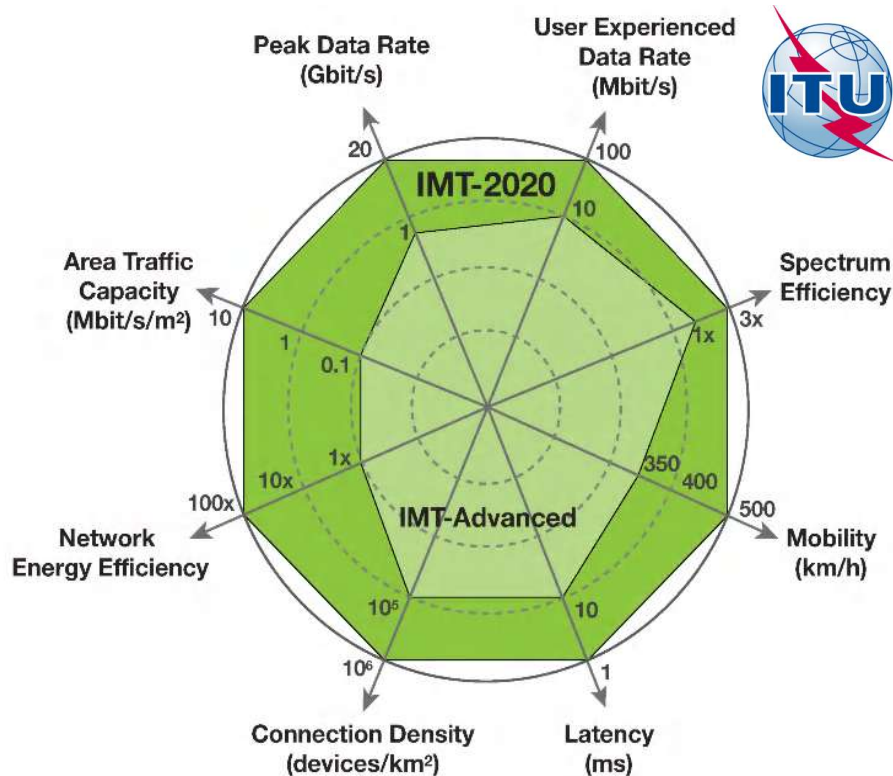


Figure 2: ITU-R Requirements for IMT-2020

The technical requirements of any standard give us an insight as to the types of applications that will be addressed. The requirements of IMT-2020 which are dealt with in the next chapter, also show how diverse these applications are.

4. IMT-2020 REQUIREMENTS

The ITU-R document [\[IMT-2020.TECH PERF REQ\]\[5\]](#) defines the requirements for IMT-2020. These requirements aim to make IMT-2020 more flexible, reliable and secure than previous IMT standards when providing diverse services in the intended three usage scenarios of (eMBB, URLLC, and mMTC).

There are 13 technical performance requirements, (Latency is divided into 2 categories) some of which have slightly different values depending on the use case (i.e. eMBB, mMTC, URLLC), as shown in the following table.

Requirement	Usage scenarios			DL: Downlink, UL
	eMBB	mMTC	URLLC	Target
Peak data rate	Y			DL: 20 Gbps UL: 10 Gbps
Peak spectral efficiency	Y			DL: 30 bps/Hz UL: 15 bps/Hz
User experienced data rate	Y			DL: 100 Mbps UL: 50 Mbps
5 th percentile user spectral efficiency	Y			(Depends on test environment) DL: 0.12 – 0.3 bit/s/Hz UL: 0.045 – 0.21 bit/s/Hz
Average spectral efficiency	Y			(Depends on test environment) DL: 3.3 – 9 bit/s/Hz UL: 1.6 – 6.75 bit/s/Hz
Area traffic capacity	Y			10 Mbit/s/m ²
User plane latency	Y		Y	URLLC: 1 ms eMBB: 4 ms
Control plane latency	Y		Y	20 ms
Connection density		Y		1000000 devices/km ²
Energy efficiency	Y			Qualitative measure only
Reliability			Y	1-10 ⁻⁵ success for transmitting 32-byte SDU in 1ms
Mobility	Y			(Depends on test environment)
Mobility interruption time	Y		Y	0 ms
Bandwidth	Y	Y	Y	At least 100 MHz of aggregated bandwidth of radio spectrum, up to 1 GHz for higher frequency bands

IMT-2020 defines a RIT (Radio Interface Technology) and SRIT (Set of Radio Interface Technologies). Also defined are five Test Environments (TE),

1. Indoor Hotspot-eMBB: An indoor isolated environment at offices and/or in shopping malls based on stationary and pedestrian users with very high user density.
2. Dense Urban-eMBB: An urban environment with high user density and traffic loads focusing on pedestrian and vehicular users.
3. Rural-eMBB: A rural environment with larger and continuous wide area coverage, supporting pedestrian, vehicular and high-speed vehicular users.
4. Urban Macro-mMTC: An urban macro environment targeting continuous coverage focusing on a high number of connected machine type devices.
5. Urban Macro-URLLC: An urban macro environment targeting ultra-reliable and low latency communications.

During the IMT-2020 submission and evaluation stage, a RIT needs to fulfil the minimum requirements for at least three of these test environments; two test environments under eMBB and one test environment under mMTC or URLLC. During later stages of the evaluation, a RIT/SRIT must fulfil the requirements of all five of the Test Environments; in general, this means that a RIT does not have to meet all requirements, as long as it is part of an SRIT that does.

The IMT-2020 submission process itself requires that candidates provide the necessary technical details, and evaluation results (some of which require simulations, and some are analytical). The submission is assessed by one or more Independent Evaluation Groups appointed by the ITU. Final consensus-building and development of the radio interface recommendations should happen in 2020.

The following figure 3 depicts the detailed time-line and process for IMT-2020 in ITU-R:

WP 5D timeline for IMT-2020 Detailed specifications for the terrestrial radio interfaces

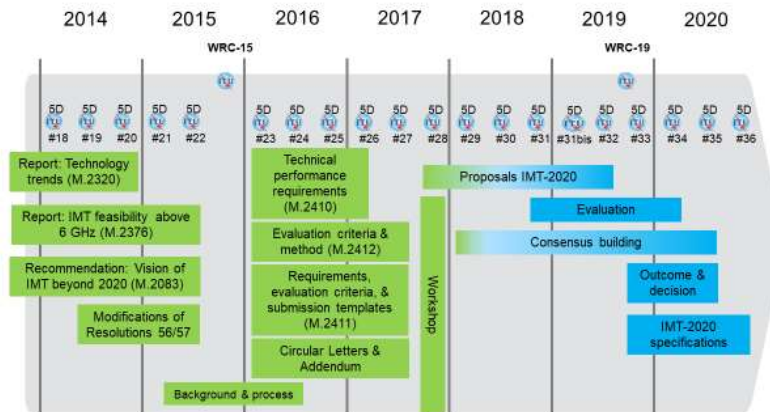


Figure 3: ITU-T WP5D IMT-2020 Timeline. Source ITU-R [3]

The roadmap to IMT-2020 approval outlined above is closely aligned with the goals of the DECT industry at large. In the following chapter, the 5G goals for the DECT industry will be examined in more detail.

5. DECT-5G:GOALS FOR THE INDUSTRY

This white paper has thus far outlined the technological landscape that currently pervades and the one that 5G will enable in the future. In such a dynamic environment, it is only natural that DECT and other technologies assess their position and create an environment that allows their industry to evolve within the context of 5G.

Several drivers for the DECT Industry merit some more analysis.

The Changing Technological Climate: The scope of 5G and its significance for DECT has been outlined above, but what will that mean for manufacturers, Chip suppliers, system Integrators and others in the value chain. Fulfilling and surpassing the requirements of IMT-2020 are a pre-condition to be part of 5G. It is also important for candidate technologies to know and accurately address their sweet spot within this scope.

DECT has traditionally been associated with cordless voice and ULE with Smart Home & Building. The market for Voice is changing beyond recognition, as it becomes the user interface and not only the application. This is a hugely positive development for a technology such as DECT. With many years of successfully perfecting audio compression codecs, micro- and speakerphone technology, as well as the DSP competence that underlies this, the technology has a new value opportunity, with the infrastructure already prepared.

