5G-HEART Newsletter

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5G HEART
5G Health, Aquaculture and Transport Validation Trials

Project website: https://5gheart.org/

INSIDE THIS ISSUE

"The healthcare use cases in 5G-HEART challenge the performance and availability of telecom, which only 5G can meet.

Healthcare use cases

One of the verticals to be field trialled in the 5G-HEART project is the health sector. Digitizing the healthcare industry is believed to have a huge impact on cost level, and with equal importance on the quality and availability of healthcare services. According to the 5G IA White paper on the e-health vertical in 2015[1], the e-health sector is identified as a priority in the European Digital Agenda and subsequently in many national digital agendas, because of the amount of spending, as well as worrying rise in healthcare costs.

In 5G-HEART, we have selected three major use cases for e-health which will challenge the performance and availability of 5G services. All the use cases share a common vision of remote care or 'hospitals without walls':

Use case H1: Remote Interventional Support	Use case H2: Automatic pill camera anomaly detection	Use case H3: Vital-sign patches with advanced geo-location
The use of advanced, rich media communications for remote monitoring, education and robotics in patient diagnostics and treatment	Colon wireless capsule endoscopy with automatic polyp detection for early detection of colon cancer with high mortality	Direct-to-Cloud, disposable, vital-sign patches to enable continuous monitoring of ambulatory patients, anytime and anywhere
• Educational surgery • Remote ultrasound examination • Paramedic support • Critical health event	• Pill based endoscopy for early anomaly detection • Remote wireless capsule polyp detection	• Vital-sign patch prototype • Localizable tag

2. Understanding the needs of the health sector

"5G-HEART investigates e-health use cases based on the real needs of the sector."

Healthcare use cases are very diverse in terms of requirements, but some typical commonalities are:

- High reliability for supporting critical applications
- High security for protecting privacy and sensitive patient information
- Low latency for remote control or analysis-based feedback

To understand this, the 5G-HEART partners have engaged with first line medical experts doing clinical simulations. A usability verification of the *Paramedic Support* scenario included checking the user experience of a video solution using a headcam worn by a nurse paramedic.

5G-HEART partners TNO, Philips and RedZinc performed this together with the Groningen Ambulance Service (Ambulancezorg Groningen) in early March 2020. The experiments revealed that there are challenges related to unstable images due to small head movements and that the video quality (resolution, colour depth, display colour rendering) deserves attention. 5G-HEART partner RedZinc performed similar tests together with the Oslo Ambulance service in January 2020 using Telenor's 4G network addressing the *Critical Health Event* scenario.

Figure 1. Challenges using head-worn video include image instabilities causing blurred images and different sight direction of eyes and camera.

Another approach taken has been to perform a business validation exercise led by 5G-HEART partners Telenor and Philips on the *Remote Ultrasound Examination* scenario, choosing the clinical case of congenital heart disease. Of all children, 0.8% are born with a congenital heart disease, which is diagnosed by ultrasound examination of the heart after birth.

In many countries, babies are transported long distances for emergency treatment at national centres. Norway has special geographic and meteorological challenges with respect to transportation. Flight distances may exceed 1000 km. A correct diagnosis at the local hospital is vital for transportation timing and emergency treatment decisions. The lack of trained paediatric cardiologists is a current limitation, so high quality, remote expert examination will improve the diagnostic situation.

Doing this exercise, we identified the stakeholders, their problems, and their benefits of solving them. Figure 2 shows our main findings and highlights the stakeholder roles: Beneficiary, Executor, Regulator, Customer and Provider.

