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An Adaptive Enterprise Architecture Design for a Digital Healthcare Platform

Toward Digitized Society – Industry 4.0, Society 5.0

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***Abstract*— Enterprises and information societies confront crucial challenges currently, while Industry 4.0 becomes important in the global manufacturing industry and Society 5.0 should contribute to a supersmart society, especially for healthcare. Physical activity monitoring digital platforms are architected to improve the healthcare status of patients with diabetes and other lifestyle-related diseases. Furthermore, digital platforms are expected to generate profits for health technology companies and help control costs in the healthcare ecosystem. However, current digital enterprise architecture approaches are not well-established, and the potentials have not yet been realized. Design thinking approach and agile software development methodologies can overcome these limitations, beginning with proof of concept and pilot projects and then scaling to the production environment. In this paper, we describe how that the adaptive integrated digital architecture framework (AIDAF) for Design Thinking approach is proposed and verified in a case of a university hospital in the Americas. In addition, challenges and future activities for this area are discussed that cover the directions for Society 5.0.**

Keywords*—*Enterprise Architecture, Digital Healthcare, Risk Management, Digital Platform, Society 5.0, Industry 4.0

I. Introduction

In the healthcare and manufacturing industries today, new enhancements to business structure and process efficiency through digital platforms such as portals and social networking services (SNSs) are considered in enterprises and information societies. Industry 4.0 offers many opportunities for companies to increase flexibility and efficiency in production processes, enabling new business models through Industry 4.0, digital platforms [1,2]. Society 5.0 can contribute to a supersmart society covering healthcare industries [37].

Continuous change is a characteristic of the information society, such as the development of new technologies, shifts in customer needs, new business models and globalization. Significant changes in cutting-edge IT technology due to recent developments in Cloud Computing and Mobile IT (such as progress in Big Data technology) have emerged as new trends in information technology. Furthermore, major advances in these technologies and processes have created a "digital IT economy," bringing about business opportunities along with business risks, and forcing enterprises to innovate or face the consequences [5]. Enterprise Architecture (EA) usefully contributes to the design of large integrated systems, helping to address a major technical challenge toward the era of Cloud, Mobile IT, Big Data, and Digital IT in Digital Transformation. From a comprehensive perspective, EA encompasses all enterprise artifacts, such as businesses, organizations, applications, data, and infrastructure, to establish the current architecture visibility and future architecture/roadmap. On the other hand, EA frameworks need to embrace change in ways that consider the emerging new paradigms and requirements affecting EA, such as mobile IT and the cloud [6,7].

In light of these developments, a previous study proposed the "Adaptive Integrated EA Framework" to align with the IT strategy to promote Cloud, Mobile IT and Digital Platform, and verified this in the case study [10]. This EA framework was named as the "Adaptive Integrated Digital Architecture Framework - AIDAF" [9].

Physical activity monitoring digital platforms are architected to improve the healthcare status of patients of lifestyle disease, diabetes in the healthcare communities. Moreover, the digital platforms are expected to make profits and contribute to cost efficiency in healthcare ecosystem and communities. However, existing enterprise architecture approaches are not well-

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established for the approaches of Design Thinking and agile software development required for the above digital platforms. Specifically, the research questions employed in this study are:

RQ1: How can the digital healthcare platform be built with Design Thinking methodology supported by AIDAF in a healthcare community?

RQ2: How can the digital healthcare platform be managed and improved in alignment with digital platform strategy using AIDAF in a healthcare community?

To investigate the architecture design and implementation of digital healthcare platforms and AIDAF in healthcare communities, we reviewed the literature, industry trends, and a case where a digital healthcare platform is designed and built with Design Thinking and agile software development methodology.

We will describe and briefly explain the latest trend of core technologies for digital healthcare and agile software development methodologies and Design Thinking approach from the viewpoint of literature reviews. We propose the AIDAF framework with Design Thinking approach. Next, we evaluate the above questions using a case in a hospital and healthcare communities in Americas. Our proposed architecture framework and model is then discussed for the analysis and verification using a case of the digital healthcare platform pilot in a hospital and healthcare communities there.

This paper is organized as follows: the next section presents the background of this study, followed by the description of proposal and overview of the "AIDAF Framework for Design Thinking approach." The results and discussions in the case study are presented, and the above framework is verified. Finally, the limitations of the current study and directions covering Society 5.0 for future research are outlined.

II. DIRECTION OF DIGITAL HEALTHCARE, ENTERPRISE ARCHITECTURE, (AGILE SOFTWARE DEVELOPMENT)

A. Related Work – Core Technologies for Digital Healthcare

Cloud computing is a cost-effective option for acquiring strong computing resources to deal with big data, with significant adoption in the healthcare industry [10].

The implementation of Big Data analytics in healthcare makes progress, enabling the exploration of large data sets incorporating EHRs to uncover hidden patterns, unknown correlations, and other useful information [11,12]. Advances in Big Data analytics can help transform research situations from descriptive to predictive and prescriptive [13]. Big Data analytics in healthcare can contribute to evidence-based medicine and patient profile analysis, as well as many other applications [14]. In terms of artificial intelligence (AI) techniques scenarios can be based on natural language processing, pattern recognition, and machine learning [23].

The term "Internet of Things (IoT)" refers to "the collection of uniquely identifiable objects embedded in or accessible through Internet hosts" [5], such as interaction devices, smart homes, other smart life scenarios. The current state of research for the Internet of Things architecture [15] lacks a holistic understanding of EA and management [16-18], showing a range of physical standards, methods, tools, and a large number of heterogeneous IoT devices [19]. Zimmermann et al. proposed a first reference architecture (RA) for the IoT [19] in context of digital enterprise architectures.