ULE on the other hand, brings great value to IMT-2020 with its low power, security, range and robustness. The low latency and power consumption targets of IMT-2020 can already be met by ULE, but in the context of a growing number of devices expanding into new application fields like Industrial Automation, further reductions are likely in DECT-5G. This will lead to improved reliability and a reduction in form factor and battery sizes, keeping IMT at the cutting edge of IoT.

Addressing New Verticals: As the landscape changes so too, the applications and customer base. With 20MHz of dedicated spectrum, DECT and ULE have distinct



The age of ubiquitous computing: Voice enabled!



Factory Automation

advantages over technologies that function within the bounds of the rules governing their spectrum use. Applications that use DECT / ULE are only restricted by the scope of the specification and the rules governing the technology. This relative freedom is highly valued in mission critical application segments such as industrial automation and professional audio. For example, DECT was originally developed as a voice technology. This means it already has an in-built Quality of Service mechanism, dynamically regulating what channel to choose at the right time. Couple this with a deep understanding and history of DSP, microphone and speakerphone competence, as well a low power standard that enables connectionless battery powered sensors and the potential for success in new verticals starts to become apparent. For this reason, the DECT 5G specification “DECT-2020” will be the product of the requirements of legacy DECT and ULE as well as incorporating the requirements of a new generation of DECT / ULE developers, system architects and manufacturers.

Securing Spectrum:

IMT-2020 will increase Spectral efficiency by a factor of three compared to IMT-Advanced. For DECT-5G, this implies preparing the technology for new usage scenarios with multitudes of clients aligned to one or several base stations. DECT will continue to place emphasis on robust and reliable data and voice transport even within this context. DECT 5G will represent a local Area 5G technology, ideal for applications that rely on interference free “wired-like” communication. These mission critical applications are highly valued by national administrations and government bodies for their significance to the economy and require the security of service that DECT offers over a timescale of up to 20 years to be aligned with typical product life cycles.

Future Proofing the Technology:

As DECT moves to 5G, so too the underlying technical specification advances. This is a quantum leap for the mobile industry and DECT specifically. DECT-5G will prepare the technology for the next decade and beyond. Many of the requirements will drive the advancement of silicon, DSPs and systems to address new application markets with longer product life cycles while remaining compatible with legacy DECT and preparing the technology for the challenges ahead.

IMT-2020 contains some lofty goals, all of which are positive for the advancement of mobile technologies and improving quality of life and extending the power of technology. In the

following sections the requirements of some potential horizontal and vertical markets will be explored and their significance for IMT-2020 and DECT-5G.

6. HORIZONTAL MARKET REQUIREMENTS

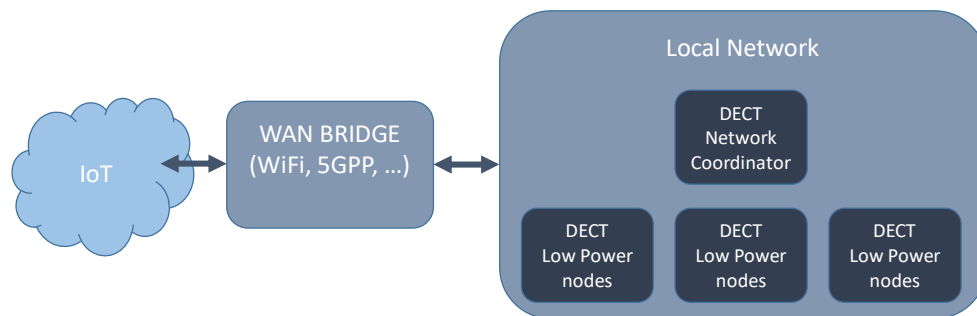
6.1. LOW POWER

This section deals with the so-called horizontal market requirements for the technology. They are typified by touching a wide range of vertical application markets.

Low power is one such horizontal market requirement addressing a range of market verticals.

Reducing a product's power consumption not only helps to reduce the product's cost, size and weight, e.g. by allowing smaller battery dimensions. For some applications, such as disposables or products with inconvenient access to chargers or battery replacement, it is even a fundamental requirement.

Sharing network resources with other services and applications may degrade Quality of Service (QoS), especially when optimizing for lower power (and low latency). Having a dedicated network is highly preferable in this situation.



Key Benefits:

- Improved power efficiency: TX output power can be lowered to cover only local area.
- Increased spectrum efficiency: low latency audio/data streaming (i.e. high duty-cycle) applications only occupy air-time in specific areas. In addition to this, lower TX output power (see previous bullet) allows for more efficient spectrum reuse.
- High degree of control over Quality of Service, since this is only defined by the local network configuration.

Low power consumption is inherently possible with the DECT technology:

- Scheduled access allows for power-efficient duty-cycle based operation. This is the basis for ULE (Ultra Low Energy).
- GFSK modulation (Gaussian frequency shift keying) utilizes a constant-envelope modulation method. This relaxes the radio architecture linearity requirements and in turn allows for low radio power consumption implementation. This especially helps reducing the overall power consumption in low duty-cycle applications. It

also helps to reduce transmit peak currents, as GFSK allows for the use of more power-efficient saturated amplifiers.

- For higher duty-cycle operation, DECT also allows for higher order modulation methods. Assuming constant payload, these allow for shorter air times. These in turn reduce the average power consumption.
- RF transmit power control not only reduces the radio footprint of a device, enabling better cell reuse. It also reduces the effective power consumption of the device when in transmit mode.
- The DECT network topology is a star network. For the portable parts this also leads to lower power consumption, since in a mesh network the portable parts may also need to function as network relay devices, thereby increasing their effective current consumption, an often-underestimated disadvantage of mesh networks. DECT in its normal mode of operation can communicate directly without any requirement to relay information, providing an inherently lower power solution

DECT-5G further expands on the inherent low power capabilities of the legacy DECT technology. A brief overview of some of the mechanisms:

- Even higher data rates will enable shorter air times and result in lower average power consumption.
 - Some battery types, such as coin-cells, are less suitable to deliver larger peak currents, regardless of average power consumption. For long range applications, where high output power is required to meet link budget requirements, this may be problematic. For this type of application, with low data rates, other power optimization techniques might be considered for future DECT generations. Examples that can be considered are narrow-band operation or low data-rate spread spectrum techniques: assuming constant link budget, the TX (transmit) output power (and resulting peak power consumption) can be reduced by the same factor as the bit rate reduction.
 - Compared to legacy DECT, power consumption can be reduced by up to a factor of two, based on a smaller technology node.
- Faster synchronization times reduce the radio scanning windows, which help lower power consumption in low duty-cycle operation.
- A-Field: Flexible use of the A-field reduces the protocol overhead, and thereby minimizes the energy per data bit.
- Advanced Technology Nodes: Though not only relevant for the DECT technology, advanced technology nodes will enable significant power consumption savings. For instance, a 50% smaller technology node may enable ~5x reduction in digital power consumption and ~2x reduction in analog power consumption. Digital power consumption is expected to become particularly dominant in future, since recent market trends show a strong drift towards (e.g. audio-) DSP-heavy applications, such as high-performance CODECs, microphone beam-forming, voice recognition, sensor data processing, etc. Low duty-cycle applications may benefit from SOI (silicon on Insulator) technology options that minimise transistor leakage currents by isolating the devices from the bulk silicon. So more advanced technology nodes will surely drive the overall

system power consumption down even further setting DECT and ULE up for a bright 5G future.

6.2. VOICE / SOUND

Introduction

Voice and sounds are unique benefits of DECT and ULE systems in the IoT world. This technology has proved itself over 20 years as the most suitable for voice communication in terms of link reliability, long range and audio quality on battery operated devices. It also includes built-in quality of service (QoS) in its DNA, using real-time capabilities to guarantee excellent voice quality.

In the following section, we will explore how DECT-5G can enhance existing voice and sound applications and introduce many benefits with new features.

Voice & Sound

With DECT-5G the number of duplex channels can be increased thereby increasing the number of concurrently active links (per fixed part) and, enabling the use of dozens of portable parts simultaneously. Within this context, portable parts can be DECT handsets, headsets, speakers, microphones or even VPAs (Virtual Personal Assistants). Together with the full home coverage of DECT, it implies that all voice and music portable parts at home can be DECT-based and double up as phones using a reliable link for voice calls over IP or any other means.

As DECT-5G will introduce higher bandwidth per channel, full band quality music (20-20,000Hz) can be supported in a multi-room, multi-speaker configuration.

