CELTIC-NEXT
Eureka Cluster

Project Achievements

Ultra Scalable Wireless Access

Project ID: C2021/1-8

Start Date: 1 December 2022

Closure date: 30 November 2025

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USWA project focused on enabling ultra-scalable and affordable wireless communications for different industrial and professional use cases. This is needed for large-scale application of digitalisation in industrial environments that have been using extensive cable installations or have not been digitised at all. The project investigated how to utilize best the European ETSI DECT-2020 new radio (NR) standard and related first products – emerging during the project – in various industrial and professional use cases with several proofs of concept (PoC), and researched also enhancements that would be beneficial in the evolution towards 6G.

Main focus

Digitalisation of industries requires efficient, flexible and cost-effective wireless connectivity solutions. Industrial facilities are still using cables, which are limiting aspects such as scalability and expandability of the digitalisation needed to optimise industrial operations and to become a self-evident part of the industrial process. USWA project was built on collaboration between end-users, technology providers and researchers, so that new wireless solutions provide best fit to industry requirements. Project focused on using and further developing DECT-2020 NR technology suitable for both massive machine type and ultra-reliable low-latency communications. Advanced mesh network architecture of DECT-2020 NR helps to simplify complex system and network planning, as well as system deployment and operation. DECT-2020 NR uses widely available DECT technology-specific licence-exempt frequency bands (e.g. 1880 -1900 MHz in Europe and many other regions). Additionally, DECT-2020 NR can be used in other license-exempt and licensed frequencies. Application requirements of the project were directing system architecture definitions and performance evaluations. Both system simulations and PoC developments were planned for assessing the performance of DECT-2020 in practical use cases. The project also provided significant contributions to ETSI DECT-2020 standardisation.

Approach

The project had five objective areas depicted in the workflow diagram below. First, application and system requirements were specified for selected use cases. Based on the requirements obtained, the system architecture and key performance indicator definitions were developed.

Next objectives were related to obtaining mesh networking solutions for industrial use cases: A) For massive-scale Internet-of-things (IoT) solutions, the number of devices is extremely high, and power-efficient operation is essential. Efficient routing and medium access methods in the DECT-2020 NR mesh network were targeted and studied at the system level. Suitability analysis of different physical layer profiles was also needed for this scenario. B) Ultra reliable and low latency communications (URLLC) solutions targeted at obtaining transmission latencies below 0.5 ms while ensuring error rates below 10^{-7} in industrial environments. For this goal, mesh concepts in the context of real-time requirements were first analysed. Then, system design and R&D were performed to enable safe end-to-end real-time communication.

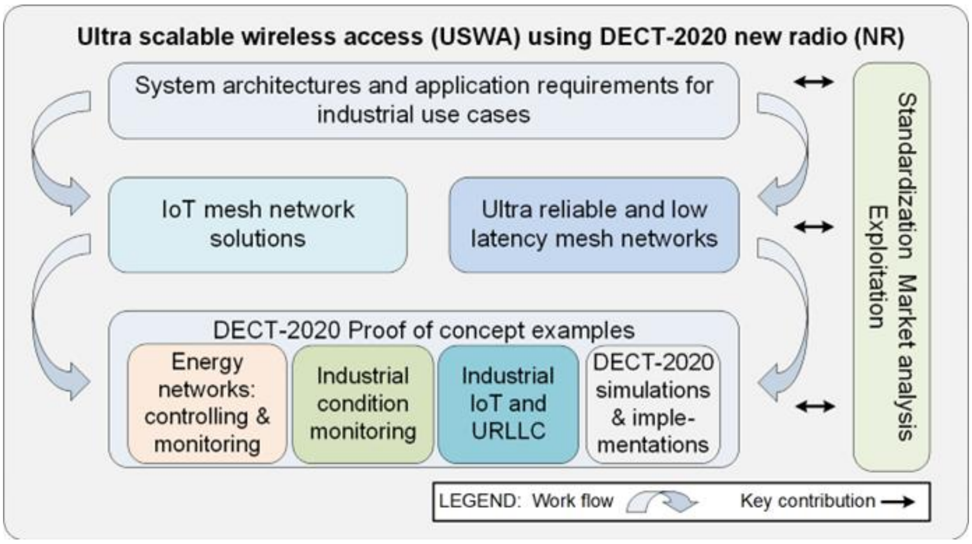

Figure 1: USWA workflow diagram

Furthermore, implementing selected PoCs were targeted to demonstrate and verify performance of DECT-2020 NR for industrial end-users. Finally, standardisation contributions and scientific publications played an important role, and market analysis was performed to maximise the exploitation potential of the results.