IoT can be the main enabler for distributed healthcare applications [20], therefore, potentially can contribute to the overall decrease of healthcare costs while increasing health outcomes, although behavioral changes of the stakeholders are required [13,20]. Medical, diagnostic and imaging sensor devices with wireless technologies constitute a core part of the IoT [21], though general-purpose smart devices such as smartphones or PDAs are leveraged in several healthcare applications [21,22]. Whereas, a patient-centric integrated healthcare system, such as a physical activity monitoring system, is designed for real-time health monitoring of patients whole health with collecting necessary healthcare data from them by using wearable IoT sensors connected to above systems via internet, to show guidance on preventive care and to increase health awareness and self-monitoring [39, 40].

B. Industry 4.0 and Society 5.0

The digitization of global industries and value chains and the associated need for structured research and standardization has given rise to four major initiatives in the USA, China, Japan and Germany. These initiatives address potentials and challenges of digitalization [1]. Industry 4.0 is dedicated to research for German industry and supports the implementation of this vision in manufacturing companies. The Industry 4.0 platform identified 17 technology development fields in its "Recommendations for the implementation of the Industry 4.0 strategic initiative", covering essential aspects of Industry 4.0 and a roadmap [1,2,24].

The Reference Architectural Model Industry 4.0 (RAMI 4.0) was developed by the Platform 4.0 in 2015. It consists of several layers, hierarchical levels, and the product lifecycle representing the value stream [2]. The "hierarchical levels" consist of seven individual levels: product, field device, control device, station, work centers, enterprise and connected world, from bottom to top. These levels represent the functional characteristics of the components and are oriented on IEC 62264 and IEC 61512 [1]. Each component consists of "six layers." Starting with the lowest layer, the structure consists of asset, integration, communication, information, functional and business. While each layer is distinctively different from the others, elements within one layer are supposed to be homogenous regarding their attributes [4]. The third axis describes the "life cycle and the value chain" of an Industry 4.0 component. The structure of this axis is based on IEC 62890 and assumes a basic division into product type and instance. While a type already exists with the basic product idea and covers the phases from order intake over product development to prototype production, an instance stems from the transition to production after the successful completion of all tests [1,2,3].

According to Japanese government documents, Society 5.0 can be defined as "through the high degree of fusion between cyberspace and physical space, economic progress can be aligned with solving social problems by providing goods and services to meet repeated latent needs regardless of location,

age, gender, or language" [37]. there are some commonalities between Industry 4.0 and Society 5.0. Both visions emphasize the use of technology, including IoT-related technology, AI, and Big Data analysis [37]. There are some differences, however. Industry 4.0 advocates smart factories, while Society 5.0 calls for a supersmart society. In terms of the future technological innovations, Industry 4.0 calls for an industrial revolution centered on manufacturing, whereas, Society 5.0 focuses heavily on the public impact of technology [37].

C. AIDAF Framework

Over the past decade, EA has become an important framework for modeling the relationship between enterprise and individual systems. In ISO/IEC/ IEEE42010:2011, an architecture framework is defined as "conventions, principles, and practices for the description of architecture established within a specific domain of application and/or community of stakeholders" [28]. EA is an essential element of corporate IT planning and offers benefits to companies, like coordination between business and IT [29].

Chen et al. have discussed the integration of EA with service-oriented architecture (SOA) [30]. OASIS, a public standards group [31], introduces an SOA reference model. Meanwhile, attention has been focused on microservice architecture, which allows rapid adoption of new technologies like Mobile IT, IoT and cloud computing [32]. SOA and Microservice vary greatly from the viewpoint of service characteristics [33]. Microservice is an approach for dispersed systems defined from the two basic forms of functional services through an application programming interface (API) layer and infrastructure services [32].

In terms of Cloud Computing, many Mobile IT applications operate with SaaS Cloud-based software [34]. Traditional EA approaches require months to develop an EA to achieve a Cloud adoption strategy, and organizations will demand adaptive EA to iteratively develop and manage an EA for Cloud technologies [35]. Moreover, few studies discussed EA integration with Mobile IT [9]. From the standpoint of EA for cloud computing, there should be only an adaptive EA framework that is supporting elements of cloud computing [36]. Moreover, according to the previous survey research [36], when promoting Cloud/Mobile IT in a strategic manner, a company that has applied the Open Group Architecture Framework (TOGAF) or Federal Enterprise Architecture Framework (FEAF) can adopt the integrated framework using the adaptive EA framework supporting Cloud related elements.

Preliminary research of this paper proposed an Adaptive Integrated EA framework depicted in Fig. 1 of this preliminary research paper, which should integrate with IT strategy promoting Cloud, Mobile IT, Digital IT, and evaluated this in the case study [8]. In the adaptive EA cycle, project plan documents including architecture for new digital IT projects should be made on a short-term basis in the context phase by referring to materials of the defining phase (e.g., architectural guidelines aligned with IT strategy) per business needs. During the Assessment/Architecture Review Phase, the architecture board (AB) reviews the architecture in the initiation documents for the IT project. In the Rationalization Phase, the stakeholders and AB decide upon replaced or decommissioned systems by the proposed new information systems. In the Realization Phase, the project team starts implementing the new IT project after weighing issues and action items [8,9]. In the adaptive EA cycle, organizations can deploy an EA framework such as TOGAF and a simple EA framework based on an operational domain unit in the upper part of Figure 1 of [8,9]. The AIDAF was treated as digital EA (DEA) framework.

D. Agile Software Development Framework

Software development processes have long been characterized by linear process models [45]. The best known is probably the waterfall model [46]. Starting with an initial elicitation of requirements, increasingly refined specifications are created, which are then converted into a design and implemented. An important criticism of the waterfall model is the low level of customer involvement. This is practically no longer included during the development, which always leads to the fact that despite the inclusion at the beginning of the project, the customers were not satisfied with the resulting end product. Basically, it is also a problem to capture all relevant user requirements in one step.