For the DECT enterprise environment, the higher bandwidth means supporting many more handsets per fixed part, thus lowering system cost and improving voice quality using advanced codecs (e.g. Super wideband).

The voice communication system comes in many forms, from a VoIP phone system with multiple handsets and headsets, to intercom systems for co-working either in-premise or free field.

Voice also can be added to IoT devices e.g. smoke detectors, sirens, Smart Plugs, etc. based on DECT-5G, introducing new and exciting features like:

- Voice commands for control and monitoring of the smart home or facilities
- Voice commands for hands-free operation of equipment
- Voice queries for assistance and general guidance (VPA)
- Voice prompts
- Instant open two-way voice channel for emergency scenario

Furthermore, as DECT simultaneously supports voice and data transfer on the same link, DECT-5G enables a large increase in the number of possible applications and adoption rates. This is most evident when applications require voice activation to trigger a portable part action in mission critical environments.

VPA (Virtual Personal Assistants)

In recent years, with the appearance of voice activated devices like Amazon Echo and Google home, we are witness to a revolution of how users interact with their devices. It is not only “vocal personal assistance” that allows users to poll the weather, order a pizza or set appointments, but also to control their smart-home and make phone calls. The solution usually consists of a (remote) server with high processing power (aka cloud processing) and a voice terminal connected to an IP network – to send the voice to the cloud and come back with a query response. DECT-5G, with its range, reliable link, low latency and high bitrate is an excellent choice for such applications, especially when coupled with its low power capabilities enabling battery powered devices which are not available today due to their high-power consumption.

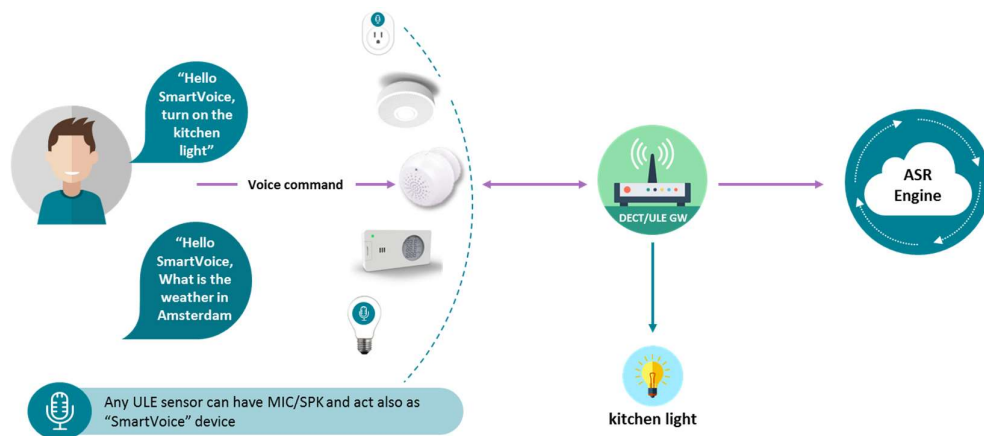


Figure 1: Voice Assistance device can be embedded in any IoT device driven by DECT-5G

Sound Analytics

Sound analytics is an emerging technology dealing with sound classification for security, monitoring and predictive maintenance.

Although theoretically sound classification can be implemented locally on an edge device, in practice due to power consumption, cost and the required processing power, it is mainly done on the local hub or on a remote server where the audio is transferred over an IP network. This implies that sound must be transmitted from the remote device to the hub. DECT-5G, is well suited to address such applications.

Furthermore, IoT devices based on DECT-5G can be equipped with microphones and act as sound sensors.

An example of such devices could be:

- Security & monitoring: Glass break detection, aggression (people shouting), dog barking, a monitored stove, baby crying, fall detection (elderly care or any other abnormal noise in the home...)
- Predictive maintenance in the home: analysis of sounds from stove, refrigerator, pipes, termites, etc. for early detection of malfunction.
- For industrial and manufacturing facilities it can be used for machine predictive analysis and inspection, analyzing moving parts like valves, rotors or any other machinery

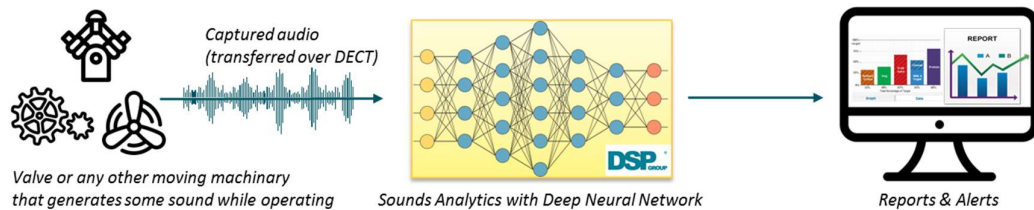


Figure 2: Example of Sound Analytics for Predictive Maintenance and Early Fault Detection in industrial environment

Conclusion: DECT is strongly rooted in voice and sound. DECT-5G will not only enhance that but ensure that IMT-2020 can live up to its promise of delivering 5G functionality to new vertical markets. By availing of DECT-5G's inherent backward compatibility to legacy DECT, this can even be achieved using current infrastructure.

7. VERTICAL MARKET REQUIREMENTS:

Whereas IMT-2000 and IMT-Advanced were developed to address mobile applications and in particular applications pertaining to high speed mobile broadband, IMT-2020 sets out to address the requirements of a host of new vertical industries that have needs other than purely high-speed data transfer. In addition to traditional markets like voice and smart home, their special needs are related to transmitting relatively small payloads, reliably and at very low latencies. These ultra-reliable, low latency types of applications are among those that DECT and DECT-5G target and are also treated in this section of the paper

7.1. MEDIA AND ENTERTAINMENT

Introduction

Media and Entertainment is a prominent sector of industry with a significant socio-economic contribution to the community. In general, its applications can be defined by production, contribution, and distribution, which also reflects to some extent the value-chain in this sector.

Distribution of content happens via broadcast networks and internet-based streaming platforms to the homes and mobile devices of end-users.

Contribution by an Electronic News Gathering (ENG) team to the daily news on TV, e.g. live Interviews are a typical use case. Such an ENG team consists of a cameraman and a reporter with a handheld microphone. The audio link of the microphone to the video camera employs local area wireless technology (e.g. DECT), while the recorded audio/video content is delivered via a wide area network (WAN) to the TV studio for further processing including (live) editing.

The production of programs and events today involves different kinds of wireless technologies, which are covered by the general term Program Making and Special Events (PMSE).

Figure 3 outlines some of the typical PMSE use cases envisioned for PMSE equipment based on 5G wireless technologies.

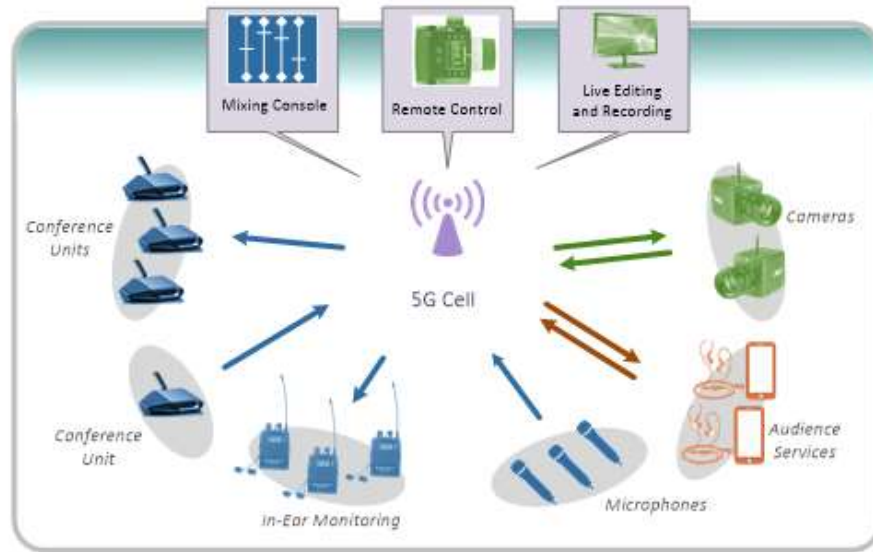


Figure 3: Envisioned setup employing a 5G cell for PMSE.