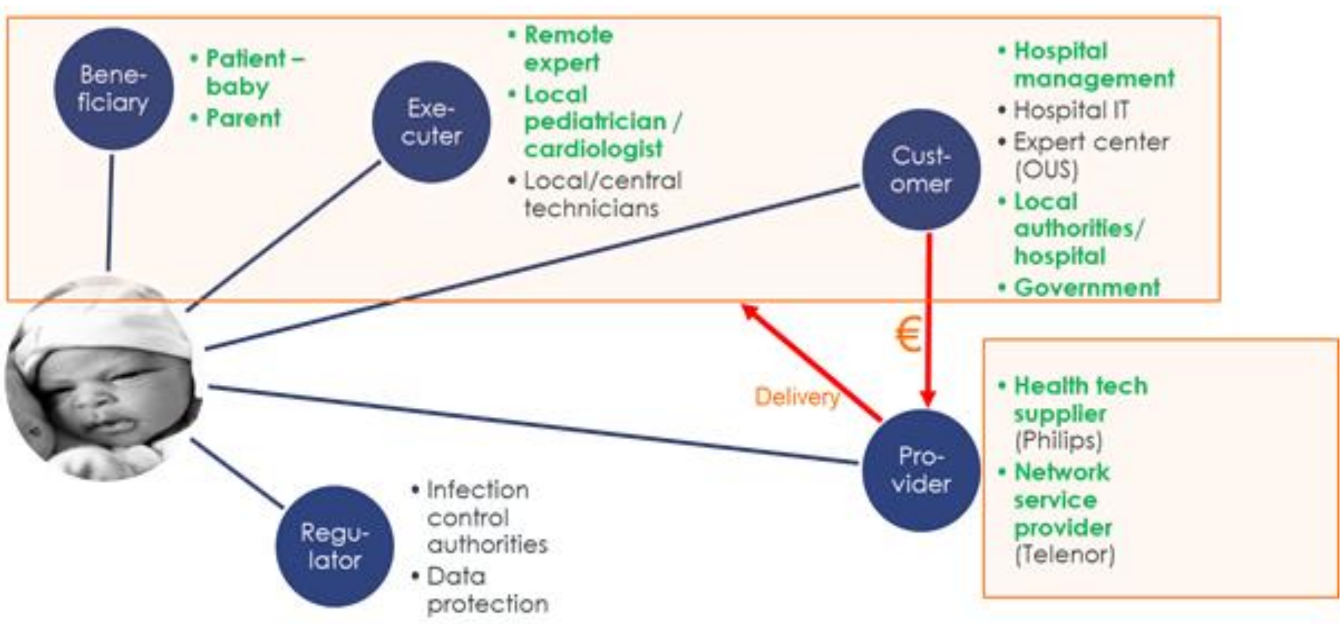

Figure 2. Congenital heart disease use case: roles, stakeholders and relationships.

3. Bandwidth intensive video for better education in healthcare

5G-HEART partner VTT is addressing the eMBB scenario *Educational Surgery* where they are setting up high quality streaming using a 360° video camera to obtain a multi/free view experience, which allows users to decide on desired viewpoint. A 360° video camera may require a data rate up to 120 Mbit/s per lens. In case of six lenses, this results in a data rate of up to 720 Mbit/s in the uplink.

For example, students can watch the live surgery operation, medical staff working around the operation room, or the monitors presenting vital information of the patient. The proposed setup runs in 5GTN[2] in Oulu, Finland. It has been demonstrated in a public event context[3] and measured in a laboratory environment.