Agile methods try to address this point in particular by working iteratively and incrementally [47]. Agile processes therefore repeatedly contact the customer to present interim results [48]. Also, the complete solution is not presented right away, but the solution is developed incrementally together with the customer. This approach is also supported by a team organization with a very high degree of freedom, so that the necessary number of customer interactions can be carried out very flexibly.

Agile software development follows four guiding principles [48]. Individuals and interactions are considered more important than processes and tools. The functionality of the software is given priority over documentation. Collaboration with the customer is seen as more significant than contract negotiations. Finally, responding appropriately to change is seen as more important than following a plan.

Agile software development today takes place within the framework of agile frameworks. They have advanced the basic ideas of agile software development. The most important are Scrum-of-Scrums [49], Large Scale Scrum (LeSS) [50], Scaled Agile Framework [51] and Disciplined Agile (DAD) [52], migrated to the current version of this framework named "Disciplined Agile 2.0." A detailed comparison of the frameworks can be found in [53]. The comparison of the frameworks' maturity shows that the Scaled Agile Framework has the highest number of contributions and also integrate an EA role [53]. To cope with high complexity, Large Scale Scrum and Disciplined Agile define less in advance and give more freedom for individual solutions [54].

III. Extended Digital Enterprise Architecture - AIDAF Framework

A. Design Thinking Approach

Design Thinking [55-58] is a user-centered creativity and innovation-oriented approach to problem solving, especially helpful for "wicked" problems. Steve Jobs famously has proclaimed, "Design is not just how it looks and feels. Design is how it

works." As originally introduced by the School of Design Thinking at Stanford University, the philosophy of Design Thinking [55] includes essential key attributes, like: (1) people-centered, (2) highly creative, (3) hands-on, and (4) iterative processes. Concretely, you start from what people, users, customers, consumers need or want to do. You need to understand peoples' motivation and problems they are trying to solve, and share the feelings of others. To be highly creative you look at situations and aspects of a problem differently and come up with new improved solutions, that go beyond existing alternatives. Hands-on means stop discussing, start working, and make ideas tangible. Prototyping is thinking with your hands. Test your hypothesis fast by using concrete prototypes. Failure is a necessary part of the process to succeed. Experiments with trial and error are key. Iterative processes are mandatory to implement because the road to success does not follow a straight line. The more you are able to loop through the understand, create, learn cycle, the higher chance you have for good results.

The Design Thinking mindset [55] encourages highly creative methods and associated practices like: (1) Show Don't Tell: Communicate your vision in an impactful and meaningful way by creating experiences, using illustrative visuals, and telling good stories. (2) Focus on Human Values: Empathy for the people you are designing for and feedback from these users is fundamental to good design. (3) Craft Clarity: Produce a coherent vision out of messy problems. Frame it in a way to inspire others and to fuel ideation. (4) Embrace Experimentation: Prototyping is not simply a way to validate your idea; it is an integral part of your innovation process. We build to think and learn. (5) Be Mindful of Process: Know where you are in the design process, what methods to use in that stage, and what your goals are. (6) Bias Toward Action: Design thinking is a misnomer; it is more about doing than thinking. Bias toward doing and making over thinking and meeting. (7) Radical Collaboration: Bring together innovators with varied backgrounds and viewpoints. Enable breakthrough insights and solutions to emerge from the diversity.

The originally defined incremental processes for Design Thinking (Fig 1) also appear in some variations in related references [56, 57, 58], among others, which essentially focus on the following key phases [55], like Empathize, Define, Ideate, Prototype, and Test.

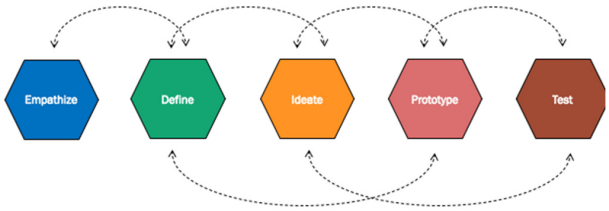

Fig. 1. Design Thinking: Iterative and Incremental Process

The empathize phase involves understanding the experience, the situation, and the emotions. Observe users, talk to people, watch and listen. The definition phase serves to synthesize your findings and approach through a systematic collection of user types, synthesis of a limited number of needs, formulation of insights and principles. Developing ideas includes creative elements and methods for idea generation including brainstorming, creativity, group synergy, presentation of new ideas, and separate idea generation and evaluation: Brainstorming, creativity, group synergy, presenting new ideas, and separate idea generation and evaluation. The essentials as working tool and both result of Design Thinking are prototypes of the future concept or system. This includes building an experimental scenario to make ideas tangible, the quick and dirty illustration of an idea, visualization, look and feel of solutions, and mainly building models and artifacts. Through testing, you gather feedback on your prototypes. Complementary, you learn about users, change your perspective, refine your prototype, and enable first concrete experiences.

B. Proposal of the AIDAF Framework with Design Thinking Approach

As a result of investigating tasks and steps for Design Thinking approach with agile software development methodologies, the authors defined and described the efficient process with Design Thinking approach while integrating the above approach into the AIDAF framework appropriately, based on the following four steps: [1A] [2A] [3A] [4A]. These steps can cover necessary items and tasks for the "Design Thinking approach with agile software development of prototypes" toward "scaling them to production environments." One of the authors performed these steps in/with Architecture/project organizations in case studies of a hospital and healthcare community in a global setting:

[1A] Design thinking approach with partners in a healthcare community is utilized in designing user interfaces with cultural preferences, before implementing prototypes for Digital Platforms with agile software development ones. The prototype is checked and modified with architecture guidelines such as user interfaces and privacy, etc. (The architecture reviews will be held, if necessary.)