Specific Technical Requirements

Wireless technologies are used particularly if mobility and reduced setup times are required. In the case of the Media and Entertainment sector, a rich set of use cases exist that require wireless technologies. There is not only one single class of use cases, but several different use cases with a wide variety of different requirements. This underscores the need for adaptability and scalability in a typical 5G system.

Some specific requirements of the PMSE industry include the following:

1. Typical PMSE deployment scenarios are confined to a local geographical area and have a large duration range. From short-term (e.g. hours to weeks) to long-term (e.g. months to years) duration.
2. Typical professional live production setups come with stringent requirements in terms of end-to-end latency, communication service availability, communication service reliability, jitter, audio/video quality, number of wireless links per site, and synchronicity. Failures of wireless links during a live event or a live production are unacceptable. Therefore, additional efforts towards improved transmission robustness and a more effective interference management must be considered.
3. For reliable operation of the wireless equipment, professional PMSE requires controlled interference environments, e. g. through appropriate spectrum access and interference mitigation techniques.
4. There is a growing demand from end users for new and more differentiated services. Examples are augmented reality (AR), virtual reality (VR) and other new

immersive experiences. These services will require the availability of more spectrum due to bandwidth requirements.

5. Use cases of typical PMSE applications, as described in the following sections, are not yet covered by the technical requirements of the ongoing discussions within the Media & Entertainment (M&E) sector by 3GPP. The reason for this is that so far, the M&E sector has focused only on media distribution and reception rather than on production, and live audio/video production contains the requirements of a URLLC use case scenario.
6. 5G systems need to support private network deployment and operation within an event location. This is required by many PMSE operators for security, liability, availability and business reasons. Nevertheless, standardised and flexible interfaces must be supported for seamless interoperability and seamless handovers between 5G Public Land Mobile Networks (PLMNs) and private 5G deployments.
7. The 5G system must be able to support continuous monitoring of the current network state in real-time, to act quickly and automatically in case of problems, and to conduct efficient root-cause analyses in order to avoid any undesired interruption of the A/V content production, which may incur huge financial damage. Particularly, if a third-party network operator is involved, accurate run-time SLA (Software License Agreement) monitoring is needed as the basis for possible liability disputes in case of SLA violations.

Significance for DECT-5G

In the production and contribution of media content, legacy DECT is primarily used for conferencing, intercoms, and radio microphones for presentations and lectures, but not for musicians. This is mainly due to its transmission latency of 10,5 ms, while professional Audio PMSE requires end-to-end latencies being below 3 ms, so that musicians are undisturbed in their performance. The envisioned DECT-5G support for URLLC use cases would provide a standard wireless technology for conferencing, electronic news gathering, and audio production (audio PMSE) - with a quality of service already required by audio professionals and audio hobbyists with professional demands.

Distribution of media and entertainment content happens via broadcast networks and internet-based streaming platforms to the homes and mobile devices of end-users. DECT-5G will be perfectly positioned to be a wireless standard to distribute audio content within the home ensuring reliability, low-latency, and synchronicity of audio links. In future scenarios DECT-5G could also enable 3D audio and augmented reality (AR) applications in the home. The possibilities are only limited by our imagination.

7.2. Enterprise

In the competitive enterprise market, good communication solutions are of the essence. Companies have many choices for these kinds of solutions, the main ones being mobile communications or cordless communications. The mobile industry offers dedicated enterprise solutions with integrated numbering plans and femtocells.

As far as cordless communications go, DECT has been the enterprise cordless communication technology of choice for many years. It has maintained its strong foothold for many reasons beyond its license exempt spectrum. In combination with the dynamic frequency allocation algorithms, DECT provides not only excellent voice quality, but other advantages such as high reliability, security, ease of deployment and PBX integration at a low cost of ownership to businesses both small and large.

For application markets like enterprise, robust and reliable smartphones are and are expected to remain much costlier than DECT phones. A substantial share of end-users that require more cost-effective, lightweight and robust handsets based on DECT will continue to exist. Typically, Enterprise DECT manufacturers have a range of handsets starting with basic, low cost entry phones to fully fledged, robust handsets fitted with alarms to address personal safety. This includes dedicated intrinsically safe handsets (and access points) that are certified according to the ATEX (ATmosphere EXplosibles) standard and can be used in potentially explosive environments.

Many additional services can be integrated in the DECT environment as required by the customer. These could include messaging, alarming, location determination, personal safety.

Coming up, a closer look will be given to 2 important enterprise sectors: Healthcare and Hospitality

7.3. ENTERPRISE VERTICAL MARKETS I: HEALTHCARE



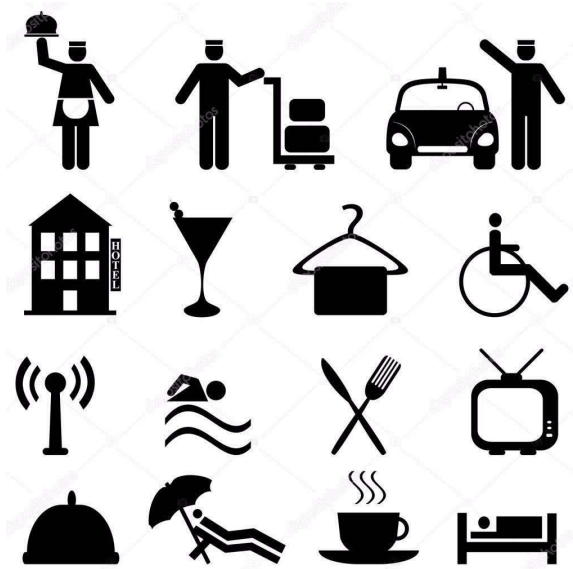
The Healthcare segment is increasingly faced with challenges to improve efficiency, patient security and patient satisfaction. On-site wireless systems play an important role in meeting these challenges. In environments where every second counts and important decisions need to be taken on the spot, critical messaging solutions require technologies that offer reliability, scalability, sufficient bandwidth and the possibility to locate people and other resources instantly.

Keeping pace with healthcare's highly demanding work environment requires the need to communicate whenever and wherever necessary with the fewest constraints possible. Healthcare-specific communications and IT solutions enable healthcare providers to improve productivity, generate cost savings and create an environment where efficiency and responsiveness foster best possible patient wellbeing.

DECT offers healthcare a safe and secure mobility solution that ensures workers stay connected anywhere, anytime to make patient care more immediate, dynamic and adaptive, reducing waiting times and improving health results.

In addition, to ensure the ongoing safety of patients, caregivers and visitors, healthcare providers must have a contingency plan should an on-site emergency occur. DECT-based emergency notification solutions help to quickly communicate the source and severity of a situation and seamlessly notify personnel and public safety officials for optimal on-site protection and the wellbeing of those within the facilities.

7.4. ENTERPRISE VERTICAL MARKETS II: HOSPITALITY



In a service-oriented market segment like hospitality, staff responsiveness is of the essence. Equipped appropriately, employees no longer need to remain in one location to respond to inquiries or to get their work done. Mobility solutions therefore play a crucial role in this market.

For hospitality staff who are frequently on the move, such as housekeeping, room service or airport shuttle personnel, greater accessibility can mean significantly improved coordination and service delivery. Mobile communication keeps all staff reachable no matter where they are across the hotel premises, including conference centers and outdoor areas. This also enhances workflow effectiveness by making staff members easier to reach and tasks simpler to prioritize and accomplish.

Enabling staff to function with fewer constraints can help free up time so the focus can shift from the necessary to the most important things. DECT communications solutions elevate responsiveness with interfaces and alarm configurations that notify and permit action when timing is critical. DECT's messaging functionality simplifies and expedites communications that don't necessitate a phone call. For example, maintenance workers can instantly receive alerts on their handsets indicating new issues for repair, such as a broken air conditioner or showerhead.

When staff are easily contacted and directed to prioritized activities, the hotel's whole organization becomes much more efficient. What's more, being able to contact the right member of staff without delay is not only efficient, it's imperative to providing the desired level of service to guests.

Mobile voice and messaging solutions can be integrated with a wide range of building management and safety systems. Solutions include facilities to capture critical events, process them and instantly send related alarm messages to various destinations (such as pagers and telephone sets, building management systems, fire alarm systems, industry control systems), with full feedback on the delivery results.

