Lean schemas for service offer formats in innovation ecosystems

Synergies amongst Tasks 5.1 'Market and stakeholder needs analysis' (Leader: UKOLN) and WP3 (Leader: KINNO) and all its encompassing Tasks

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Contents

1. Context and purpose of the document

In the document we come up with a first approach to identify synergies amongst Tasks 5.1 'Market and stakeholder needs analysis' (Leader: UKOLN) and WP3 (Leader: KINNO) and all its encompassing Tasks, namely:

- T3.1: Stakeholder promotion, cooperation and procurement opportunities (Leader: BOOST)
- T3.2: Open co-creation to accelerate solution development and uptake (Leader: KINNO)
- T3.3: Access to funding (Leader: BOOST)
- T3.4: Smart Health literacy, learning and skills (Leader UPORTO)
- T3.5: Discover, demonstrate and test before invest (Leader: UKOLN)
- T3.6: Living Labs to empower patients and citizens (Leader: AUTH)

The most critical issue relates to the definition of basic needs that shall of the different Tasks that shall guide the development of synergies amongst them and the corresponding Deliverables.

Our aim is to *design a lean scheme for the Service Offer*, that its value will be demonstrated with a respective 'storylines' that will help build the regional ecosystems. To this we make a start in the document by providing insights of the ecosystems in Porto and Cologne. In the next version we shall include also information on the Thessaloniki ecosystem and elaborate for the other two ecosystems as well.

1.1. Ecosystems, business models and value generation

Business models are expected to answer question related to how benefits driven by the adoption of innovations as in our case for the area of Smart Health technologies and services, 'flow back' into a particular actor or stakeholder like e.g. a company that has developed the core technology for the particular innovation or an actor who takes part in its promotion to a market sector or a customer base. Success of a business model is primarily measured or judged in the form of revenues. To this, the recent study of (Schlecht et.al., 2021) to the field of Blockchain is providing an adequate comparison in terms of the authors building their postulates on all three constituents namely a number of interviews with experts, results from the conduct of interactive workshop, and last but not least prior literature, upon which they developed their set of projections of implications for business models.

In our case the aim here is to explore the most appropriate format for a Service Offer that will possess all necessary expressive power to describe both demand- and supply-side scenarios for which the Shift-Hub Service Offer may foster the uptake of innovations in smart health technologies and services. The latter will take place either in existing and operational ecosystems, or demand the creation of new ones that will be developed as part of the project lifetime and shall, following the definition of (Chesbrough, 2007) set up and configure suitable business models that shall create and capture the respective value of the innovations promoted.

The most important aspect in the innovation ecosystem approach we take in the project, apart from the network effects created, is that all actors maintain their roles in the ecosystem and their loose interconnection to each other. This aspect is important to capture in the Service Offer: it is not a weakness or a risk if the actors are chance-oriented. Testing and experimentation are important properties and there is no need to stick to 'formal structures' that might contribute with little or no potential for success. To this, both formal structures as well as the track record of an actor is of little or even no significance, and as long as they contribute to the successful realisation of a particular Service Offer, their role is considered as positive and should be encouraged to participate. We expect this to enrich the Shift-Hub ecosystems with new possibilities and shall help both demand-

and supply-driven innovators to reflect upon their innovations and get the chance of action-oriented reflection.

The field of digital business Ecosystems has facilitated the characterization of innovation ecosystems in terms also of detecting commonalities with properties of general ecosystems [Briscoe, 2010]. And it is in the latest years with an increasing prevalence supported by the proliferation of technologies and increased competition due to globalisation that importance of value co-creation is given more significance as a success factor within ecosystems and other similar constellations. As a consequence, many approaches have emerged to model and analyse business ecosystems; we mention here few that span between 2010 and 2020 namely [Al-Debei-Mutaz, 2010], [Adner, 2013], [Basole, 2015 & 2016], [Aldea, 2018], [Faber, 2020].

For the needs of the project we shall study Service Offers that can be mainly related to one of the following two 'basic' reference cases:

1. Supply-side driven innovation: from the researcher and scientist to the market
2. Demand-driven innovation: from the patients and customers back to the researcher

However, as will be evident from our work, the Service Offer format shall allow also several other hybrid forms of Service Offers to get realized and instantiated.

As supported by (Iansiti and Levien, 2004), our Service Offer will be conceptualized for a network of interacting actors where the large number of interconnected partners and competition to allow for their survival form the most important properties of the ecosystem. This aspect is welcome as it may incentivise innovations and help the expansion of the various ecosystems. It is to this that the role of start-ups may act as a catalyst due to their dynamism and their willingness for experimentation and risk-taking.

2. Stakeholders of the ecosystems

2.1.   The Porto ecosystem

For the Porto ecosystem we present two supply-side innovation scenarios that relate to two respective innovations being developed in the regional ecosystem (porto4ageing). Some additional information on the Porto4ageing ecosystem and the reference site as a whole are also provided at the end, as these relate to the described innovations.

2.1.1.   DialGames: Co-creation development of therapeutic digital games for patients under haemodialysis treatment

Haemodialysis, a renal function replacement technique used in end-stage renal disease (ESRD), is associated with an accentuated loss of cognitive function (even when compared to other ESRD treatment options), that is up to three times more common than in the general population and may manifest at younger ages [1]. There may be underlying mechanisms related to uraemia, stress fluctuations during dialysis therapy with cerebral hypoperfusion, depression, social isolation, among others[2].

Cognitive intervention mediated by therapeutic serious games (TSG) may bring benefits to haemodialysis patients through systematized assessments and subsequently customized interventions with physical and cognitive stimulation that may result in an improvement in decision-making, reduction of depressive symptoms, and therapy-related stress, and, consequently, improve quality of life during and after haemodialysis therapy[3]

Although there are numerous studies on cognitive interventions in these populations, results are still inconsistent, with limited evidence supporting treatments to mitigate the degree of cognitive impairment observed. Despite insufficient tailoring to patient needs [4], some show promising results.