[2A] In Context phase of the Adaptive EA cycle in the AIDAF, project manager can adopt the Design Thinking approach for production environment's platforms to define necessary enhancements of the prototypes.

[3A] In Assessment/Architecture Review phase in the AIDAF, the digital IT project's proposal with enhancements of prototypes can be reviewed for deployment into actual societies in consideration of production environments and Rationalization there.

[4A] In Realization phase in the AIDAF, Risk Management process can be started based on the review's results and necessary policies (i.e. privacy). In digital IT projects, project managers can cope with each Risk Mitigation strategy for risks defined in Architecture Board.

The authors propose the AIDAF Framework for Design Thinking Approach with Strategic Risk Mitigation (STRMM) model in Fig 2, based on the above processes and approach with the AIDAF framework and Design Thinking approach.

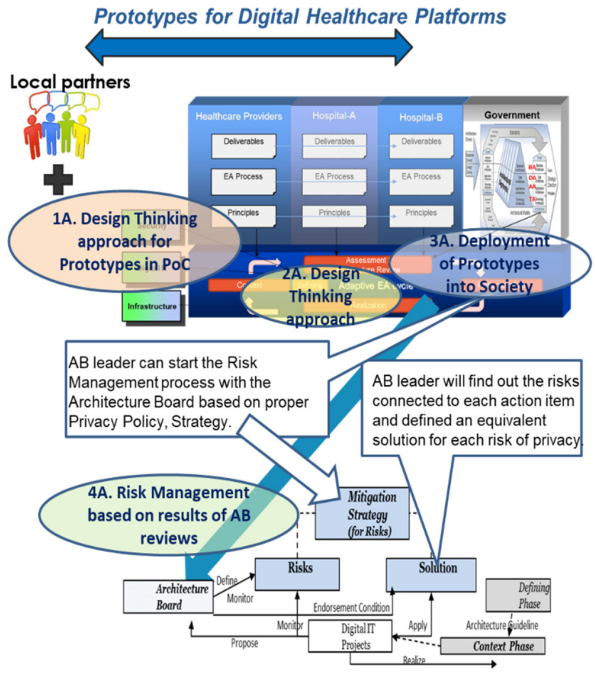

Fig. 2. AIDAF Framework for Design Thinking Approach with STRMM model.

IV. Case of a University Hospital in Americas with Digital Platform

Diabetes is a key problem in the Caribbean. In Jamaica, it is described as an epidemic as it is found in more than 10 percent of the population who are 15 years or older; it is the leading cause of death of women and the third highest cause in men [41]. Increased physical activity for persons with diabetes is a key step to address this problem. Because of this, a university hospital in the Caribbean started a pilot program to encourage additional physical activity among diabetic patients through digital financial incentives. It is expected to decrease medical costs and improve health. To capture the relationships between monetary incentives, increased physical activity, and improved health indicators, the above university hospital in Americas, Carnegie Mellon University and Brandeis University started the pilot project for a physical activity monitoring platform by applying Design Thinking approach and the AIDAF framework with agile software development. Figure 3 illustrates the AIDAF proposed model in the healthcare community in Americas, as the case of applying AIDAF across the healthcare community with the physical activity monitoring system.

The AIDAF proposed model with physical activity monitoring system is an EA framework model integrating an adaptive EA cycle in the bottom portion with a FEAF by government or simple EA (framework) by hospitals and healthcare providers covering medical ones and devices to measure physical activity in the upper portion. It involves physical activity monitoring systems, that are accessed and used by doctors in hospitals and healthcare professionals providers, while patients of lifestyle disease having wearable IoT sensors connected to the above system and using it via internet, which should be managed and improved in the alignment with the national digital health strategy, necessary privacy policy and each digital IT architecture strategy in hospitals and healthcare providers covering healthcare device companies, as shown in Figure 3.

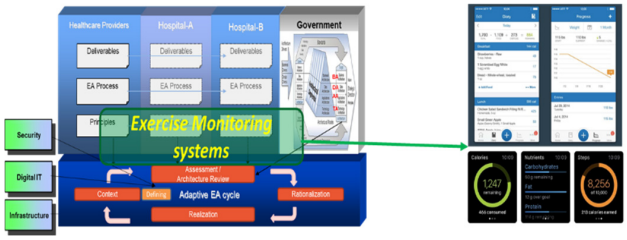

Fig. 3. AIDAF proposed model with physical activity monitoring digital platform in the healthcare community.

V. Discussion

A. The Case of the AIDAF Framework with Design Thinking Approach in Americas

Physical activity monitoring using a digital platform with digital financial incentives is expected to help diabetic patients to increase physical activity, thereby decreasing care cost and improve health status.

In the case of the pilot project for physical activity monitoring digital platform in the university hospital and healthcare community in Americas, Design Thinking approach was applied and utilized for the basic design of this digital platform. While performing the design of this platform with Design Thinking approach, cultural perspectives for user interfaces of this digital platform were checked and enhanced with using a value comparison tool with Hofstede cultural dimensions and insights [59] among the three countries such as the US, Australia, and Jamaica in the step [1A] of our proposed "AIDAF Framework for Design Thinking approach" in Figure 2. The greatest difference was uncertainty avoidance and individualism. The risk in designing user interfaces was that was culturally insensitive to Jamaican values of "Individualism" because Jamaican people tended to have a higher sense of community than the U.S. or Australia. To mitigate this risk, the participant in-processing website is being designed to give the participants a sense that they can help to improve the health of Jamaicans, that was reflected into step [1A] and step [4A] of STRMM model through steps [2A] and [3A] of our proposed approach in Figure 2. The SAP Fiori guidelines for user interface design [60] is also utilized and referred for the cultural perspectives of this platform [60] in terms of this platform's connection with electronic health record (EHR) in the step [2A] of our proposed approach in Figure 2. Moreover, while performing the design of this platform with Design Thinking approach, privacy aspects of this digital platform were also checked and enhanced with safeguarding scheme of patients' identity through concerns' separation within database architecture in step [1A] of our proposed approach. Furthermore, the General Data Protection Regulation (GDPR) principles [61] is also taken into considerations to make the privacy internationally compliant in this digital platform in step [2A] of Design Thinking approach to define

necessary enhancements for production environment's platform, and they are reflected into step [4A] of STRMM model through step [3A] of reviews for scaling to production environment of societies in our proposed approach in Figure 2.