In the case of a fire, for example, handset users will not only receive notification of the fire but also the exact location of the fire to properly evacuate and avoid further danger. Users can initiate an alarm using the emergency call button. Man-down, escape, and no-movement alarms can automatically be triggered by the handset. In addition to this, detailed positional information of employees can be polled, to locate staff needing assistance and sending support immediately to the location.

While much of the functionality described above is possible with alternative mobile solutions, DECT is unique in that it guarantees connectivity in mission critical environments where getting the right message to the addressee is imperative and best effort will not suffice.

To conclude enterprise, we will explore some of the enhancements that will be required of DECT-5G to effectively serve the enterprise vertical markets.

7.5. SPECIFIC TECHNICAL REQUIREMENTS ENTERPRISE

Although many of the requirements are met by the current DECT standard there are also use cases where the standard falls short. Below some of the requirements are discussed that could be addressed by DECT-5G.

Increased data bandwidth

Driven by increasing digitalization there is a demand for smartphones in the Healthcare segment. Most of the apps that are used require bandwidth that normally implies WiFi or LTE carriers, but here DECT and especially DECT-5G can and do play a key role. Patient Monitors for example generate alarms that are forwarded to DECT handsets. Optionally these alarms can contain additional content such as heart waveforms, or for enhanced content in messages/alerts. Today's DECT radio supports video for applications (up to 10 frames/second). Even doubling the data bandwidth with DECT-5G would allow a more dynamic display of such heart waveforms or enable improved video surveillance of residents in elderly care homes or psychiatric wards.

Patient monitors are a good example of where DECT is unique and yet has potential to extend functionality within the scope of DECT-5G to include applications like Vital Signs and Collaboration. In this instance, DECT can be seen as performing credible backhaul support for Wi-Fi and Bluetooth when the ISM (Industrial, Scientific, and Medical radio band) band is congested or out of range and complies with the goals of IMT-2020 with 5G

technologies complementing and not competing with each other, ensuring improved services that benefit staff and patients alike.

Reduced power consumption – Improved Battery Autonomy

In both the healthcare (hospitals, but also elderly and psychiatric care) and hospitality verticals there is a requirement for various types of wearable devices. Examples of these include:

- Pendants: patients in hospital and residents in care homes carry these wireless devices to send alerts to nursing staff to indicate they require assistance. Pendants like this use DECT with the capability to initiate calls and receive calls.
- Messaging pagers: small and light-weight devices for receiving and sending messages.

These devices need to be small and light-weight by their nature, which sets limitations on the size of the batteries and since the devices are carried by patients, residents or staff they will not always be charged regularly. ULE has already driven down power consumption enabling the use of smaller coin cell type batteries to improve battery life. More sensitive wake and sleep modes also enable full functionality even when woken out of sleep mode. DECT-5G could enable new patient monitoring devices with longer battery life expectancy and more functionality in mission critical environments, taking advantage of the in-built voice capability.

Extended Coverage

Healthcare institutions like hospitals and care homes are usually housed in large buildings and quite often in multiple buildings spread out over large sites. This means that large areas need cover where full roaming and handover has to be maintained. Guaranteeing this seamless coverage is one of DECT's key USPs in campus type environments. By extending the range of the radio to cover even more devices, DECT -5G will offer compelling arguments to system planners to reduce Total Cost of Ownership.

Indoor positioning

Within enterprise markets, there is an increased requirement for indoor positioning to track, locate and help to navigate equipment, patients, and staff members. Available technologies today include GPS, IR, ultra-sound, RFID, Bluetooth, BLE, WiFi and DECT. To enhance the use cases offered by DECT-5G, support of indoor positioning by allowing the creation of DECT beacons, would provide a low-cost and low energy option that can be used in triangulation or fingerprinting positioning methods.

Significance for DECT 5G

DECT today is a technology that meets many of the requirements for indoor wireless communication systems. In particular, the dedicated frequencies for interference-free

communication, the reliability, ease-of deployment and security are features that have made DECT the technology of choice for many healthcare and hospitality institutes.

By building on available functionality, the envisioned DECT-5G standard will provide for even more diverse use cases, such as those mentioned above but also take advantage of its existing infrastructure in hospitals, campuses and homes. By complementing other mobile 5G technologies, the promise of seamless 5G coverage all the way to the end-user is more of a possibility than ever.

7.6. SMART HOME AND BUILDINGS:



Introduction

The IoT (Internet of Things) carries the promise of improving peoples' life by connecting “everything”, (things) and making them remotely accessible through the internet. The impact will be felt in our homes, offices, factory buildings, on our roads – practically everywhere we go. This will be accomplished through many diverse applications. Specifically, for smart homes, the applications for home security, home automation, energy control and personal wellbeing play a major role in fulfilling the vision of the IoT.

Low power wireless technologies play a major role in smart home and building applications. These place strict requirements on the underlying wireless communication protocols. Many technologies are competing to capture the largest chunks of IoT, but so far there is no single “perfect” technology, capable of providing adequate solutions to the diversity of the application requirements.

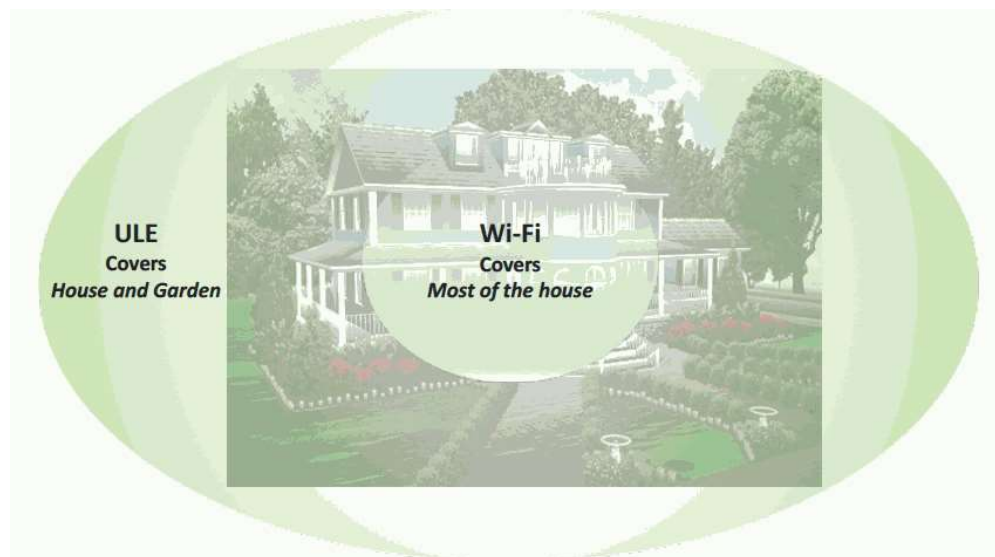
ULE – Ultra Low Energy technology, based on the DECT radio, stands out for its reliability, and simplicity and for its delivery of advanced features with low power consumption, and its unique guaranteed voice communication quality and secure transmission.

Specific Technical Requirements

There is a broad set of technical requirements for smart homes and buildings that wireless technologies should meet. These requirements are intended to create an excellent user experience through simplicity, reliability and convenience when interacting with the smart home.

Communication Range – Coverage

The communication range is one of the most critical topics in wireless communication protocols. The range determines the complexity of the network and user friendliness of the resulting product and service. When the range is not long enough to cover the entire house and building, additional techniques, such as meshing and repeating of signals is required to deliver a message from one sensor/actuator to another. This makes the network more complex and costly due to additional repeater devices. As a result, do-it-yourself installation is no longer a simple procedure. This is one of the reasons that the smart home market, based on mesh technologies has not taken off as fast as initially envisioned. Conversely, when a wireless technology, (such as ULE), enables a long enough range to cover the entire house and garden, the installation becomes very straightforward – simply position the hub/base/router and sensors where needed, and that's it – no repeaters or any other intermediate devices are required.