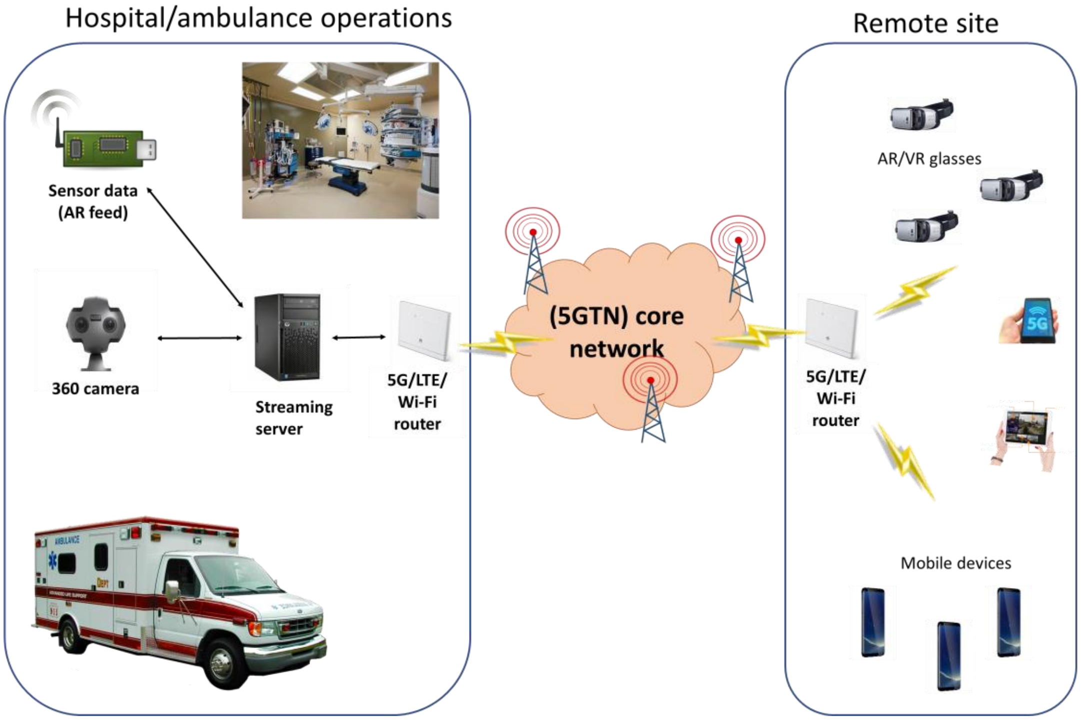

Figure 3. High-level architecture of the educational surgery use case

4. Addressing latency sensitive applications

Many e-health applications require real-time communications and fall into the category URLLC. *Robotic-assisted ultrasound examination* is investigated by 5G-HEART partner Oslo University Hospital and will use the 5G-VINNI[4] platform provided by Telenor.

Teleoperated robotic systems in healthcare consist of three main parts: the master or expert site, the slave remote manipulator or patient site and the communication link. In a bilateral teleoperation system, the master site sends the position command to the slave site while receiving medical and ambient visual feedback and sensory information from the slave remote manipulator. 5G-HEART has already done system verification tests using cabled connections as shown in figure 4.

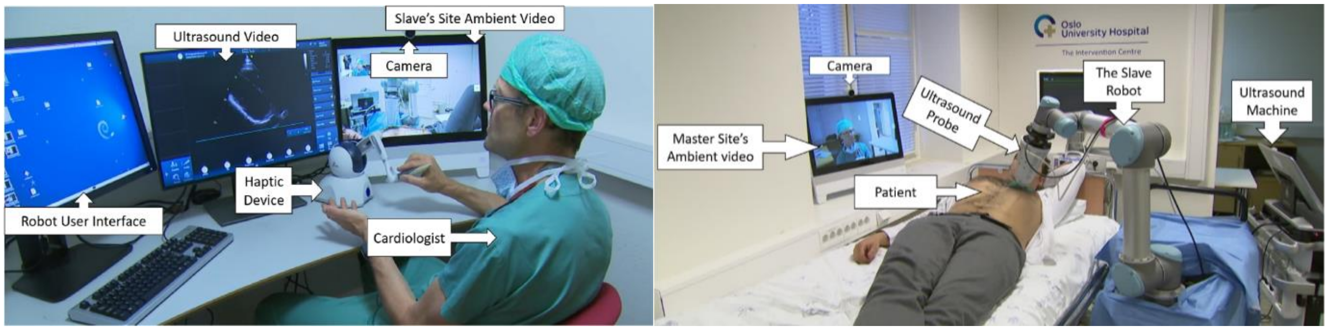

Figure 4. Robot-assisted remote ultrasound examination concept verification.

This setup is quite complex, as the system architecture shows (figure 5). It involves several logical communication links in both directions. Our plan is to investigate how 5G slicing can be used to meet the diverse requirements of the different links. In a hospital situation, it is easy to think that everything is cabled, but it is quite desirable that the slave site can be in a mobile and remote situation, where high speed fibre connections are unavailable.

