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Impacts and Value Chains of the Cloud-Edge-IoT Continuum in the Healthcare Sector

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Why is the CEI continuum important for the Healthcare Sector?

By enabling seamless data transmission and processing from various IoT devices, the CEI Continuum ensures real-time monitoring and analysis of patient health metrics, fostering proactive and personalised healthcare. It also facilitates the swift transfer of critical patient information to cloud servers for comprehensive analysis, leading to more accurate diagnoses and treatment plans. Finally, it supports the development of sophisticated healthcare applications and services, including remote patient monitoring and telemedicine, thereby enhancing accessibility to quality healthcare services for individuals residing in remote areas.

Cloud computing:

- **36%** Extensive use
- **31%** Limited use
- **13%** Plan to use

Edge:

- **15%** Extensive use
- **26%** Limited use
- **26%** Plan to use

IoT:

- **25%** Extensive use
- **29%** Limited use
- **16%** Plan to use

As part of its efforts to promote the CEI Continuum, the EUCEI initiative has carried out a series of industry focused surveys on current and planned adoptions. The Healthcare sector sees a lot of yet-untapped potential for CEI development, though it's comparatively ahead on Edge. Whilst Cloud is already present in almost 70% of the surveyed companies, Edge and IoT are projected to grow significantly over the next few years, highlighting the transformation that is taking place across the Computing Continuum in Europe (see percentages for usage and uptake by 2025).

What are the main opportunities for CEI in Healthcare?

Intelligent IT systems in the health sector hold the potential of simplifying and automating processes while making them also more reliable and safer, enhancing patient care, improving diagnostics and monitoring in different fields, supporting the decisions of doctors and thereby relieving the medical staff. The development of AI algorithms as well as Edge, Cloud and IoT technologies in recent decades created new possibilities in many different domains. The possibility of analysing large amounts of data shows many benefits of deploying those approaches to deliver personalised treatments.

The following five different use cases illustrate the wide range of opportunities for CEI in Healthcare:

Individual health monitoring: e.g. preventive lifestyle/medical screening, use of wearables or apps to monitor own health status, prediction of future potential pathologies. This use case is built on the major trends of empowerment and healthier lifestyles in which citizens without specific medical prescription are willing to take control of their health and to invest in it.

Hospital asset tracking: overview of condition and location of medical devices and other tools in the hospital setting to optimise logistics flows and increase safety, (predictive) maintenance of costly equipment, compliance to hygiene standards. This use case is particularly relevant for the Internet of Things in large infrastructures with a large inventory of heterogeneous devices (different types of devices, different generations, different vendors, …).

AI-enabled diagnosis and treatment systems: early diagnosis of diseases, detection of abnormalities, prediction of course of disease, prevention and identification of risks, data analysis for best individual

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treatment, consideration of multimorbidity factors, seamless support for first responders and emergency services. This use case exemplifies the crucial role of digitalisation to ensure a life-long personalised Continuum of Integrated Care. In this model, data are a link between the different phases of healthcare and enable improved personalised healthcare.

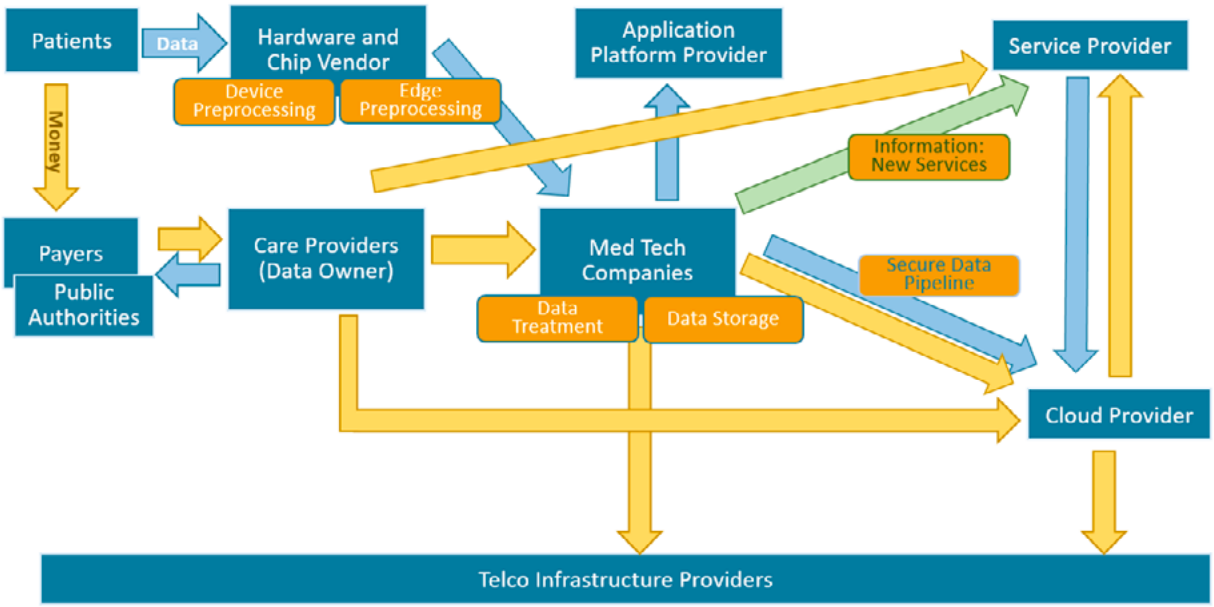
Home-care and telemedicine: remote patient monitoring and surveillance, especially monitoring of vital signs and compliance to medication, robotic-assisted nursing and rehabilitation. This case may at first sight have similarities with the first case on individual health monitoring. However it follows another approach as the patient monitoring is mostly triggered by a health event requiring medical intervention. This case contributes to the decentralisation of healthcare in which data is playing the role of the binding agent between the nodes in the mesh and the different stakeholder groups, notably the informal caregivers whose role gains in significance in this model. Furthermore the edge-cloud continuum is crucial in managing the risks induced by decentralising healthcare.