The Xano platform-based security management is being used [62,63] as a security architecture standard on the abovementioned platform to ensure the security of the data stored on its platform through information security and single-tenancy architecture in the step [1A] and [2A] of our proposed approach, and this software can be reviewed in the step [3A] and reflected into step [4A] of our proposed approach in Figure 2. Because Xano platform has the ISO 27001:2013 certification, patients' data can be better protected against cyber-attacks and data leaks [62,63], and this software can act as the security architecture standard in alignment with the digital platform strategies.

Whereas, the AppGyver platform-based data privacy protection can be utilized [64] as privacy architecture standard on this digital healthcare platform to comply with the European Union's GDPR policy that met all requirements for data privacy under the Jamaican Data Protection Act, in the step [1A] and [2A] of our proposed approach, and this software can be reviewed in the step [3A] and reflected into step [4A] of our proposed approach in Figure 2, because this software can act as the privacy architecture standard in alignment with the digital platform strategies.

Furthermore, the above design of user interfaces with Design Thinking approach can be used and checked in the step [1A] and [2A] of our proposed approach, and this user interface design can be reviewed in the step [3A] and reflected into step [4A] of our proposed approach in Figure 2 and can make an alignment with cultural aspects of user interface and digital platform strategies suggested by stakeholders in the local government in Jamaica.

As the above ways, RQ1 is verified in terms of cultural perspectives of user interface design and privacy aspects, and RQ2 can be verified from standpoints of architecture conformance for security and privacy architecture standardization as well as cultural aspects of user interface in the alignment with digital platform strategies.

B. Directions of Digital Healthcare Platform by the AIDAF with Design Thinking approach toward Society 5.0

Society 5.0 is proposed as Japan's vision of a human-centered society, one that can deliver comfort and happiness through high degree of cyber-physical systems [37]. The key factor that can differentiate Society 5.0 from other concepts is that in Society 5.0, connectivity can extend to humans as well as things; in other words, Society 5.0 covers an Internet of Humans, not just an Internet of Things [37]. In Society 5.0, the source of economic value will lie in people and data according to the Growth Strategy 2017 [42]. As a result of Hitachi study, the activity patterns of call center employees were measured using wearable sensors, as shown in Fig. 4. The data, that represented a total of over 1 million days, showed that the sensors tended to emit signals suggesting happy atmosphere during times of active behavior patterns [43]. A call center team with levels of high happiness showed 34% more business than a team with lower happiness levels [37].

We have described one aspect of IoH—the use of wearable sensors to monitor human activity. The desirable form of IoH, according to Habitat Innovation, is one where citizens can provide data actively, not passively [37]. For example, a pilot project aligned with this approach to IoH is Kutsuplus, an on-demand minibus service launched by Helsinki City Transport (HSL) [44]. Kutsuplus was a service that matched travelers' needs with a minibus driver. Users can enter their starting point, destination, and desired arrival time into a smartphone application. The application can match the query with suitable points of boarding and getting off, and timetable then. Moreover, minibus drivers can adjust their routes and timetables to reflect the data collected from users. Minibus drivers can deduce the optimum routes to meet user needs, and the result was an economical transport coping with citizens' demand, that can lead to objectives of Society 5.0 vision and make the alignment with digital IT strategies and target architectures in governments in Japan, as visualized in Figure 4. In the above way, we show the "AIDAF proposed model with digital healthcare platforms toward Society 5.o" in Figure 4, while the Society 5.0 vision can cover the IoH and the on-demand minibus service by HSL from standpoints of digital healthcare there.

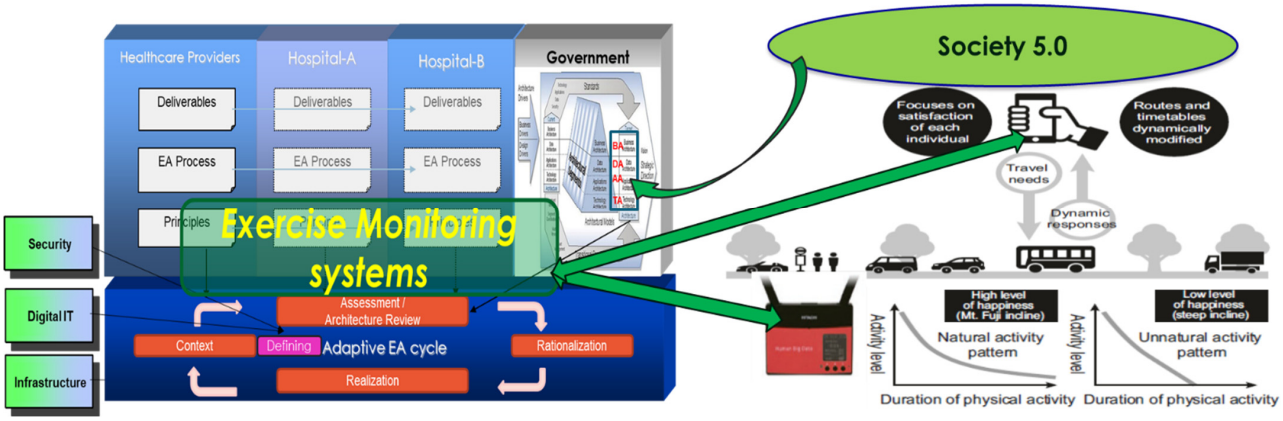

Fig. 4. AIDAF proposed model with digital platforms extended to the IoH associated with happiness and urban traffic services for Society 5.0 [37, 44]