In Portugal the long waiting list for renal transplantation leads to a median waiting time on list that can be greater than 10 years and many patients are not candidates for this treatment due to their age and comorbidities [5]. Therefore, long waiting time leads to greater depression levels and cognitive impairment levels, and it is needed to devise systems and develop a longitudinal and transdisciplinary program to understand the needs of this population and develop solutions for them to prevent their cognitive decline.

Protecting their brain, it is also assuring their future, assuring a long-term active life, active aging, providing a lifelong education and their quality of life, during and after the haemodialysis treatments.

To archive these goals, the plan intents to assess to the levels of depression and cognitive impairment on patients under the haemodialytic treatments at Hospital de Braga. After assessing to this data, patients, and health professionals, will be part of a co-design program to develop a mobile application (mhealth app) with a collection of digital TSG, accessible, focused on cognitive stimulation. The mhealth app,. intends to assess the influence of TSG on cognitive skills and depressive

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[1] Crowe K, et. al (2021) "Is It Removed During Dialysis?"—Cognitive Dysfunction in Advanced Kidney Failure—A Review Article. Front Neurol. https://doi.org/10.3389/fneur.2021.787370

[2] Mosleh H, *et. al* (2020) Prevalence and Factors of Anxiety and Depression in Chronic Kidney Disease Patients Undergoing Hemodialysis: A Cross-sectional Single-Center Study in Saudi Arabia. Cureus. https://doi.org/10.7759/cureus.6668

[3] Bento SR, *et. al* (2018) Use of digital game therapy among elderly persons undergoing dialytic treatment: cognitive aspects and depressive symptoms. Rev Brasil Geriatr Geront 21:447–55

[4] Patel M, et. al (2016) Cognitive impairment in hemodialysis patients: What can slow this decline? Hong Kong J Nephrol 18:4–10

[5] Sampaio S (2018) The Portuguese kidney transplant allocation system – a change is needed. Port J Nephrol Hypert 32:365–66

symptomatology in adults/elderly patients undergoing haemodialysis therapy, during their treatment at the Hospital de Braga. At the same time, the intervention using TSG provide an occupation and promote a social interaction, digital inclusion by using the games during the long haemodialytic treatment sessions.

With this study it is also expected to produce and validate a new approach of applying Montreal Cognitive Assessment (MoCA), Mini-Mental State Examination (MMSE) using mobile information and communications technology (ICT).

2.1.2. Mask air: an App dedicated to those who are bothered by allergic rhinitis

MASK-air is an App dedicated to those who are bothered by allergic rhinitis. Its goal is to provide the opportunity to regularly record all symptoms, to facilitate optimal management of allergic rhinitis condition and to improve the quality of life of patients. It invites users to record their symptoms for at least 7 days in a row (answering a questionnaire), to record their current treatment and to monitor the consequences on their quality of life. This data enables their healthcare providers to better advise users on the most appropriate strategy and optimal treatment for their allergic rhinitis throughout the year and across different seasons.

Link: https://www.mask-air.com/   (in   google   play: https://play.google.com/store/apps/details?id=nl.peercode.allergydiary&pli=1)

Related publications:

1. Digitally-enabled, patient-centred care in rhinitis and asthma multimorbidity: The ARIA-MASK-air approach   (http://www.scopus.com/inward/record.url?eid=2-s2.0-85147105865&partnerID=MN8TOARS)

2. Allergen immunotherapy in MASK-air users in real-life: Results of a Bayesian mixed-effects model (http://www.scopus.com/inward/record.url?eid=2-s2.0-85127220768&partnerID=MN8TOARS)

3. Assessment of the Control of Allergic Rhinitis and Asthma Test (CARAT) using MASK-air (http://www.scopus.com/inward/record.url?eid=2-s2.0-85116774862&partnerID=MN8TOARS)

4. Behavioural patterns in allergic rhinitis medication in Europe: A study using MASK-air real-world data   (http://www.scopus.com/inward/record.url?eid=2-s2.0-85126344447&partnerID=MN8TOARS) ,

5. Comparison of rhinitis treatments using MASK-air® data and considering the minimal important difference   (http://www.scopus.com/inward/record.url?eid=2-s2.0-85131752144&partnerID=MN8TOARS)

6. Consistent trajectories of rhinitis control and treatment in 16,177 weeks: The MASK-air® longitudinal   study   (http://www.scopus.com/inward/record.url?eid=2-s2.0-85143420123&partnerID=MN8TOARS)

7. Correlation between work impairment, scores of rhinitis severity and asthma using the MASK-air App   (http://www.scopus.com/inward/record.url?eid=2-s2.0-85081893884&partnerID=MN8TOARS)

2.1.3. Information on the Porto4Ageing regional Ecosystem (Reference site)

The Competences Center on Active and Heathy Ageing of University of Porto (Porto4Ageing, https://www.porto4ageing.up.pt) competency centre is a four-starred Reference Site and Partner Plus of the former European Innovation Partnership and Healthy Ageing of the European Commission, bringing together over 90 organisations, the large majority of them established within the Porto Metropolitan Area, in the Northern Region of Portugal. The partnership is built upon the quadruple helix approach – it involves different stakeholders (regional governments and health and care providers, academia and research, industry and civil society), which are in good position to drive structural changes far beyond the scope any organization could achieve on its own, aiming to innovate

and experiment in real world settings. Despite the different backgrounds, goals and actions, Porto4Ageing revolves around a shared vision and common targets, where each organisation actively contributes in a specific way to the overall goal of responding to the citizens' needs, specifically in matters related to active and health ageing in the Porto Region. The Porto4Ageing alliance is committed to promoting local convergence and improving the health innovation ecosystem, while reducing and overcoming existing bottlenecks. It is doing so by promoting joint work for high impact, thus bridging the gap between public and private actions and instruments and, ultimately, facilitating knowledge exchanges and scaling up of results (www.porto4ageing.up.pt).The Porto4Ageing consortium stems from the UPORTO Ageing Network, established in 2013, as UPORTO considered that it could play a vital role in the improvement of health and quality of life of European citizens, and particularly relating to elderly population, by contributing through research and development in this particular field. In this context, the top management of UPORTO had decided that a network composed of experts in the field of ageing should be created within the university, to bring together, not only different stakeholders to join up forces and expertise, but also different visions and contributions (health and social services, social, cultural, behavioral determinants, etc.). Adoption of European good practices (GP) by our region is a priority for Porto4Ageing. For instance, we have participated actively in 2016 Call for Twinnings of Scale AHA of EIP-AHA (www.scale-aha.eu/2016-twinnings.html), in one of the most successful twinning activities, the implementation of MASK Allergy Diary   (www.scale-aha.eu/fileadmin/documents/twinnings_overview/macvia_france_10_adopters_twinning.pdf).