Robots/AR-assisted surgery: reduce treatment errors, time to surgery and recovery time through minimally invasive surgery, computer-controlled/assisted or robotic mimicking of the surgeon' actions, advanced simulators for surgeon training, virtual assistants with natural language interface, image-guided surgery, AR/VR surgery, functionalised surgical tools, for instance with haptic feedback. This use case clearly aims at increasing performances and proficiency in healthcare with a focus on safety and reliability of medical interventions.

What are the data, value and information flows in Healthcare?

In the healthcare industry, many different actors are interacting with each other, collaborating or competing in complex data-driven value chain networks.

The following network shows the different dependencies between the identified stakeholders, especially concerning money and data flow and gives better insight into the interconnectedness of different actors in the health sector. It highlights the key role of MedTech companies as they are at the centre of the network and at the interface of both money and data flows. Normally, care providers are the owners of the data and medical technology stakeholder act as the main stakeholder. Basic requirement for all interactions are the services provided by telco infrastructure providers. The network shows a possibility of how the different actors might interact. For specific use cases the interaction of actors might differ.



There is a huge amount of data collected by sensors in an operating room or at a hospital bed, sensors installed in the patient's home (telemetry and telemedicine, biochemical analysis in medical laboratories) or sensors integrated into healthy lifestyle wearables. Important actors in this step are manufacturers of sensors and wearables as well as companies who offer tools for the digitalisation and data capturing in the health sector.

There is a strong demand for efficient data pre-processing that involves data compression, anonymisation and pseudonymisation. Compressed and protected data saves bandwidth and energy when transferred to a centralised cloud. Edge computing or embedded intelligent devices allow for local processing and merging of data captured and generated by multiple sensors.

In the next step, ICT and connectivity providers offer services for data transition into cloud computing systems for further data processing or merging with additional sources. In hospitals exist a variety of legacy applications and systems incrementally developed for specific medical treatments and procedures. Often, the data needs to be transferred from one legacy system into another. Therefore, there is a strong demand for open interoperable interfaces and standards to facilitate this process.

Emerging data platforms collect and merge different data sources (e.g. from patients or even hospitals) into a single database for more precise data processing, analyses, and visualisation. Currently, interoperable data sharing formats, ontologies and especially standards for data quality are under development. Medical high quality data is crucial for obtaining reliable diagnosis results. Therefore, platform providers with high quality data offerings play a central part in the healthcare data economy. Furthermore, data spaces for data sharing among multiple platform providers can optimise the patient treatment processes in the healthcare system and allow for more precise diagnosis and successful treatment of seldom disease.

What are the key service requirements for the Healthcare sector?

Design

- Challenge "highly regulated sector": Specific and strong regulatory requirements and procedure for approval and vigilance. Complying with these regulatory requirements is cost-intensive and time-consuming, but in most cases also compelling.
- Challenge "high ethical constraints": In healthcare, human lives and highly sensitive data are at stake. A responsible and compliant handling of data is paramount, taking into consideration the highest standards of data protection, confidentiality and security. This may result in difficulties in accessing data for cloud-edge solutions.