Citizens enable urban service providers to adjust their services dynamically, that can lead to economic potential However, the IoH also shows problems, concerning the reliability of data and the privacy of the data principals, that we must overcome to realize Society 5.0. As for privacy, the importance of this issue has been focused by the GDPR, which came into force in May 2018 and should extend to all multinational companies around the world that process the personal data of EU residents [65].

C. The Consideration of the AIDAF framework with Design Thinking approach for Industry 4.0

The aforementioned physical activity monitoring digital platform provides participants with prepaid telephone credit based on meeting targets for daily physical activity (number of steps), a biometric market (HbA1c), and uploading their daily activity. The architecture structure and components for the above data interfaces can be designed and implemented based on "hierarchical level" of "enterprise, connected world" and "layers" of information and communication defined in RAMI 4.0 in the following Figure 5. In our extended view to RAMI 4.0, successful digital service platforms can support a network of actors and host a set of loosely coupled open services and software products as part of a rapidly growing digital ecosystem. The DEA cube supports digital platforms [66].

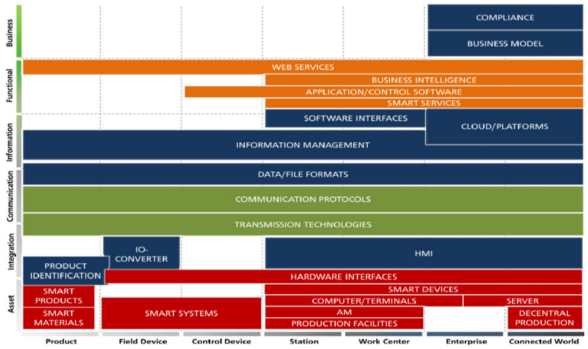

Fig. 5. Instance, Production of the application-oriented RAMI 4.0 [1]

D. Challenges, Future Issues

When designing and implementing digital healthcare platforms with "AIDAF framework for Design Thinking approach" for Society 5.0, practical architecture deliverables for the aforementioned IoH should be necessary. However, the architecture deliverables exist scarcely. Additionally, in Jamaica and other middle-income countries, resources are limited, so financial incentives must be set at sustainable levels based on anticipated savings in healthcare costs. To reduce costs, existing platforms, such as AppGyver and Xano, can be used where possible.

In designing digital platforms with "AIDAF framework for Design Thinking approach" for Industry 4.0, few practical architecture deliverables for data interfaces on "hierarchical level" of "enterprise, connected world" and "layers" of information and communication in RAMI 4.0 exist currently. Furthermore, the reviews from standpoints of "regulatory requirements such as validation of systems" need to be considered and added in this approach of the AIDAF framework.

E. Limitations

The main limitation of this study is related to the scope of the pilot program underway at one university hospital. The number of actual architectural deliverables of the IoH for Society 5.0 and aforementioned data interfaces in Industry 4.0 are limited in the societies.

VI. Conclusion

In this paper, we proposed the "AIDAF Framework for Design Thinking Approach with STRMM model" based on the investigation of tasks and steps of Design Thinking approach and agile software development methodologies that could define the efficient process with Design Thinking approach into the AIDAF Framework properly. Based on the results and progress of the pilot project for physical activity monitoring digital platform in a university hospital and healthcare community in Americas, this research is showing that the physical activity monitoring digital platform can be built with Design Thinking methodology supported by the AIDAF in a healthcare community, especially in terms of cultural perspectives and privacy aspects, to cope with RQ1. Furthermore, we demonstrated by this research that the physical activity monitoring digital platform can be managed and improved in the alignment with digital platform strategy using the AIDAF in a healthcare community, that can lead to the answer for RQ2.

In future research, we hope to test that the approach generates the anticipated economic and health impacts and then scale the pilot into a production environment with managing risks.

Acknowledgments

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References

[1] Y Wang, T Towara, R Anderl, : Topological Approach for mapping technologies in reference architectural model Industrie 4.0 (RAMI 4.0) - Proceedings of the World Congress on Engineering and Computer Science (2017).

[2] H. Kagermann, W. Wahlster, and J. Helbig (2013, April). Recommendations for implementing the strategic initiative Industrie 4.0. Securing the future of German manufacturing industry [Online].

[3] P. Adolphs, H. Bedenbender, D. Dirzus, M. Ehlich, U. Epple, et al. (2015). Referenzarchitekturmodell Industrie 4.0 (RAMI 4.0).

[4] VDI. (2016, November). Industrie 4.0 Service Architecture – Basic Concepts for Interoperability [Online].

[5] Boardman S,Harrington E.: Snapshot-Open Platform 3.0™. The Open Group, 2015.