There are more than 1000 users of this app in Portugal. Furthermore, Porto4Ageing is setting up a regional Living Lab, dedicated to the study and development of technological solutions to treat dementia, is being developed by Santa Casa da Misericórdia de Riba d'ave (SCMRA). SCMRA via the Center for Research, Diagnostic, Training and Tracking of Dementias (CIFAD - https://www.scmribadeave.pt/CIDIFAD/CIDIFAD) is a partner of Porto4Ageing and has participated in a twinning activity (organized by IN-4-AHA) with LABSAUD, a Galician Living Lab, in order to learn from their example.

2.2.   The Cologne ecosystem

For the Cologne ecosystem we present two supply side innovations scenarios that relate with innovations that have been either co-developed by the active participation of the Shift-Hub partner University Hospital Cologne and in particular the Biomedical Informatics Institute, or have been identified as part of the Institute's MedTech Entrepreneurship research and teaching activities.

2.2.1.   PADME – a platform for Analytics and Distributed Machine Learning for Enterprises

For the needs of the project and in order to scale up the intervention potential of medical and health information provision into several settings and communities in Europe, there is need for a federated analysis infrastructure. This can be achieved by the deployment of PADME, that is a 'Platform for Analytics and Distributed Machine Learning for Enterprises'. PADME enables secure and privacy preserving analysis of patient data with federated and incremental learning shall be used and deployed within the project. PADME is a distributed analytics platform that will be provided and customised for data driven healthcare and medical service provision, spanning from applications in clinical research to 'routine' sharing and exchange of medical and health data as part of adopted interventions. Secure federated learning methods will enable partners to conduct multi-cohort analysis, develop and test their AI/ML learning models without sharing their data. PADME has been deployed and validated in several research data infrastructures, such as German Medical Informatics initiative (MII) and National Research Data Infrastructures (NFDI). It offers a secure platform to transfer algorithms and analytics tasks, an isolated environment to run tasks with data, and tools to

prevent data leakage. Clinical partners will be able to control who can access their data and preserve the privacy of the patient. PADME deploys the Personal Health Train (PHT) concept for performing distributed data analytics tasks to address the federated learning. Data will remain in its original location, and analytical tasks will be sent to all participating intervention nodes. This guarantees the highest data protection standards.
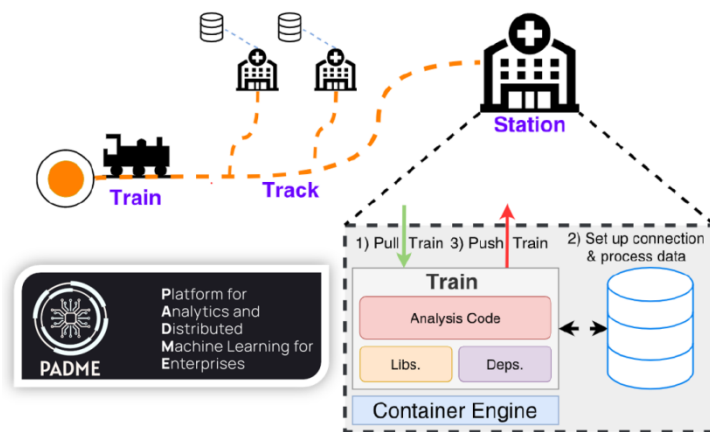

Figure 1 Main notions of PADME implementation of Personal Health Train

The PHT approach comprises three core components, as also shown in the Figure, namely: *Train, Station*, and *Track (Handler)*. The *Train* created by a data consumer, e.g., a researcher, is a data analysis algorithm encapsulated in a lightweight application container. The purpose of the *Train* is to access privacy-sensitive data from multiple institutions and then execute the algorithm to reveal valuable insights about the data. The *Station*, on the other hand, is an institution that contains privacy-sensitive and confidential data. The unique value that PADME offers to any adopters as a federated learning platform, relates to privacy preservation: a large part of the patient data cannot be shared amongst the six nephrology clinical research centres as there is no patient consent and this cannot be acquired retrospectively. To this, the use of PADME offers an optimal solution, due to the ability to train models at scale across the different sites and without moving the data. Distributed federated learning boosts patient numbers and algorithm quality. PADME is already completely developed, evaluated in various projects such as CORD[6] and NFDI4Health[7] and will be only deployed and executed to the different sites.

Link: https://padme-analytics.de/

Related publications:

Mehrshad Jaberansary, Macedo Maia, Yeliz Ucer Yediel, Oya Beyan, and Toralf Kirsten (2023) Analyzing Distributed Medical Data in FAIR Data Spaces. In Companion Proceedings of the ACM Web Conference 2023 (WWW '23 Companion). Association for Computing Machinery, New York, NY, USA, 1480–1484. https://doi.org/10.1145/3543873.3587663

Welten S, Mou Y, Neumann L, Jaberansary M, Ucer Yediel Y, Kirsten T, Decker S, Beyan O. (2022). A Privacy-Preserving Distributed Analytics Platform for Health Care Data. Methods of Information in Medicine. doi: 10.1055/s-0041-1740564.

Welten S, Hempel L, Abedi M, Mou Y, Jaberansary M, Neumann L, Weber S, Tahar K, Ucer Yediel Y, Löbe M, Decker S, Beyan O, Kirsten T. Multi-Institutional Breast Cancer Detection Using a Secure On-

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[6] The Use Case "Collaboration on Rare Diseases" (CORD-MI) is a project involving the four consortia of the Medical Informatics Initiative and involving numerous German university hospitals and partner institutions. The aim is to improve care and research in the field of rare diseases.