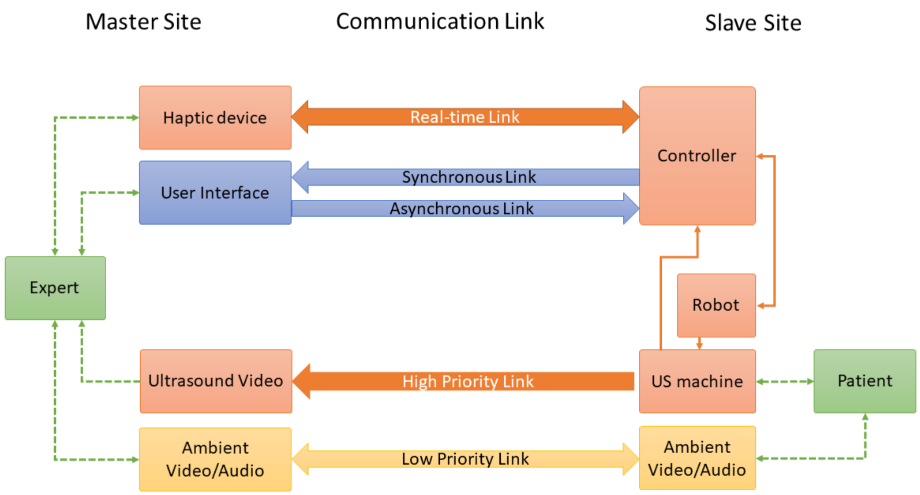

Figure 5. Robot-assisted remote ultrasound examination system architecture.

Another URLLC scenario which 5G-HEART investigates, is the use of *Colon Wireless Pill Endoscopy* as a replacement for traditional endoscopy. Colon cancer is the second most common cause of cancer mortality for both men and women. It is a cancer type where early detection is of clear value.

As an example, colorectal cancer cases have doubled in Norway since the 1950s and 4000 new cases are diagnosed every year. Traditional colonoscopy is a demanding procedure requiring a significant amount of time by specialized physicians, in addition to the discomfort and risks inherent to the procedure.

Figure 6. Pill camera.

The proposed alternative is a wireless capsule endoscopy (WCE) camera seating inside a vitamin-size capsule, which the patient swallows. As the capsule travels through the digestive tract, the camera records video, which is transmitted to the wireless capture system (WCS) placed in a belt around the patient's waist.

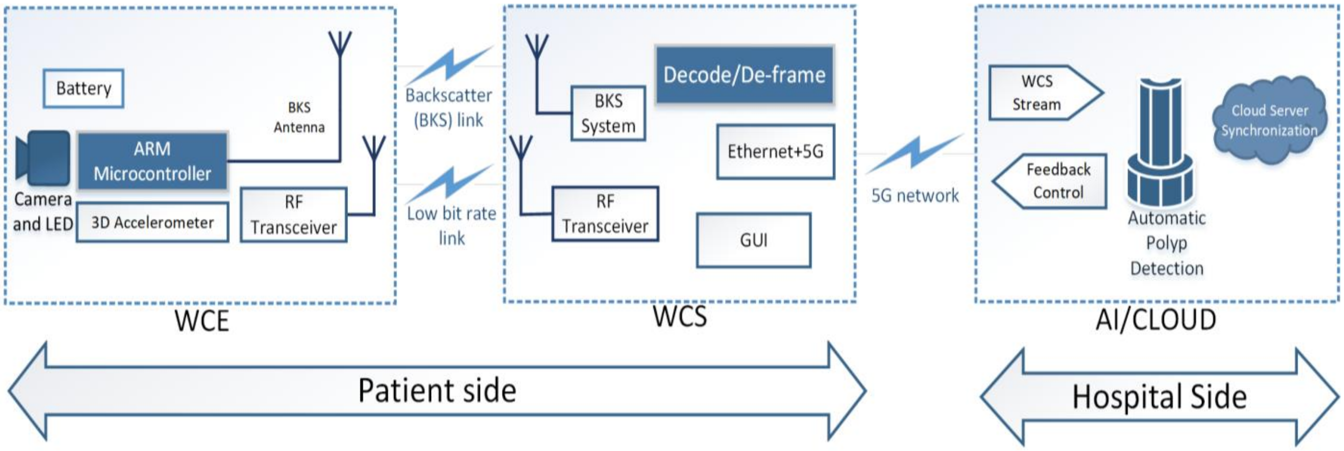

Figure 7. Wireless capsule endoscopy system.

In 5G-HEART, Oslo University Hospital and Telenor will investigate how the WCS can be connected to the 5G network and camera pill videos can be transferred in real time to a cloud server.

