Healthcare Transformation Impacts Design and Management of Health and Social Care Ecosystems

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The ongoing health systems transformation aims at personalized, preventive, predictive, participative precision medicine (P5M). Contrary to the former care paradigms empiric or phenomenological medicine, evidence-based medicine, person-centered (managed care) medicine and the personalized medicine, it considers individual health status, conditions, genetic and genomic dispositions in personal social, occupational, environmental and behavioral context. That way, the health and social care business evolves to a highly complex interdisciplinary and highly dynamic ecosystem in variable context with increasing impact of new technologies, resulting in dHealth and eHealth. This transformation requires the advancement communication and cooperation among the involved actors from different domains (disciplines) with different education, skills and experiences. The challenge of P5M is the understanding and proper management of the ecosystem with its related components, their functions and relations in the use-case-specific context for meeting the business objectives.

Integration and interoperability in such ecosystems requires the formal representation of the different knowledge spaces involved in the business system use-case to allow their correct mapping. There are different levels of knowledge representation (KR): symbol, transformed through syntax into data, interpreted by semantics as information, combined with pragmatics as knowledge, and enabling strategic and operational decisions as action. A key parameter of KR is the KR language expressivity. A highly expressive KR language can express easily and compactly knowledge elements within the semantics and grammar of that KR for processing. For representing the aforementioned ecosystem, they require quite complex logic and algorithms to construct equivalent inferences. Therefore, a highly expressive KR is less likely to be complete and decidable. Thereby, it is possible to agree broadly and even internationally on information and data models to represent small and rather static domains such as mechanical construction elements. In highly complex, highly dynamic, context-sensitive, multi-disciplinary domains such as health an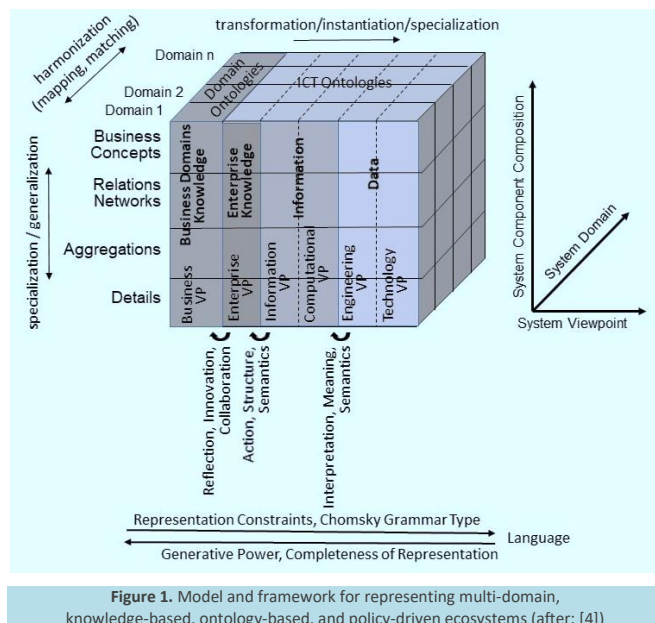d social care however, many experts from different sub- domains come into play, using their domain-specific perspectives, objectives, methodologies, languages, terminologies/ontologies, etc. Thereby, they could represent different concepts by the same information/data model or the same concept using different informational or data representations. The solution for solving the aforementioned problems is a system-oriented, architecture-centric, onto-logy-based, policy-driven approach for modelling and managing transformed health ecosystems, standardized in ISO 23903 Interoperability and Integration Reference Architecture, I have authored. The deployment of this standard is meanwhile mandatory for all projects at ISO/TC215 and CEN/TC251 dealing with more than just one domain, but also used in projects of other SDOs such as IEEE, OMG, etc. For more details about the discussed challenges and solutions look at [1, 2, 3].

We have to start with the real-world business system representation using natural languages and domain onto-logies. This can then be transformed into an ICT system solution using business process modeling language (BPML). Thereafter, we have to transform the business system use-case-specific concepts into an informational representation, using information models, terminologies, glossaries, thesauri and taxonomies, etc. Finally, we conclude the process by the related data

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representation using data models, data base schemas, etc. The model and framework of the described approach is shown in Figure 1.

One important domain is the policy domain defining structure and function of the subsystem controlling the behavior of the ecosystem. Thereby, policy sub-domains such as

the International Scientific Committee and responsible Editor from 2012 until 2022, followed in 2024 by Mauro Giacomini, University of Genoa, Italy. My co-worker, our unforgettable friend Peter Pharow, who became later Chair/Co-Chair of the EFMI WG Personal Portable Devices, supported my engagement. [6-12]

Figure 1. Model and framework for representing multi-domain, knowledge-based, ontology-based, and policy-driven ecosystems (after: [4])

legal regulations, ethics incl. security and privacy, but also the inevitable process policy as well as the user policy must be considered [2].

The basics of the approach have been developed in the late nineties and summarized, e.g., in [5]. The further work was mainly performed and published in the context of my engagement as Chair/Co-Chair of the EFMI WGs "Security, Safety and Ethics" and "EHR" as well as of the IMIA WG "Security in Health Information Systems", later advanced to "Ethics, Privacy and Security in Health Informatics". An important driver was the EFMI-supported conference series pHealth – Wearable micro- and nano-technologies for personalized medicine and perso-nalized health service provision, starting in 2004. I have been Chair of

If we do not understand the 5P medicine ecosystem in its components, functions and relations, we cannot properly formulize and model it, and therefore we cannot formulate the requirements for correct solutions. We cannot decide on correct integration and interope-rability at data level, but shall do this at real-world business system level. This challenge is first an educational one and shall become a focus of EFMI.

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