[7] NFDI4Health is part of the German national research data infrastructures initiative and aims to create a comprehensive inventory of German epidemiological, public health and clinical trial data to date. To this aim it builds, amongst others, a data analysis toolbox, while respecting stringent requirements for privacy concerning personal health data. Standardization services will ensure a high degree of interoperability.

Boarding Service for Distributed Analytics. Applied Science. 2022, 12, 4336. doi: 10.3390/app12094336.

Welten S, Neumann L, Ucer Yediel Y, da Silva Santos LOB, Decker S, Beyan O. DAMS: A Distributed Analytics Metadata Schema. Data Intelligence 1–17. May 12 2021. https://doi.org/10.1162/dint_a_00100.

Mou Y, Geng J, Welten S, Rong C, Decker S, Beyan O. Optimized Federated Learning on Class-Biased Distributed Data Sources. International Workshops of ECML PKDD 2021 (Virtual Event). September 13-17, 2021. In: Machine Learning and Principles and Practice of Knowledge Discovery in Databases. Proceedings, Part I / edited by Michael Kamp, Irena Koprinska, Adrien Bibal [u.a.] Page(s)/Article-Nr.: 146-158.

2.2.2. Puraite

Puraite is an innovative startup from Paderborn, Germany, that aims to support daily work to medical and health researchers, clinicians and life sciences professionals by providing up-to-date medical research results in a reliable and user-friendly way. Whether you work in research, care, treatment or management, you know how important it is to be informed about the latest advances in your field. Unfortunately, the ever-increasing number and complexity of scientific publications can mean that this task takes up more and more of your time, which could instead be used much more effectively for your core tasks.

With Puraite, we want to help you meet this challenge. Our vision at Puraite is to make it easier for everyone to access the latest scientific knowledge. By developing an intelligent knowledge base, supported by advanced Artificial Intelligence (AI) technologies, we aim to save you the time and effort that is sometimes required to find and use the information you need. Our knowledge database is completely free of advertising and provides you with exactly the information you need - in a nutshell. We take great care to offer our product in a personalised way, as the needs of a practising doctor are certainly different from those of a researcher in the pharmaceutical industry.

What exactly is Puraite? Puraite is an interactive web platform that serves as a configurable dashboard. It consists of different modules that can be selected and configured according to individual needs. These modules are designed to facilitate the search for information and the understanding of current research results. A central module is the innovative, AI-based search, which is more efficient and convenient than traditional search engines such as PubMed or Google Scholar due to a constantly growing knowledge base, the consideration of semantic factors and the possibility of natural language communication. However, Puraite offers even more, because even if you find the publications you want quickly, you still need time to get to grips with them. To help you do this, Puraite offers additional modules that extract relevant information from the publications you find and present it in a convenient format. There is a wide range of options here, from a textual abstract of the publication in question to automated trend detection and visualisation of causal relationships. Our ultimate goal is to maximise your convenience and efficiency, regardless of which modules you you want to use.

How does Puraite work? Puraite is a knowledge system that automatically processes existing and newly published medical publications by using modern AI technologies such as machine learning. By linking the knowledge gained with the knowledge already available in the system, not only is the state of knowledge kept up to date, but new opportunities to acquire more knowledge are also opened up. The use of computer technology makes it possible to process and link larger amounts of information faster than a human could, which makes Puraite a valuable tool for research, especially in the field of medical meta-analysis.

How far along is development? The development of Puraite is in its early stages. After a market analysis and feasibility study, an initial system prototype (MVP) is currently being developed. Our goal is to bring this to market as soon as possible in order to collect feedback from customers in the early stages and incorporate it into further development. We are currently looking at a market launch in Q1 2024, but individual modules may be tested earlier.

What does our team look like? Our team currently consists of three people: Karlson Pfannschmidt, Shahin Baki and Vitalik Melnikov. Karlson and Vitalik are PhD students in computer science at the University of Paderborn and are doing their doctorates in machine learning. They are responsible for the AI know-how of the team. Schahin has solid business skills in addition to his in-depth computer science knowledge, so he can not only support the software development but also take care of the entrepreneurial side of the startup. Puraite also has several external mentors who support us with their unique expertise. Through the expert mentoring of Prof. Dr. Axel Ngonga from the University of Paderborn, the development of AI technology at Puraite is ensured.

What is our vision for the future? Unlike many modern AI technology developments such as PubMedGPT or ChatGPT, which are essentially a closed system (black box), at Puraite we aim to build a knowledge system based on principles of transparency and quality control. We respect the intellectual property rights of research results and ensure that all information published on Puraite actually corresponds to the current state of research and can be verified down to the last detail if necessary. Our aim is to be perceived as a reliable and fair source of up-to-date research results and not like a company that profits from the openness of science at the expense of society.

How much may Puraite cost? As the final pricing model is still under development and depends on several external factors, this question cannot be answered conclusively at the moment. Currently, we expect to offer a flexible licensing or subscription model (Software as a Service) that takes into account factors such as the number of users or the required functionalities. As we place a high value on inclusion and social justice, we also plan to provide free (or profit-free) licences for educational institutions or institutions from developing countries.

Links: https://puraite.com/

2.2.3. SRDC

SRDC is a high-performance SME that originates from a successful academic spin-out from the Middle Easter Technical University in Turkey. The company has been one of the early stage innovators in the field of digital health technologies and solutions, with contributions both to scientific and research excellence as well as innovative industry applications and successful commercial deployments.

As part of the Cologne ecosystem SRDC promotes their OnFhir.io service ecosystem briefly described below.

OnFhir.io Ecosystem

onFHIR (https://github.com/srdc/onfhir), is a secure and high-performance health data repository, which is used as the cloud-based clinical data repository in currently running three H2020 projects, C3-Cloud and Power2DM , FAIR4Health , and Chronic Disease Management Platform of Turkey.