In later phases, we want to combine this with an automatic polyp detection algorithm based on AI and provide feedback to the pill to increase frame rate and light to automatically investigate suspicious areas of the colon. This feedback puts extremely high requirements on the communications latency, down to 1 ms, in order for the feedback commands to reach the pill before it has moved too far away in the colon.

5. Remote monitoring – anytime – anywhere

Monitoring patients with different conditions can be done using cost-effective, single-use, direct-to-cloud, vital-sign patches. 5G-HEART partner Philips is developing a *Vital-sign Patch Prototype* which connects directly to the network using mMTC technology. Currently, this is done based on LTE-M, but NB-IoT is also in scope. The obvious advantage of using the 4G – and later the 5G – network instead of short range IoT technologies is to avoid going through gateways, which significantly complicates the setup for the user, and also increases cost, complicates logistics and reduces reliability. The patient can then avoid lengthy stays in hospital care, but can instead go home and be safely monitored remotely.

Important KPIs for this case are the energy and power consumption of the patch, down to 1mWh per 100 byte payload transmission, and the peak current for the battery. By introducing the latest 3GPP Release 14 features like power class 6 (+14 dBm) we also want to assess potential improvements to energy and power, while understanding the impact on the coverage for this service. Initially, testing will be done using commercial service providers in the Netherlands, and more advanced tests using the 5G-VINNI platform in Norway will eventually be considered.

If the patch reports a condition requiring attention from the medical side, it is also important that the patch can be quickly and precisely localized. Therefore, 5G-HEART partner CEA is developing and investigating new localization methods, aimed at providing a much better resolution than currently achievable for LPWA systems for a *Localizable Tag*. Field tests done in Grenoble show that the method can achieve 30 m accuracy for 90% of the retained measurement points of the trial, compared to 250 m for conventional methods[5].

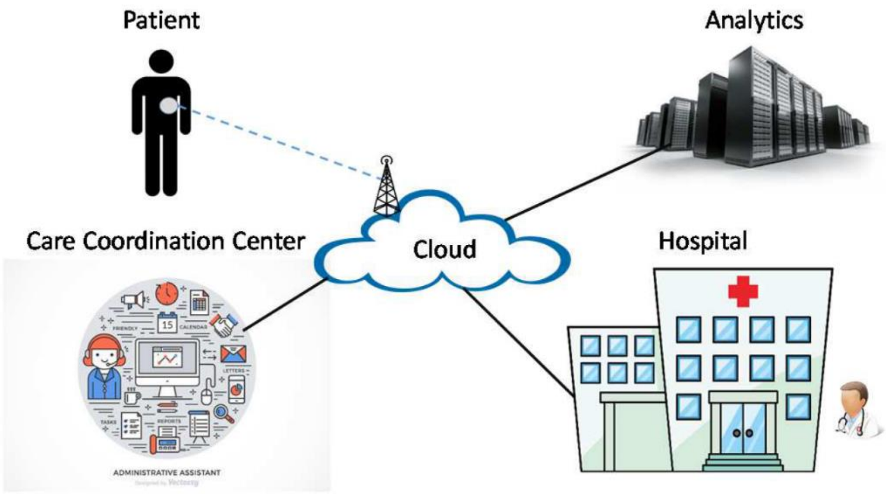

Figure 8. Vital-sign patch service architecture.

6. Summary

All healthcare use cases in 5G-HEART are motivated by value propositions for the involved stakeholders: The patient, the healthcare professionals, the hospital management, the authorities, both local and national, the health technology suppliers, and the network service providers. The requirements are diverse, and the goal is to evaluate to what extent 5G is able to deliver on these through extensive field trials.

For more in-depth reading about what 5G-HEART is doing within e-health use cases, please read our latest report, *D3.2: Initial Solution and Verification of Healthcare Use Case Trials*, available at the project web-site.

Notes:

1. 5G Infrastructure Association. White Paper on “5G and e-Health”. September 2015. https://5g-ppp.eu/wp-content/uploads/2016/02/5G-PPP-White-Paper-on-eHealth-Vertical-Sector.pdf
2. https://5gtn.fi
3. https://5gheart.org/the-7th-cnl-demonstration-competition
4. https://www.5g-vinni.eu
5. Florian Wolf et al. “Accurate Narrowband LPWA Ranging: Principles, Performance in AWGN and Multipath Channels.” EUCNC2020, 16 June 2020.