Achieved results

The project adopted a user-centric approach, identifying 21 practical use cases across domains such as electricity network monitoring, industrial condition monitoring, and wireless communication for robotics. The use cases were categorised into mMTC, URLLC, and emerging near-URLLC classes, demonstrating a vast area of use cases that are between two extremes: mMTC and URLLC. Each category was analysed for its specific requirements. Based on this, a layered system architecture was developed. See [1] for scientific USWA publication in this area.

Mesh networking solutions were developed and evaluated for DECT-2020 NR in massive IoT scenarios. Simulation studies demonstrated that the physical layer of DECT-2020 NR offers robust performance with high spectral efficiency and low power consumption. Enhancements considered medium access and routing protocols, including optimisations for downlink routing and configuration data distribution, several of which are now supported in the DECT-2020 NR in release 2 standard revision. Developed methods improved system performance significantly, e.g., the downlink performance was improved by a factor of 20 or more compared to the method defined in release 1 of DECT-2020 standard. The project also assessed positioning techniques for DECT-2020 NR in industrial environments, which is expected to be an integral part of any IoT network in future.

In the URLLC domain, USWA developed mesh network topologies capable of achieving packet error rates as low as 10^{-7} and sub-millisecond latencies in dynamic environments such as smart factories. Channel-aware resource allocation methods were introduced to minimise outage probability, and network-coded cooperation techniques were explored to enhance reliability. For future-proof security, hardware acceleration for post-quantum cryptography was investigated.

PoC implementations played a vital role in validating the technology. Link distance measurements were first conducted in diverse environments, including factories, campuses, and open fields, using early DECT-2020 NR chipsets. One notable PoC demonstrated DECT-2020 technology capable of supporting wireless energy quality monitoring for substation use cases, replacing wired connections with resilient mesh networks and enabling cost-efficient modular deployment of intelligent electronic devices. The other two PoCs demonstrated the capability to operate in factory environments for condition monitoring, as well as the capability to control and command autonomous guided vehicle (AGV) robots operating in the factory. Finally, PoC developments demonstrated the capability of DECT-2020 NR technology to support low latency communication for e.g. audio transmission (see figure below), and high data rates well beyond the chipsets available today, as well as impacts of supporting post-quantum cryptography in industrial systems.

Standardisation and dissemination were integral to the project's impact. USWA partners actively contributed to ETSI TC DECT, influencing e.g. the development of release 2. The project's findings were shared through numerous publications, webinars, conference sessions, and a Winter School organised for postgraduate students.

Figure: DECT-2020 NR proof-of-concept for audio

Impact

USWA project has firmly established DECT-2020 NR as a mature and reliable wireless technology for industrial IoT in various use cases. Through collaborative research, real-world testing, and active standardisation, the project has laid the groundwork for future innovations in wireless access, offering scalable, secure, and cost-effective solutions for a wide range of industries and applications in Europe and worldwide. The project significantly impacted the ETSI DECT-2020 NR standard, which was also updated in the latest ITU-R recommendation M.2150-2, Detailed specifications of the terrestrial radio interfaces of International Mobile Telecommunications-2020 (IMT-2020).

Further USWA project results contributed significantly to the establishment of DECT NR+ Building Automation Interest Group (BAIG), which is promoting technology acceptance and adoption to an entirely new level among different types of industrial players.

The first commercial products supporting the technology's adoption across different industries are expected to appear on the market soon after the project's closure.

[1] A. Samuylov, D. Moltchanov, A. Gaydamaka, E. Lyczkowski, A. Frotzscher, F. von Schoettler, J. Pirskanen, J. Numminen, J. Salokannel, E. Llaguno, R. Pires, D. Bayar, and M. Valkama, "Empowering Near-URLLC IoT with 5G DECT-2020 NR: Current State and the Road Ahead," IEEE Communications Magazine, vol. 63, no. 4, pp. 130-136, April 2025.

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