The open-source initiative, onFHIR.io provides a secure HL7 FHIR based EHR repository to handle records of millions of patients without compromising for write or query performance. It provides mechanisms for secure data exchange, fine-grained access control, backups, audit logs.

onFHIR uses MongoDB as a persistency mechanism and uses its sharding mechanism for horizontal scalability of the system. It supports subscription mechanisms, enabling SmartHT components to be immediately informed about EHR, PHR updates in the Patient Data Store

What onFHIR.io Offers:

- Interoperability: A common, standardized, HL7 FHIR® compliant way for data access and storage for your health data
- Data Security: Mechanisms to secure health data for secure data exchange, fine-grained access control, backups, audit logs, etc.
- Scalability and Performance: Flexibility to handle records of millions of patients without compromising for write or query performance
- Compliance with EU Privacy Regulations: Support for easily complying with the current and forthcoming EU privacy regulations and member states' data protection laws, and security standards for healthcare

Where can onFHIR be used for?

- Large Healthcare Facilities: As a secure central health data repository to enable interoperable health data exchange among different medical systems running in your organization while conforming privacy policies and access control rules.
- Health Information Systems: As your secure PHR repository where your mobile or web based self-management or homecare applications can easily access to patient's data via FHIR compliant REST services.
- Clinical Studies or Research Projects: As data integration platform among different data collecting systems or multi partner research projects and serve the data to your researchers or value added services with a common standardized model.

References

onFHIR is used as the cloud-based clinical data repository in 3 H2020 projects which have been successfully completed: C3-Cloud, Power2DM and FAIR4Health.

 It is currently being used in 4 of our active EU projects, namely: ADLIFE, CAREPATH, AICCELERATE and DataTools4Heart.

onFHIR is also utilized as the backbone of the national Chronic Disease Management Platform of Turkey, which is currently being used daily by more than 25,000 Family Medicine practitioners for the screening and monitoring of Turkish citizens for several chronic diseases, including hypertension, diabetes, obesity, and cardiovascular disease risk. onFHIR setup for the national Chronic Disease Management Platform currently maintains ~15 terabytes of FHIR re-sources for more than 70 million Turkish citizens, and millions of new resources are added every day. The daily number of handled FHIR interactions is above 100 million, and the average response time is around 30 ms, with read and search performance being around 4-5 ms. At peak times of the day, the system can easily handle 5,000 FHIR interactions per second.

toFHIR Suite

In the onFHIR ecosystem, we have been building a health data interoperability pipeline where toFHIR is a major component. toFHIR (https://github.com/srdc/tofhir) is a data mapping and high-performant data transformation suite to convert existing health datasets from various types of sources to HL7 FHIR. It provides a graphical user interface to configure mappings from source data to FHIR resource types and a powerful distributed data processing engine to execute those mappings.

On top of toFHIR we have also developed a *REDCap - FHIR Integration Service* which includes the provision, demonstration, testing and deployment of a data transformation route using the open-source toFHIR Engine (https://github.com/srdc/tofhir) for REDCap form instruments. In collaboration with the service requester, mappings are developed from REDCap form fields to different FHIR resources (e.g., Patient, Condition, Observation etc.) conforming to required FHIR profiles (e.g., German MII FHIR profiles). With the deployment of this service, any data entry/update on REDCap is automatically reflected to the configured FHIR server endpoint.

References:

toFHIR is currently being used in 2 of our Horizon Europe projects for enabling standardization of heterogenous data sources for secondary use for clinical research in order to train AI models: AICCELERATE and DataTools4Heart.

Together with the Medical Data Integration Center (MeDIC) of the University Hospital of Cologne (Universitätsklinikum Köln – UKK) we have collaborated for the co-shaping and provision of the following services:

- We added REDCap integration capability to toFHIR and developed mappings from REDCap forms to FHIR resource types. We are deploying it to automatically catch any data entry/update on REDCap and reflect that to their FHIR server according to the developed toFHIR mappings.

- We provided a FHIR data transformation service to map UKK's lab result data to corresponding FHIR observation resources in line with the German Medical Informatics Initiative (MII) FHIR profiles.

Links: https://www.srdc.com.tr

2.2.4. Information on the Cologne regional Ecosystem
To be added in next version of the document.

2.3. The Thessaloniki ecosystem
To be added in next version of the document.

3. The Shift-Hub service offer

3.1.   What it is about

As defined in the project description, in the project we aim to both develop and test with our community a 'complete service offer', integrating 'both networking and matchmaking, identification of partners and support for procurement, guidance for access to funding, research infrastructures and scientific expertise'.

As mentioned in the project description, the SHIFT HUB service offer, an approach based open innovation to foster a collaborative, demand-driven and SME-inclusive development and uptake of Smart Health solutions, should allow the community members to:

1. present and promote the profiles of their companies, the solutions they develop and their business needs;
2. look for profiles of potential technology or business partners and service providers across Europe, have access to tailored matchmaking services;
3. have access to the online services and tools developed by the consortium: self-assessment, scouting, training/webinars, self-monitoring, value-chain analysis and mapping, registering to events;
4. organize workshops to foster collaboration and identify research, development and innovation project ideas that will be recommended funding opportunities;
5. offer guidance to the community members to identify relevant investors and public funding sources for the implementation or upscaling of their projects;
6. allow practitioners and health institutions to discover and test Smart Health solutions answering their patient management, healthcare and decision-making process related challenges (test before invest);
7. identify and make visible training and educational offer made available by the consortium partners, parallel initiatives and partner organizations allowing community members to strengthen their skills;
8. set up an interactive process based on the Living Lab approach to raise awareness and allow experimentation for patients and citizens, consequently stimulating the adoption of Smart Health monitoring and prevention solutions.

We have spent considerable time and efforts in discussing amongst the consortium members and in particular amongst the authors of the present working report to come up with a solution that might offer a simple path for the implementation of the Service Offer, that would on the one hand fulfil the purposes and the requirements as set by the project description, but also cater for the appropriate versatility and scale-up potential in terms of meeting requirements with other platforms such as the European Cluster Collaboration Platform (https://clustercollaboration.eu/) that is meant to be the European 'online hub for cluster stakeholders (cluster organisations, policymakers and other related stakeholders from the cluster ecosystem)' and a 'reference one-stop-shop for stakeholders to set up partnerships'.