[6] Alwadain, A., Fielt, E., Korthaus, A., Rosemann, M.: A comparative analysis of the integration of SOA elements in widely-used enterprise architecture frameworks. Int. J. Intell. Inf. Technol., 54–70 (2014)

[7] Buckl, S., Matthes, F., Schulz, C., Schweda, C.M.: Exemplifying a framework for interrelating EA concerns. In Ontology, Conceptualization and Epistemology for Information Systems, Software Engineering and Service Science, M. A. Sicilia, C. Kop, F. Sartori, eds. (Berlin, Heidelberg, New York: Springer), pp. 33–46 (2010)

[8] Masuda, Y., Shirasaka, S., Yamamoto, S., Hardjono, T.: International Journal of Enterprise Information Systems. IGI Global ***13***, 1-22 (2017)

[9] Masuda, Y., Shirasaka, S., Yamamoto, S., Hardjono, T.: Architecture Board Practices in Adaptive Enterprise Architecture with Digital Platform:A Case of Global Healthcare Enterprise International Journal of Enterprise Information Systems. IGI Global 14, 1 (2018)

[10] Giuseppe Aceto, Valerio Persico, Antonio Pescapéa. The role of Information and Communication Technologies in healthcare: taxonomies, perspectives, and challenges. Journal of Network and Computer Applications 107, 125-154 (22018)

[11] Archenaa, J., Anita, E.M.: A survey of big data analytics in healthcare and government. Procedia Comput Sci 50, 408–413 (2015)

[12] Chawla, N.V., Davis, D.A.: Bringing big data to personalized healthcare: a patient-centered framework. J. Gen. Intern. Med 28, 660–665 (2013)A. Cruz and A. Vasconcelos, "Architecture for the CRM domain: the Portuguese citizen space case study," Int. J. Enterp. Inf. Syst., vol. 11, no. 2, pp. 24–49, 2015.

[13] Osmani,V,Balasubramaniam,S, Botvich,D.: Human activity recognition in pervasive health-care: supporting efficient remote collaboration. J Netw Comput Appl ***31***, 628–655 (2008)

[14] Jee, K., Kim, G.-H.: Potentiality of big data in the medical sector: focus on how to reshape the healthcare system. Healthcare Inf Res ***19***, 79–85 (2013)

[15] Patel, P., Cassou, D.: Enabling High-level Application Development for IoT. Journal of Systems and Software, Elsevier, 1-26 (2015)

[16] Iacob, M.E., et al.: Delivering Business Outcome with TOGAF® and ArchiMate®: BiZZde-sign (2015)

[17] Johnson, P., et al.: IT Management with Enterprise Architecture Stockholm: KTH (2014)

[18] The Open Group. TOGAF Version 9.1: Van Haren Publishing (2011)

[19] Zimmermann, A., Schmidt, R., Sandkuhl, K., Jugel, D.: Digital Enterprise Architecture – Transformation for the Internet of Things. In Enterprise Distributed Object Computing Workshop (EDOCW), IEEE 19th International (2015)

[20] Couturier, J., Sola, D., Borioli, G.S., Raiciu, C.: How can the internet of things help to overcome current healthcare challenges. Commun. Strat ***87***, 67–81 (2012)

[21] Islam, S.M.R., Kwak, D., Kabir, M.H., Hossain, M., Kwak, K.S.: The internet of things for health care: a comprehensive survey. IEEE Access ***3***, 678–708 (2015)

[22] Yeole, A.S., Kalbande, D.: Use of internet of things (iot) in healthcare: a survey. In Proceedings of the ACM Symposium on Women in Research, pp. 71-76 (2016)

[23] Masuda, Y.; Zimmermann, A.; Viswanathan, M.; Bass, M.; Nakamura, O.; Yamamoto, S. Adaptive Enterprise Architecture for the Digital Healthcare Industry: A Digital Platform for Drug Development. Journal Information 2021, 12, 67. https://doi.org/10.3390/info12020067

[24] BITKOM, VDMA, and ZVEI (2015, April). Umsetzungsstrategie Industrie 4.0 – Ergebnisbericht der Plattform Industrie 4.0 [Online]: https://www.bitkom.org/Publikationen/2015/Leitfaden/Umsetzungsstrategie-Industrie-40/150410-Umsetzungsstrategie-0.pdf

[25] Masuda, Y.; Shepard, D.S.; Yamamoto, S.; Toma, T. Clinical Decision-Support System with Electronic Health Record: Digitization of Research in Pharma. In Proceedings of the 7th International KES Conference on Innovation in Medicine & Healthcare, St. Julians, Malta, 17–19 June 2019; Springer: Singapore; Volume 145, pp. 47–57.

[26] Masuda, Y., Zimmermann, A., Shirasaka, S., Nakamura, O., (2020): Internet of Robotic Things with Digital Platforms: Digitization of Robotics Enterprise, Human Centred Intelligent Systems. pp.381-391. Smart Innovation, Systems and Technologies, vol 189. Springer, Singapore. https://doi.org/10.1007/978-981-15-5784-2_31

[27] Masuda, Y.; Shepard, D.S.; Nakamura, O.; Toma, T. Vision paper for enabling internet of medical robotics things in open healthcare platform 2030. In Proceedings of the 8th International KES Conference on Innovation in Medicine & Healthcare, 2020; Springer.

[28] Garnier, J.-L., Bérubé, J., Hilliard, R.: Architecture Guidance Study Report 140430, ISO/IEC JTC 1/SC 7 Software and systems engineering. (2014)

[29] Tamm,T,Seddon,P.B,Shanks,G,Reynolds,P:How Does Enterprise Architecture Add Value to Organizations? Communications of Association for Information Systems ***28***,10 (2011)

[30] Chen H-M, Kazman R, Perry O. From software architecture analysis to service engineering: an empirical study of methodology development for enterprise SOA implementation, IEEE Trans Serv Comput 3, 145–160 (2014)

[31] MacKenzie,C.M, Laskey,K, McCabe, F., Brown, P.F., Metz, R.: Reference Model for SOA 1.0. (Technical Report), Advancing Open Standards for the Information Society. (2006)

[32] Newman, S.: Building Microservices: O'Reilly Media (2015)