Range Comparison: ULE vs. Wi-Fi

Low Power Consumption

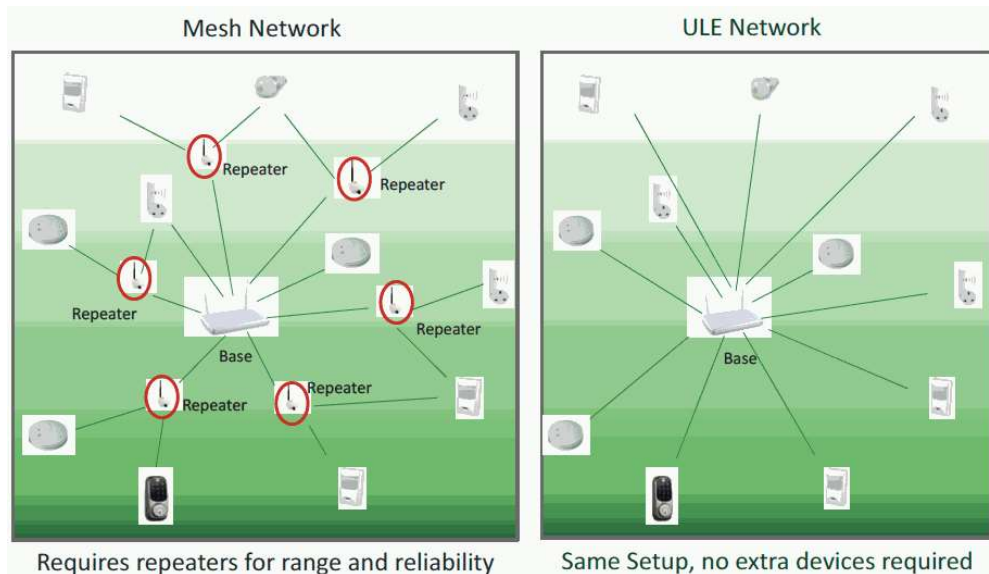
This is another crucial requirement for a successful roll out of smart home services. Typically, mobile phones using WiFi need to be charged almost daily. DECT cordless phones can last for several weeks without charging. However, such performance is not acceptable for battery-based sensors – they should be able to operate for several years on small batteries. Operation of 3+ years is considered normal. Sensors are usually small devices and cannot use large batteries. The ULE variant of the DECT protocol has been especially enhanced to enable such devices with ultra-low energy consumption.

For example, if a smoke detector is using two AA batteries (capacity of ~1,300mAH), and the device communicates with the base every 15 minutes, such a device can operate for over 5 years.

Low Interference

Modern homes contain significant numbers of devices communicating wirelessly. This creates a challenge for the quality of service and makes interference a sensitive topic. The wireless home automation system should work ALWAYS, without regard to the nature of what is being transported over Wi-Fi, Bluetooth, or similar wireless connections. Wireless technologies, that are using highly populated frequencies, such as 2.4GHz, 800 or 900MHz frequency bands, and do not have high transmission power (which is the case for most technologies), are exposed to interference and packet loss and subsequently disturbance in the quality of service offered. For this reason, they need to implement special techniques to avoid packet loss – Mesh is normally used to address this problem. The cost of that though, is redundant repeaters, increased complexity of installation and maintenance, and not always living up to consumer expectations, in terms of communication robustness.

The DECT radio on the other hand, uses the exclusive 1.9GHz radio frequency, and is best positioned to enable communication with minimal interference. Combined with long range, the low interference delivers a very simple and highly reliable network.



As shown in the above graphic, mesh-based technologies are forced to use repeaters to cover the entire house or building, increasing the cost of the overall solution because of the additional repeater devices. ULE, which does not need repeaters to cover house and garden, delivers a highly cost-effective network, simple to install and maintain.

Advanced User Interface – voice communication

The rapid growth of the “smart personal assistant” market, served by Amazon Echo, Google Home, Apple Home, and others, testifies to the importance of voice for interfacing with smart home devices. A Natural voice interface saves users from learning complex settings and activation sequences for a variety of devices. Further evolution in the natural voice interface and artificial intelligence techniques will make voice the primary, user friendly interface within the smart home.

Reliable, high quality voice delivery represents a significant challenge for most wireless communication technologies, due to strict real-time and bandwidth requirements. Most smart home wireless technologies are lacking either bandwidth or adequate real-time support. Wi-Fi, for example, has sufficient bandwidth for delivering high quality voice, however, it does not have mechanisms to guarantee timely delivery of packets to maintain a high quality of voice communication over a long period of time. So, while communication over Wi-Fi may be of high quality in some cases, in others it can be of poor quality – depending on the surrounding network traffic and conditions.

ULE benefits from DECT technology’s built-in support for a guaranteed quality of service for voice communication. In fact, the DECT radio is the only smart home wireless technology that guarantees quality of service for voice. Thus, ULE can be used as a secure, reliable resource for two-way voice communication, voice activation via speech recognition, and additional voice-based use cases.

Significance for DECT 5G

As mentioned above, the number of use cases for IoT in general, and smart homes and buildings in particular, is very broad and diverse. There isn't a single wireless technology that can efficiently and effectively support all the various use cases. Considering its unique performance characteristics, ULE technology supports a significant portion of relevant use cases. Moreover, ULE effectively addresses use cases beyond smart homes and buildings. The enhancements, introduced by DECT-5G will enable ULE to support ultra-reliable, low latency, and machine to machine type applications making a compelling case for industrial automation. Combined with DECT's embedded support for roaming and hand-over, ULE can even enable the seamless coverage of a campus of buildings.

7.7. INDUSTRIAL: WIRELESS COMMUNICATION IN INDUSTRIAL VERTICAL DOMAINS

Introduction

Wireless communication has not been widely used in the industrial domain in the past. This is mainly because existing wireless technologies have not been powerful enough to support the often very demanding requirements of industrial applications. At the same time, the potential damage and financial loss that may occur if the communication system used does not behave as expected may be huge (for example a line-stop on a production line). For this reason, the industrial domain is traditionally rather conservative and unwilling to experiment. The few existing wireless applications in industry that can already be found today are typically non-critical (such as hand scanners or sensors for condition monitoring), or help to connect devices which are hard to connect otherwise, such as sensors or actuators in harsh or remote environments, for example as part of an extended process plant. To this end, either standard wireless technologies, such as Wi-Fi or Bluetooth are used, or more robust ones such as WirelessHART or ISA 100. Even legacy DECT can often be found in current factories, but mostly for cordless telephony only.

The industrial domain is currently subject to fundamental change. This change is driven by the fusion of the classical production techniques with modern information and communication technologies. This development, which is frequently also referred to as Industry 4.0 or the Industrial IoT, builds on a ubiquitous connectivity layer, which interconnects all sorts of sensors, actuators and other devices and thus creates so-called cyber-physical production systems. The ultimate goal of Industry 4.0 is to significantly increase the flexibility, versatility, productivity and resource efficiency of industrial production in order to address current market needs. This leads to a strong demand for novel industrial-grade wireless technologies since only wireless connectivity may enable a maximum degree of flexibility, mobility, versatility and ergonomics and optimally support the ongoing developments towards Industry 4.0. At the same time, recent advances on the technological front lay the foundations for a new generation of wireless systems that can offer unprecedented performance and potentially overcome many of the concerns that have prevented the widespread usage of wireless communication in industry in the past.

The potential of a suitable wireless technology for industry is tremendous. Possible use cases include all sorts of mobile devices, such as automated guided vehicles, connected fork lifts, mobile robots or mobile control panels, but also classical closed-loop control applications in factory and process automation, for example for connecting moving or rotating parts. Currently, slip rings or cable carriers are used for that purpose, but this is something people usually would like to avoid as these may be costly devices, which are regularly replaced and maintained. Apart from that, a variety of new human-machine-interfaces are about to enter the market, such as augmented or virtual reality devices, which ideally should be connected wirelessly. Suitable wireless technologies could also enable completely new approaches to building factories. In future highly modular production units, could easily be re-positioned, seamlessly connecting to each other and re- configuring themselves in a fully automated manner.



Requirements for Industrial Applications (for Wireless technologies)

A major challenge in the industrial domain is that there is usually no single killer application or use case, which would justify the deployment of a dedicated wireless network, but there are rather many different use cases with a wide variety of diverse and often very demanding requirements. In fact, for all three main flavors of 5G as outlined above (eMBB, mMTC and URLLC) corresponding use cases and applications exist. Some general requirements in this respect can be summarized as follows:

- 1) Industrial-grade quality of service, particularly in terms of latency, reliability and dependability. Many use cases actually involve cyclic communication between a master node (e.g. a programmable logic controller) and a number of slaves (e.g. sensors or actuators), with latency requirements in the millisecond region and a required communication service availability exceeding 99.9999%, so that a wireless link becomes comparable to a wired-connection. The data packets that are exchanged between the various nodes are often fixed and relatively small (e.g. 50-250 bytes). An indispensable prerequisite for this purpose is exclusive access to spectrum.
- 2) Efficient differentiation of traffic flows and support of diverse QoS classes. This is crucial as even between just two devices, different traffic flows may exist, for example for real-time and non-real-time data.
- 3) Seamless mobility support as the basis for an uninterrupted service to connected mobile devices. The lack of seamless mobility in factories is an existing problem with standard Wi-Fi networks.
- 4) Strong, integrated security mechanisms for ensuring confidentiality, authenticity, data integrity and system availability even against potentially highly skilled

attackers, who may have an interest in sensitive production data or in disturbing regular operation of a factory.