It is the latter aspect related to the one-stop-shop element that we consider a service offer needing to provide the required expressive power, while keeping its simplicity that might also help its wider adoption. What we consider would be a mistake is to build yet-another information system that might be poorly maintained and operated, and would have limited or little potential for uptake by stakeholders after the project completion.

Below we present a set of basic, guiding principles for the realisation of the Shift-Hub Service Offer. We try to relate them with examples that demonstrate their relevance and relation to the project context and the use cases to be supported with all necessary features.

3.2.   Principles and implementation essentials

Supply

- Knowledge
- Know-how
- Technology
- Tools
- …

Demand

- Needs
- Requirements
- Wishes
- Preferences
- …

Figure 2 Starting points and 'reason of existence' for the Service Offer

Supply-triggered Service Offer route, navigating directly to Demand

Supply   **Demand**

Demand-triggered Service Offer route, navigating directly to Supply
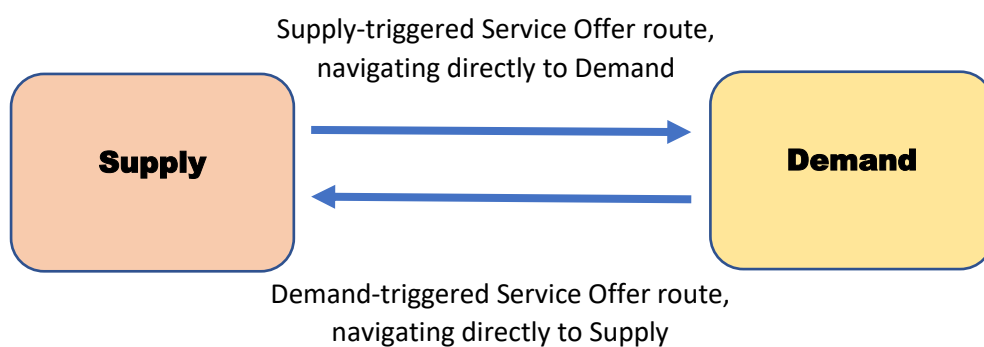
Figure 3 Basic scenario of demand and supply matching

Supply-triggered Service Offer route, navigating through several nodes

Supply   **Demand**

Demand-triggered Service Offer route, navigating through several nodes
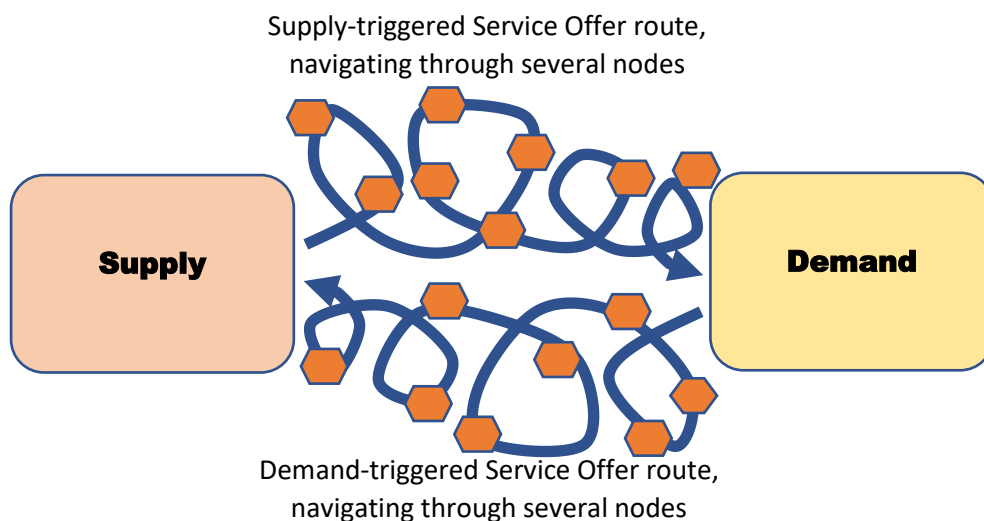
Figure 4 Advanced scenario where a demand- or supply triggered

In the advanced scenario, the idea is that a supply- or demand-triggered Service Offer 'navigates' through several mediators till a successful pairing with demand or supply respectively takes place.

3.2.1. Challenges of Open Innovation projects and strategic collaborations towards the development and uptake of innovative Smart Health Solutions

The execution of an OI project rarely follows a 'straight line'. A recent survey by Accenture revealed that more than 50% of the corporations said that "OI partnerships don't seem to be yielding as many new products or other benefits as they had hoped" and "the reasons are … political and cultural, not technical" [Deichmann, 2017]. The root of this problem is that the OI process involves a number of difficulties, drawbacks and tensions (see Table below for difficulties identified by INSPIRE), for which the involved OI partners are neither prepared, nor supported.

Our contention is that an effective Service Offer facilitating the development and uptake of Smart Health Solutions cannot ignore or neglect these difficulties [Su, 2019]; it must provide mechanisms and services to allow (potential) partners to prepare sufficiently before they actually get into the process of interacting with each other.

Corporations and Large Organizations (LCs) should have sufficient space to meet, discuss and interact with technology providers (SMEs, start ups and researchers) before they make decision to engage in OI with them. LCs should also exhibit a minimum level of commitment towards the SMEs, start ups and researchers by making a sufficient level of effort towards discussing the potential OI project with them. On the other hand, SMEs, start ups and researchers need to become clear about the effort and the resources required to go from a brilliant new idea to commercialization and adoption by the market. They also need to build-up their understanding of what the OI process with a LC actually entails (e.g. different timescales in decision-making). Most importantly, SMEs, start ups and researchers need to develop their absorptive capacity, i.e. the necessary skills, mindsets and routines to enable an effective and efficient interaction with an OI partner. The academic literature provides ample evidence of how the SMEs' lower absorptive capacity affects their ability to establish OI partnerships [Muscio, 2007] or the development of OI partnerships with distant LCs (which may have the missing set of competences and resources) [de Jong, 2010]. These 'preparations mechanisms and services' are vital elements of developing an efficient SHIFT HUB Service Offer

Table 1 Difficulties in the OI process between SMEs and LCs [Christian, 2018]