Due to handling sensible (personal) data, regulatory requirements are especially high in the health sector. Certification aspects need to be considered as early as possible. As certification procedures are time and cost consuming, aspects of recertification need to be checked when deciding on how much a device or service needs to be modified. IoT solutions might also help meeting those requirements: Data transfer can be reduced by running algorithms that use safety critical data directly on the edge device.

Usability plays an important role as well. Users need to be able to use edge, IoT and cloud solutions as intuitively as possible. Designing products and services with respect to products already known by the user can help when it comes to enable easier and faster usage. Furthermore multiple target groups of users with different medical background and knowledge (professionals and non-professionals, patients, relatives …) need to be considered when designing products and services. Systems have to be designed with a high level of usability in order to be able to use soft- and hardware efficiently and avoid mistakes that bare risks for the patients.

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Installation

- Challenge "lack of standardisation": Apart from imaging and storage, the preconditions/requirements for other types of data (e.g. physiological) differ between hospitals or devices.
- Challenge "complex governance": Decision-making processes and money flows are lengthy and require the intervention of many actors with sometime diverging perspectives.
- Challenge "digitalisation of healthcare not extensively implemented": Lack of best practices, guidelines etc.; requirements may sometimes not be fully known. There are only few reliable and scalable cloud providers; fragmented market for data storage and consequently limited choice.

When a new system or product is to be integrated e.g. in a hospital infrastructure, corresponding software and hardware interfaces must be implemented in order to be able to establish connections to already existing systems (which might differ greatly from each other) and the underlying hospital or clinic IT systems. Every care provider might have different preconditions and requirements which must be met (e.g. hospital regulations, existing devices (in different versions), cloud or on-premise). Therefore the development of a modular system with different options that can be customised for every care provider is recommended. On the one hand backwards compatibility represents an important requirement, on the other hand openness of new systems and products is crucial to allow future innovations.

Performance and efficiency play a crucial role as well. If the costs of an innovative system are not affordable, it will not be implemented in Healthcare.

Operation

- Challenge "high granularity": The huge number of recipients (patients and potential patients) implies challenges in the amount of data to handle.
- Challenge: "digitalisation of healthcare not extensively implemented": The old and heterogeneous pool of devices and IT infrastructure in hospitals implies connectivity and latency issues.

Concerning the requirements "performance and efficiency (cost)" end-to-end-performance needs to be taken into account. Solutions normally consist of a pipeline of different devices or services. In the health sector data are often needed in real-time. Therefore the goal is to ensure low latency throughout the whole pipeline (including hardware as well as software).

Maintenance

The question "Who owns and maintains the hardware?" needs to be addressed properly in order to ensure safe usage.

Remote monitoring features will allow for more efficient maintenance of CEI infrastructures installed and deployed in the hospitals.

Disposal/Upgrade

- Challenge "very dynamic sector": The high level of research and the constant flow of innovation constantly remodel the sector and new value chains may grow fast. Continuous updates of applications are necessary to cope with the pace and avoid obsolescence.

When updating existing software and hardware, continuity of service needs to be guaranteed.

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What are the value chain catalysts for CEI adoption?

Today, a large number of different devices and services are used in hospitals and clinics. This leads to the challenge to find a way to effectively connect these systems. Edge, IoT and cloud solutions hold the chance to use the full potential of existing systems by letting them communicate with each other, sharing data and gaining new insights. The following points are key to accelerate CEI adoption:

- Reviewing regulatory requirements at an early stage in order to implement solutions and systems that comply with current requirements on different levels (EU, country, hospital) is essential. Early engagement with this topic ensures a wide range of possible applications and brings competitive advantages.
- Adhering to high ethical standards: As health data is sensitive data and decisions may have a severe impact on the health of patients, corresponding requirements must be met. CEI technologies may incorporate advantages when it comes to data protection and data privacy as e.g. less data needs to be transferred.
- The current lack of standardisation in some subareas in the health sector can also be seen as possibility: Companies may contribute to specifying those standards or implement interfaces in order to overcome this challenge.
- Early definition and selection of the specific target group of a system is essential as well. As there are many different stakeholders involved in the health sector there is the chance to establish a unique selling point.
- New research findings and new (technical) innovations shape the innovation landscape. CEI technologies may help bringing those technologies to the medical staff and patients. Furthermore developments need to be tracked.
- Pushing the digitalisation in the healthcare sector may also be a chance for companies in this domain. Finding the right balance between innovation and use of existing infrastructures is essential.

If you're interested in growth opportunities in this sector or want to learn more, contact us at: info@eucloudedgeiot.eu