- 5) Seamless integration with existing (typically wired-) communication technologies. This is essential as machinery and production lines may have rather long lifetimes up to 10, 15 or sometimes even 20 years. Additionally, not every cable will be replaced by a wireless link in the foreseeable future.
- 6) Adequate self-management support, to avoid using valuable resources to plan, deploy, operate and maintain a wireless factory network and that the network can – at least to some extent – automatically react to potential problems to avoid unplanned downtimes of production facilities.
- 7) The ability to operate a wireless network without a third-party network operator. This is requested by many factory owners for security, privacy, business and liability reasons. On the one hand, production data is often very sensitive, forcing factory owners to want full control of the data and of the security mechanisms in use. On the other hand, a third-party network operator will always charge something for his services, which adds otherwise avoidable costs to the balance sheet. Most importantly however is the question who is liable and to what extent if the production line stops due to a connectivity problem in the infrastructure. Given that the possible financial damage would be huge, a third-party network operator would most likely not be willing to take over this liability or only with an unacceptably high service fee.
- 8) Worldwide availability of suitable spectrum as local markets for industrial automation equipment are too small to justify the development of specific solutions. Moreover, many companies have production facilities in different countries, but want to avoid large heterogeneity of equipment and solutions across these countries.
- 9) Ideally an integrated positioning system, supporting positioning accuracies smaller than 10 cm, so that no separate solution has to be deployed for that purpose. Location information is very valuable in the industrial domain and the basis for a wide variety of different use cases.
- 10) The ability to monitor the current network state in a fine-granular manner in real-time, so that potential problems can be quickly detected, and appropriate actions be initiated.

Significance for DECT-5G

Although DECT-5G alone will not address the requirements of all use cases in industry, especially bandwidth hungry applications, it may represent an important building block if combined with other (complementary) wireless systems, such as Wi-Fi. The biggest potential for DECT-5G in future factories exists for URLLC-type applications, the most important field in this vertical. In fact, the structure of standard DECT is already well suited

to the important class of cyclic traffic (as outlined above), and if further enhanced towards lower latencies as well as higher reliabilities, it may readily fulfill all corresponding requirements. Clearly, seamless mobility has been mastered by DECT right from the outset and represents a very attractive option in terms of cost. The particular beauty (*uniqueness*) of DECT is the dedicated spectrum that is available in many countries, avoiding the need for a third-party network operator. However, radio spectrum is also a challenge, as important markets, such as China, do not have a corresponding allocation yet. However approved proponent technologies will have the right of using spectrum which is available on a worldwide basis.

All in all, DECT-5G is highly interesting and promising for the industrial domain and the further developments will certainly be closely tracked by many players in this field.

7.8 SUMMARY: REQUIREMENTS FOR VERTICAL MARKETS

This section has given the reader an insight into the range of applications and their specific requirements that are or could be addressable by DECT/DECT-5G. Given its legacy in telephony, the breadth of applications described in this section is testimony to how good technologies lend themselves to system design, irrespective of the targeted market. Some of the requirements stand out and help to shape the contours of the proposed specification for DECT-5G:

- Ultra-Reliable, Low latency: In many of the outlined vertical markets, the emphasis has been on serving the requirements of reliable communication, often paired with low latency. Achieving latency below 1ms is a challenge that will help define DECT-5G
- Mission Critical: Either as a simple voice connection or including the capability to deliver mission critical connectivity, data, alarms and signaling, this is a requirement that identifies DECT, making it a unique and unreplaceable 5G Local Area technology
- Seamless handover between 5G WAN and 5G LAN: This is the premise of interworking between 3GPP and DECT-5G and bears the promise of seamless end to end services.
- Guaranteed low latency, and reliable connectivity for media distribution, production, conferencing, and Electronic News Gathering
- Range: Coverage of the whole home (and garden) for reduction of complexity, and cost
- Interference free data transfer for mission critical sensor control and voice/data communication
- Cost effective, ease of installation and widely deployed existing infrastructure for healthcare and hospitality solutions
- Higher Bandwidth for richer applications(video) in Healthcare and Media (PMSE)
- Low power consumption with wake up to address “always on” battery powered applications
- Seamless mobility, seamless connectivity to existing wired networks for use in the industrial market segment



- Worldwide availability of spectrum and spectrum autonomy for license exempt use in industrial environments.
- Self-management/ Remote management of a wireless factory network.
- Secure mechanisms to ensure confidentiality, authenticity, for highly sensitive production and system data in industrial applications

8. TECHNICAL PARAMETERS DECT-2020

Thus far, this white paper has covered the current and future requirements of products and services for IMT-2020 (5G) TO understand the scope of DECT-5G, it requires a closer look at the technical parameters. The new DECT-5G air interface will have to coexist with the existing DECT system offering backward compatibility. Therefore, the time frame of 10 ms will be maintained, with the possibility to add shorter sub-frames for low latency operation. For additional robustness in multi-path scenarios OFDMA (Orthogonal Frequency-Division Multiple Access) combined with coding has been proposed. The selected parameters provide coexistence of DECT-5G with legacy DECT. A comparison is shown in the table below.

	Legacy DECT	DECT-2020
Channel access	TDMA/FDMA	TDMA/FDMA
Time frame	10 ms	10 ms
Nominal slot duration	416.67 μ s	416.67 μ s
Basic carrier spacing	1.728 MHz	1.728 MHz
Bandwidth	1.728 MHz	1.728 MHz, 3.456 MHz, 6.912 MHz, 13.824 MHz, 20.736 MHz, 27.648 MHz, up to 221.184 MHz
Carrier type	Single-carrier	Multi-carrier (OFDM)
Modulation configurations	GFSK, BPSK, QPSK, 8-PSK, 16-QAM, 64-QAM	BPSK, QPSK, 16-QAM, 64-QAM, 256-QAM, 1024-QAM
Spatial streams	1	1 to 6
Bit-rate	Scalable up to 10 Mbit/s	Scalable up to 10 Gbit/s

Additional DECT-2020 technical parameters:

- Physical packets consisting of multiple OFDM symbols
- Nominal sub-carrier spacing is 27 kHz
- Nominal Fourier transformation period is 37.037 μ s
- Nominal OFDM symbol duration 41.67 μ s
- Packet duration is variable
- Packet transmission starts at half slot boundary
- Packet formats:
 - Long preamble format (6 symbols for synchronization and header), which is an example of a packet using a robust packet level synchronization pattern.
 - Short preamble format (2 symbols for synchronization and header)
 - High efficiency (HE) format (1 symbol for pilot). These packet types enable more efficient communication for certain scenarios, including 'Low Latency Communications'.

9. TECHNICAL BENEFITS OF DECT-5G

DECT-5G is built on the many features that have been developed and matured through the existence of the traditional DECT technology. DECT-5G will support all the services and features of the traditional DECT, just more efficiently and reliably. To understand the scope of legacy DECT, information can be found at the following websites:

https://en.wikipedia.org/wiki/Digital_Enhanced_Cordless_Telecommunications

<https://www.dect.org/> and <https://www.dect.org/magazine-dect-today>

<https://www.ulealliance.org/>

In this section, the benefits of DECT-5G will be explored more deeply.

Here are some of the key characteristics of DECT-5G:

Co-existence with legacy DECT and ULE equipment: DECT-5G will share the RF spectrum with traditional DECT products without affecting the operation and performance of these devices and without limiting the performance and reliability of DECT-5G. It operates with the compatible timeslot and RF channel resolution and is using compatible procedures for spectrum allocation, awareness and avoidance of collision and interference.