Experienced difficulty	Underlying problem
Lack of a clear value proposition and proof of concept	Technology Provider inadequate preparation
Lack of clear roles between the partners, which includes knowledge sharing and HR division	
Failure to clearly agree vision and business model	
LC little or no high-level sponsorship for the OI partnership	Differences in organisational culture between a Technology Provider and LC
Misalignment of timing and processes	
Complex and slow corporate decision making for the LC	
Misaligned objectives and troublesome relations	Technology Provider enters into partnership too quickly
Underestimate difficulties in finding the right contact in LCs	
Unintended leakage of the technology	Technology Provider does not understand importance of IPR
Failure to protect their IP when negotiating contracts with LEs	

Technology Provider finds difficult to determine the cost of acquiring new technology	Technology Provider invests in non-essential assets
	Technology Provider lack of awareness of OI business models

For the needs and the implementation within the scope of the project, Service Offers can be considered as 'permanent' and needing to be distinctly identifiable, fulfilling also FAIRness requirements so that these can be, when maintained by the project or other 3rd party repositories such as this of the European Cluster Collaboration Platform. To this a DOI may be required for each offer that will help it also meet the aforementioned FAIRness criteria. This may also facilitate matching a Service Offer with corresponding supply- or demand-driven events like 'have a technology to offer' or 'have a demand or a need to meet'.

Similar to other application fields, there may be a need for ensuring long-term sustainability of the Service Offers that will be guaranteed. in the following way:

- *Findability:* Metadata schemas derived by the Service Offer definition will be published in broadly accessible portals such as FAIRsharing.org. Service Offer data sets and data items will be findable by a globally unique identifier, and this will persist on the Shift-Hub Service-Offers-as-an-infrastructure.
- *Accessibility:* Service Offers as implemented by the project should set the processes for accessibility. It should be possible to offer pseudonymisation or, if necessary, anonymisation of parts of the Service Offer from the demand- or the supply partners. For the scope of the project there is no need for authentication or authorisation mechanisms to be implemented.
- *Interoperability:* Metadata and data will follow established standards that can be broadly applicable and adopted. Relevant terminology servers may be used in the future to provide consistencies of the different vocabularies, and terminologies employed. However, for the needs of the project there is no need to elaborate more than the necessary level related to an operational proof of concept.
- *Reusability:* Metadata will be published with clear and accessible data usage licence. Service offerers preferences regarding privacy aspects can be queried before Service Offer data are shared. In addition, the data will be harmonized and the quality of the data will be reviewed and improved by queries to the Service Offer authors if necessary.

And apart from the simple case of a direct match between supply and demand, there is usually an entire value chain that is created, sometimes on an ad hoc basis and some other times as part of an already existing setting (in our case this can be the innovation ecosystem), as presented in Figure 4 above, that will facilitate the 'brokerage' amongst the various actors involved. To this we provide some more specific information in the next section.

3.3. Brokerage of the Shift-Hub service offers

Between the final demand and supply nodes there is an entire value chain that needs to be considered. To this reason we call brokerage any activity that takes place with respect to a Shift-Hub Service Offer, following it from its creation and initialisation till its execution and completion. In other words, a Service Offer facilitate the delivery of a solution to a problem, or supplies a technology where there is a demand for it, etc., using the Shift-Hub assets in terms of the project community, the network of expert providers, and last but not least the participating innovation ecosystems. The brokerage aspect relates to the need to facilitate connections, collaborations, and partnerships between the different stakeholders in the innovation ecosystems in order to satisfy each of the 'incoming' Service Offers.

This includes identifying opportunities, bridging gaps, and fostering relationships to accelerate the development and commercialization of innovative ideas, products, and services.

Key aspects of the Service Offer implementation process include:

1. **Needs identification and analysis**: Understand the specific needs, challenges, and goals of stakeholders (e.g. corporates, public organisations, start-ups, research institutions) to identify areas where innovation is required, and potential solutions or collaborations can be explored.

2. **Market and technology scouting**: Conduct research and analysis on emerging trends, technologies, and market opportunities to identify potential partners, collaborators, and innovation sources for stakeholders.

3. **Networking and relationship building**: Establish and maintain relationships with key stakeholders in the innovation ecosystem, such as industry experts, researchers, investors, and government agencies, to facilitate collaboration and knowledge exchange.

4. **Matchmaking and partnership facilitation**: Identify, evaluate, and introduce potential partners and collaborators to stakeholders based on their specific needs and objectives, and support the negotiation and development of agreements to initiate collaborations.

5. **Knowledge sharing and capacity building**: Provide guidance, tools, and resources to stakeholders to help them navigate the innovation landscape, develop their capabilities, and enhance their understanding of relevant technologies and market trends.

6. **Monitoring and evaluation**: Track and assess the progress and outcomes of facilitated partnerships and collaborations, providing feedback and recommendations for improvement, and ensuring that objectives are met.

7. **Support in securing funding and resources**: Assist stakeholders in identifying and accessing funding opportunities, grants, and other resources necessary to support their innovation efforts.

8. **Promotion of an open innovation culture**: Encourage and promote a culture of innovation and collaboration within the Shift-Hub ecosystems, fostering an environment conducive to the growth and success of innovative ideas and ventures.

Service Offers as implemented in our project serve three main goals:

1. **Facilitate collaboration** amongst the various members of an ecosystem like Demand-side organisations that provide 'Challenges' and potential solutions providers that find themselves rather at the Supply side and which may lead to solving specific challenges.

2. **Help all involved organisations** better understand the open innovation process, mature, and clearly define their needs, their assets as well as their solutions and challenges into targeted actionable information.

3. **Help cutting-edge and high-performance medtech, healthtech and deeptech companies, startups and SMEs** bring their innovations into the domain of the problems outlined above.

In this setting, for the Service Offer implementation we shall combine market pull and technology push to find the most suitable matches to the each-time given context. And while they may already be part of a regional or national innovation ecosystem within their country, stakeholders are expected to reach out to other networks and ecosystems to ensure reach of their goals.

For the needs of the project, we considered the NESTA Innovation Brokerage Model (https://innovationbrokerage.nesta.org.uk) as a flexible guideline, allowing our Shift-Hub Service Offers to adapt and customise themselves to suit the needs and circumstances of each stakeholder involved.