[33] Richards,M:Microservices vs. Service-Oriented Architecture,1st Ed:O'Reilly Media (2015)

[34] Muhammad, K., Khan, M.N.A.: Augmenting Mobile Cloud Computing through Enterprise Architecture: Survey Paper. International Journal of Grid Distribution Computing 8, 323-336 (2015)

[35] Gill, A.Q., Smith, S., Beydoun, G., Sugumaran, V.: Agile Enterprise Architecture: A Case of a Cloud Technology-enabled Government Enterprise Transformation. In Proceedings of the 19th Pacific Asia Conference on Information Systems (PACIS), pp. 1-11 (2014)

[36] Masuda, Y., Shirasaka, S., Yamamoto, S.: Integrating Mobile IT/Cloud into Enterprise Architecture: A Comparative Analysis. In Proceedings of the 21th Pacific Asia Conference on Information Systems (PACIS), Paper 4 (2016)

[37] Deguchi, A., Hirai, C., Matsuoka, H., Nakano, T.: Society 5.0, Springer: Singapore, (2020)

[38] Masuda,Y, Toma, T:A Vision Paper for Enabling Digital Healthcare Applications in OHP2030: KES2018, In 6th International KES Conference on Innovation in Medicine & Healthcare (2018)

[39] Shepard DS, Masuda, Y: Digital Financial Incentives for Improved Population Health in the Americas: In Proceedings of the 8th International KES Conference on Innovation in Medicine & Healthcare, 2020; Springer.

[40] Nedungadi P., Jayakumar A., and Raman R., Personalized Health Monitoring System for Managing Well-Being in Rural Areas. J Netw Comput Appl. 42: p. 22.

[41] Ministry of Health and Wellness: Interim Guidelines for the Clinical Management of Diabetes in Jamaica. August 2020. [Online]: https://www.moh.gov.jm/wp-content/uploads/2020/10/DIABETESGUIDELINES_Interim_final.pdf

[42] Growth Strategy Council (Headquarters for Japan's Economic Revitalization) (2017) Growth strategy 2017: reforms aimed at achieving society 5.0, June 2017.

[43] Yano K, Lyubomirsky S, Chancellor J (2012) Sensing happiness: can technology make you happy? IEEE Spectr 49(12):32–37

[44] Toyota (2015) On-demand public transportation changing human mobility in cities.

[45] A. Alshamrani und A. Bahattab, „A comparison between three SDLC models waterfall model, spiral model, and Incremental/Iterative model", *International Journal of Computer Science Issues (IJCSI)*, Bd. 12, Nr. 1, S. 106, 2015.

[46] K. Petersen, C. Wohlin, und D. Baca, „The waterfall model in large-scale development", in *International Conference on Product-Focused Software Process Improvement*, 2009, S. 386–400.

[47] M. Fowler und J. Highsmith, „The agile manifesto", *Software development*, Bd. 9, Nr. 8, S. 28–35, 2001.

[48] K. Beck *u. a.*, „Agile Manifesto". 2001. [Online]. Verfügbar unter: https://www.agilealliance.org/wp-content/uploads/2019/09/agile-manifesto-download-2019.pdf

[49] S. A. Qurashi und M. Qureshi, „Scrum of scrums solution for large size teams using scrum methodology" *arXiv preprint arXiv:1408.6142*, 2014.

[50] C. Larman und B. Vodde, *Large-scale scrum: More with LeSS*. Addison-Wesley Professional, 2016.

[51] D. Leffingwell, *SAFe 4.5 reference guide: scaled agile framework for lean enterprises*. Addison-Wesley Professional, 2018.

[52] S. W. Ambler und M. Lines, *Disciplined agile delivery: A practitioner's guide to agile software delivery in the enterprise*. IBM press, 2012.

[53] Y. Masuda und M. Viswanathan, „Direction of Digital IT and Enterprise Architecture“, in *Enterprise Architecture for Global Companies in a Digital IT Era*, Singapore: Springer Singapore, 2019, S. 17–59. doi: 10.1007/978-981-13-1083-6_2.

[54] C. Ebert und M. Paasivaara, „Scaling agile“, *Ieee Software*, Bd. 34, Nr. 6, S. 98–103, 2017.

[55] Stanford d.school bootcamp bootleg https://dschool.stanford.edu/resources/the-bootcamp-bootleg

[56] Curedale, R.: Design Thinking Processes & Methods. Design Community College, Los Angeles, 2018

[57] Ling, D.: Complete Design Thinking Guide for Successful Professionals. Emerge Creative Group LLP, 2015

[58] Mueller-Roterberg, C.: Handbook of Design Thinking. Tips and Tools for How to Design Thinking. 2018

[59] Hofstede, G.: “Country Comparison.” Hofstede Insights. Accessed July 28, 2021. [Online].

[60] Mathew, B.: “ Beginning SAP Fiori.” Apress, Inc. 2015. https://experience.sap.com/fiori-design-web/ [Online]

[61] “General Data Protection Regulation.” Intersoft Consulting. Accessed August 9, 2021. [Online]

[62] “ISO 27001:2013.” Xano Documentation. Accessed July 28, 2021. [Online].

[63] “ISO 9001:2015.” Xano Documentation. Accessed July 28, 2021. [Online].

[64] “Terms of Service.” Appgyver.com. Accessed July 28, 2021. [Online].

[65] EU GDPR.ORG (2019) GDPR key changes. https://eugdpr.org/the-regulation/. Accessed 4 June 2019

[66] Zimmermann, A., Schmidt, R., Sandkuhl, K., Masuda, Y., Chehri, A.: Architecting Intelligent Service Ecosystems: Perspectives, Frameworks and Practices. In Buchmann, A. et al.: Proceedings of BIR 2021, Springer 2021