Interoperability with legacy DECT and ULE devices. DECT-5G base stations will service both new advanced DECT-5G devices and legacy DECT devices (Handsets) simultaneously. This allows a seamless transition to the new and improved technology without having to replace all installed devices and handsets at once.

Scalability from single cell to large multicell networks. Interconnection and roaming between networks will be supported as it is currently in legacy DECT. This means scalability from a home to a building and beyond to a campus or a factory

Mobility, Multicell network operation for extending coverage area: Network topology will remain the same as in legacy DECT. Mobility, including seamless roaming and handover will be supported (Handover by make-before-break).

Licensed, Royalty Free operation:

DECT-5G operates in licensed spectrum and the technology is not dependent on network operators. The user or installer can set up a DECT-5G network without the need for a connection to any operator networks. This is especially important when a quality of service guarantee and independency of external infrastructure are hard requirements (e.g. Industrial applications).

- The principal benefit of license exempt frequency bands is that so long as devices conform to specified regulatory rules and technical specifications they may operate on an unrestricted basis without any need for prior authorization. They are therefore ideal for wireless devices that are not directly connected to a network and hence entirely under the control of the end user.

As far as mobile users' benefits are concerned, the capability of DECT-5G to work within license free spectrum will eventually introduce improved flexibility and provide an ability to connect mobile devices to a fixed broadband network. This reduces dependence on the mobile network and saves costs both for the service provider and the end-user as well as delivering enhanced convenience, safety and security, e.g. through installation of low cost wireless alarm systems.

Dynamic channel allocation is a key feature of legacy DECT and is also used in DECT-5G. It allows deployment of DECT equipment without any frequency planning or specific technical radio skills of the installer. DECT is a cognitive technology, continually reacting to the radio environment around it using dynamic channel selection to select the best signal providing excellent spectrum usage and improved system capacity without fixed frequency planning.

Spectrum resource allocation is much more advanced than in traditional DECT. It is still based on dynamic channel allocation procedures but allows the support of much wider ranges of throughput and latency. Spectrum resources can be allocated in two dimensions, ie. timeslots (TDMA) and RF channel frequency (FDMA). For bandwidth hungry services, several consecutive timeslots and multiple RF channels can be allocated, whereas low bandwidth services may only occupy down to half timeslot and half RF channels. The DECT-5G base station allocates the required spectrum for ensuring efficient interworking between different services, such as streaming applications requiring predictable QoS and low latency packet data applications.

Reliability though the use of OFDM (Orthogonal Frequency Division Multiplexing) modulation and coding. A variety of different modulation and coding rates allow adaption and use of an optimal configuration in the given radio conditions.

Low latency is supported by flexible timeslot allocation procedures. Low latency streaming applications, duplex circuit mode connection and sporadic packet mode data services can all be served concurrently on a base station. Latency down to approx. 1 ms is possible. Packets are always transmitting at slot boundaries; hence the jitter of application packets will be very low.

Concurrent support of different services, such as streaming, duplex connection (e.g. audio), sporadic packet data and ULE. New spectrum allocation schemes in the base station coordinate and allocate the spectrum resources for serving these concurrent services most efficiently.

Higher bandwidth than legacy DECT is possible through a range of different modulation rate coding schemes and MIMO in combination with spectrum resource allocation of several timeslots and bonding of multiple RF channels. This enables both traditional telephony type applications, as well as new and more demanding applications in Audio, Industrial and other vertical markets that require bandwidth from 10-100 Mbps.

Secure communication is a key issue for IMT-2020. DECT-5G **Security** features are based on state-of-the-art standards for providing access control, confidentiality and message authenticity. CCM (Counter with CBC-MAC) based on AES is used and provides

encryption and per packet authentication. Security keys are private for each device and temporary keys are used for each independent application session.

Interoperability between equipment from different vendors. Call control and multimedia configuration features from mature legacy DECT are carried in to the new technology standard and will enable the interoperability advantages associated with the GAP and CAT-iq standards and provide significant benefits for 5G users.

Range

Range has been always a critical issue for legacy DECT systems for providing customers the freedom to move around and install nodes anywhere in their homes even in non-ideal places (like the cellar). - In DECT-5G, range has improved in comparison with legacy DECT. This is mainly achieved by use of robust modulation and coding schemes. The OFDM physical layer is carefully designed to achieve good indoor and outdoor coverage. Data bandwidth will gradually decrease at longer ranges. Range extension by use of repeaters will also be supported.

Power consumption is expected to be kept on the same levels as today's mature DECT implementations. Low duty cycle techniques similar to what is used in today's DECT will also be used in DECT-5G.

Cost of implementations are expected to be on the same level as legacy DECT and become attractive compared to similar mobile cellular implementations. This is mainly due to one (or few) supported frequency bands and a more focused feature set.

Location of Terminals. The DECT-5G radio technology supports determination of distance between terminals and base stations. In a multicell DECT network it will be possible to determine the location of terminals by gathering information from several base stations and using Multilateration technics.

IP termination for integration into common network architectures. The DECT-5G API's will support both classic DECT application interfaces as well as IPv6.

ETSI standard specifies the features and functionality of DECT-5G. This standard will be open and publicly available and supported by multiple chipset and equipment vendors.

Regional support.

Spectrum currently is allocated for DECT in more than 100 countries worldwide (see map below). Today, regional frequency allocations of DECT operation are 1880-1900 MHz, 1893-1906 MHz, 1910-1930 MHz and 1920-1930, for Europe, Japan, Latin America and US/Canada, respectively. The channel plan is based on 10 channels with 1.728MHz spacing in Europe and 5 channels in US with the same spacing. Furthermore, average TX power is 10 mW (250 mW peak) in Europe and 4 mW (100 mW peak) in US applications

Considering spectrum for 5G applications, various new bands are under investigation for covering new 5G services including 700 MHz, 3.4-3.8 GHz and even 26 GHz. In the context of SRITs, DECT-5G will enable a flexible use of available spectrum. This can be achieved

by “*carrier aggregation*” (CA) combining dedicated bands for IMT-2020 operation to satisfy the carrier bandwidth demanded by new services.



DECT World map

Conclusion

The goal of this white paper is to inform diverse audiences about what 5G is and where DECT-5G fits into this movement. It sets out to provide an overview of the scale of the opportunity at hand, as well as the challenges it poses to the technology proponents for 5G. The Paper also describes the 5G opportunity for societies, and for technologies and focuses on the chance for DECT to bring 5G to clients/nodes in every corner of the home and building, complementing but not competing with 3GPP.

5G is critical to leverage digitalisation and ensure that consumers and businesses can benefit across all industry sectors, while at the same time maintaining and enhancing competitiveness in various regions of the globe. The significance of addressing application markets like URLLC and mMTC in an economical fashion and not only breaking technological boundaries is critical for the success of 5G.

By incorporating DECT-5G in IMT-2020, the mobile communication industry is afforded the opportunity of 5G living up to its true potential and touching the vast numbers of people and devices forecast for the coming decade. For those being introduced to the technology for the first time, the paper explains how DECT-5G will address existing and future key target markets, specifying the parameters of the technology, and providing the technological scope for products and applications.

Remaining true to the uniqueness of DECT and being backward compatible to the millions of legacy devices and infrastructure will be a vital element of DECT-5G. Retaining the attributes that set it apart from other wireless technologies will ensure that it will be welcomed into the 5G list of approved RITs and counted upon for Local Area 5G performance in new application markets like Industrial Automation, Audio, Healthcare, Hospitality and beyond. Thank you for reading. We hope you have enjoyed it.

Annex 1:

Glossary of Abbreviations

DECT: Digital Enhanced Cordless Telecommunications

ULE: Ultra Low Energy

OFDM: Orthogonal Frequency Division Multiplexing

TDMA: Time Division Multiple Access

FDMA: Frequency Division Multiple Access

IMT: International Mobile Telecommunications

ATEX: (ATmosphere EXplosibles)

PLMN: Public Land Mobile Networks

eMBB: Enhanced Mobile Broadband

mMTC: Massive Machine Type Communications

URLLC: Ultra-reliable and Low Latency Communications

RIT: Radio Interface Technology

SRIT: Set of Radio Interface Technologies

WirelessHART: Highway Addressable Remote Transducer Protocol (HART)

GFSK: Gaussian Frequency Shift Keying

QFSK: Quadrature Frequency Shift Keying

QAM: Quadrature Amplitude Modulation

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