Table 2 The 4 phases of NESTA model as adapted for Shift-Hub Service Offer

	In the **Prepare** phase, the Service Offer is customised to meet the needs of the organisation initiating it.
	In the **Search** phase, the Service Offer is communicated within the project ecosystems to find corresponding matches.
	In the **Align** phase, the Service Offer has been preliminarily matched with some respective organisations and effort is now given to *establish trust* and align motives, culture and working practices from all sides involved with the goal of implementing the match.
	In the **Support** phase, we take care so that the necessary *support* is provided to the Service Offer to make the relationship with all involved actors and stakeholders a success in the long run.

SHIFT HUB Service Offer methodology will follow a set of priorities to focus its available resources:

- *Technological focus* with emphasis on Smart Health solutions based on advanced technologies and digital technologies;
- *Value Chain broadness*, including as many stakeholders and sub-sectors as possible;
- *Geographical inclusiveness*, including stakeholders from as many as possible European regions.

Based on the above, SHIFT HUB Service Offer methodology will follow three major key phases:

A. **Engage with a Critical Mass** of stakeholders (and their needs) and digital health providers, solutions etc

B. **Prepare and support technology providers for co-creation and OI as well as scaling up and investment** through offering **Support & Connect services**

C. Offer Value-added services to **Facilitate development and uptaking of** Smart Health solutions

The working team has designed the aforementioned approach considering the interrelations between WP3 and WP5 activities (See Figure below)
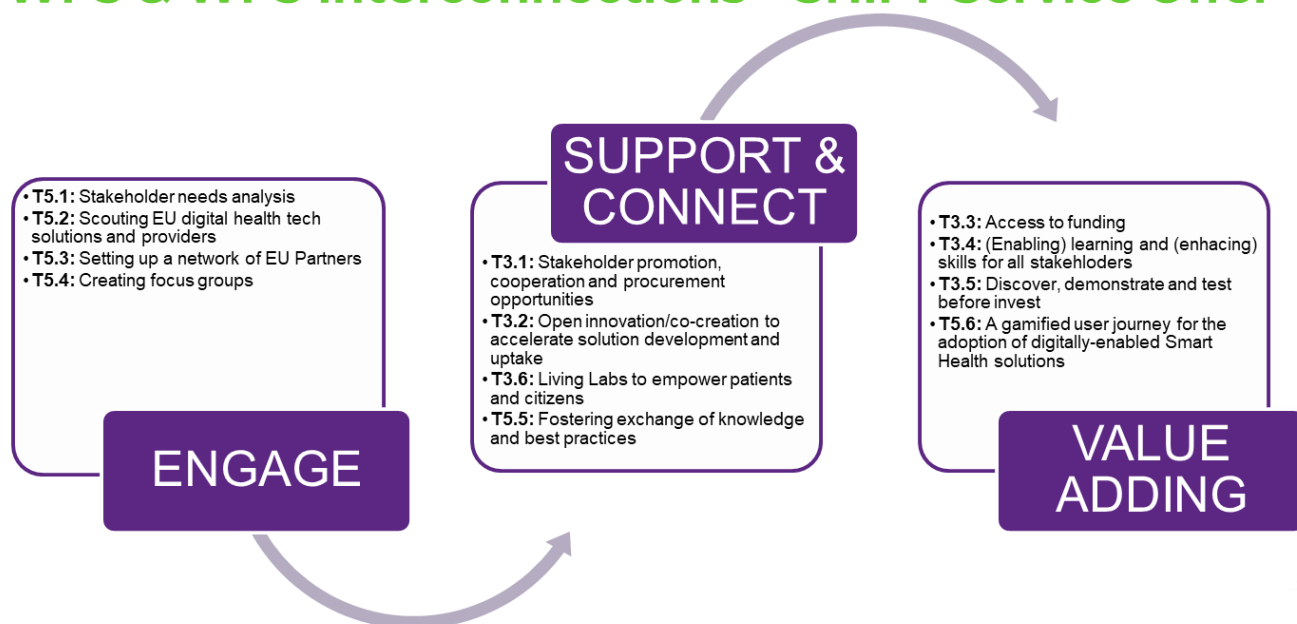
WP3 & WP5 Interconnections – SHIFT Service Offer

- **T5.1:** Stakeholder needs analysis
- **T5.2:** Scouting EU digital health tech solutions and providers
- **T5.3:** Setting up a network of EU Partners
- **T5.4:** Creating focus groups

ENGAGE

SUPPORT & CONNECT

- **T3.1:** Stakeholder promotion, cooperation and procurement opportunities
- **T3.2:** Open innovation/co-creation to accelerate solution development and uptake
- **T3.6:** Living Labs to empower patients and citizens
- **T5.5:** Fostering exchange of knowledge and best practices

- **T3.3:** Access to funding
- **T3.4:** (Enabling) learning and (enhacing) skills for all stakenloders
- **T3.5:** Discover, demonstrate and test before invest
- **T5.6:** A gamified user journey for the adoption of digitally-enabled Smart Health solutions

VALUE ADDING

Figure 5 WP3 and WP5 interconnections with respect to the Shift-Hub Service Offer

3.4.   Service offer template

Below we present a possible template for Service Offers to be discussed within the Shift-Hub consortium and with external actors and stakeholders.

SHIFT-HUB Service Offer	<<title>>	DOI
Related Resources:		
Projected		
Planned		
Needed		
Acquired		
Allocated		
….		
Market opportunities:		
Identified		
Potential		
Possible		
Secured		
…..		
Collaboration opportunities:		
Named entities		
Types of entities		
….		
Products / Services / Processes / Other types of offerings:		
Generic product or service type		
Instance of product type		
…..		

Service Offer Ownership:
Organisation / institution
Individual person
Groups of the above
Service offer description
Textual description
Images, data, code, patents
Other references
…..
Related Actors and ecosystem partners:
<<Name and Role>>
<<Name and Role>>
<<Name and Role>>
…..

4. Conclusions and next steps

To be added in next version of the document.

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