Towards a Reference Model for Configuring Services Portfolio of Digital Innovation Hubs: The ETBSD Model

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Abstract. In today's manufacturing domain, companies need to be able to join the Industry 4.0 paradigm and, more in particular, the Cyber-Physical Systems (CPS) revolution. However, along this transition, often for companies it could be not enough to deploy new digital technologies in their plant, demonstrating a digital technology readiness. They need to be able to adequately employ this kind of technologies and exploit their potentialities for reaching a suitable digital maturity. In this context, technical expertise, experimental capabilities, and specialist knowledge often represent for companies, and more particularly for SMEs, relevant gaps in the CPS application domains. To lower barriers, especially for SMEs, and to realise the potential of growing autonomy in CPSs, competence centres and, with a broader perspective, (regional/pan-EU) Digital Innovation Hubs (DIH) are arising. This paper introduces the conceptual Ecosystem-Technology-Business-Skills-Data (ETBSD) reference model that DIHs can use to configure their services portfolios unveiling new technological and business opportunities.

Keywords: Digital Innovation Hub (DIH) · Service portfolio configuration · Reference model

1 Introduction

Digital technology's role is rapidly moving from being a driver for marginally enhancing efficiency to becoming an enabler of fundamental innovation and disruption [1]. However, along this transition, often for companies, it could be not enough to deploy new digital technologies in their manufacturing plant, to demonstrate a suitable digital technology readiness. They need to be able to adequately employ these kind of

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technologies in value-added processes for exploiting their full potentialities, and thus reaching a suitable digital maturity [2]. Rüßmann et al. [3] grounded the Industry 4.0 (I4.0) paradigm on nine building blocks: big data and analytics, autonomous robots and vehicles, additive manufacturing, simulation, augmented and virtual reality, horizontal/ vertical system integration, Internet of Things (IoT), cloud fog and edge technologies, and blockchain and cyber-security [3]. In this context, connected systems can interact between each other using standard Internet-based protocols and can analyse data to predict failure, configure themselves, and self-adapt to changes [3], in other words, being sustainable and resilient.

However, mostly focusing on the CPS application domains, technical expertise, experimental capabilities, and specialist knowledge often represent, for companies, and more particularly for SMEs, relevant gaps. Moreover, several boundary challenges and hurdles (e.g. always changing customer expectations, cultural transformation, updated regulations and skills, etc.) contribute to hamper the digital transition. In this context, industry and government leaders need to manage these challenges to reveal and make exploitable the set of benefits digital technologies offer to both society and industry [1]. Indeed, to properly support the products upgrade, processes improvement and business models adaptation to the digital age, several initiatives have been launched both at European and international level [1, 4, 5] leading to the creation of Digital Innovation Hubs (DIHs). They are defined as support facilities that assist companies (in particular SMEs, start-ups and mid-caps) to improve their competitiveness, through innovations, fostering the implementation of up-to-date digital technologies [4, 6]. These organisations, involve different stakeholders belonging to a heterogeneous ecosystem in a people-public-private partnership (PPPP). They provide a set of supportive services that helps companies to become more competitive by improving their business/ production processes by means of digital technology. This paper aims at introducing the conceptual Ecosystem-Technology-Business-Skills-Data (ETBSD) reference model, a tool designed to configure the services portfolio of DIHs and unveiling new business and technological opportunities. The paper is structured as follows. Section 2 provides a brief overview about DIHs. Section 3 presents the proposed conceptual ETBSD reference model. Finally, Sect. 4 discusses the role of the model in the extant DIHs networks and concludes the paper, also providing limitations of the study and proposing further researches.

2 Research Context: Digital Innovation Hubs

Digital Innovation Hubs (DIHs) are, together with Partnerships & Platforms, Skills & Jobs and Regulatory Framework, one of the four key elements of the Digitizing European Industry (DEI) strategy, launched by the European Platform of national initiatives on digitizing industry [5]. Its paramount scope is to enable European industries (of whatever type, sector, and dimension) to fully take advantage from digital innovations for empowering their solutions portfolios, also enhancing their processes and fitting their business models to the new digital era. In this context, the DIHs act as a one-stop-shop, providing their stakeholders with several assets, i.e. test before invest, support to find investments, innovation ecosystem and networking skills and training [4].

In the EU roadmap, the plan is to have in each region of the European territory, a DIH that could support companies at a working distance. Several investments (i.e. regional, national and European) have been done both locally and globally in Europe to establish the DIHs infrastructure. Moreover, the European Commission (EC) is also fostering the collaboration and networking among the network of DIHs, financing the foundation of extended pan-European DIHs. These directives started in 2013 with the ICT Innovation for Manufacturing SMEs (I4MS) and continued in 2015 with the Smart Anything Everywhere initiative (SAE). Their common paramount goal is to allow SMEs, start-ups, and mid-caps to empower their products and services through the adoption of innovative digital technologies.

In particular, the I4MS is a European program thanks to which SMEs can participate to open calls asking for technological and financial support to carry out small experiments and test digital innovations in their business. The I4MS initiative is now in its third phase. Each phase has complementary objectives and mutually focuses on four technology areas (additive manufacturing, CPS and IoT, robotics, HPC), all strategic for the manufacturing companies' digital shift [7].

The SAE program [4] belongs to the EC Digitising European Industry (DEI) Strategy [5]. DIHs have the role of supporting the connection of technology providers and suppliers not only among them but also with the other users dealing with non-core activities (business support services, collaborators, capital providers, academics, HR). The SAE initiative is divided in two phases, both aimed at the creation of consolidated ecosystems around regional DIHs in four technology areas: (i) Cyber-Physical and Embedded Systems; (ii) Customized low energy computing powering CPS and the IoT; (iii) Advanced micro-electronics components and Smart System Integration; (iv) Organic and large area electronics.

In particular, this research is aimed at supporting the first technology area whose goal is to aid companies from any sector in raising the quality and performance of their solutions (products, services and system of them) with advanced embedded ICT components and systems and to sustain eco-system building for promising platforms.

3 The Proposed Conceptual Reference Model

With the main scope of configuring DIHs services portfolios in a systematic way, the Ecosystem-Technology-Business-Skill-Data (ETBSD) reference model (Fig. 1) is proposed. It is grounded on the threefold Ecosystem-Technology-Business (ETB) I4MS [4] service model, the only existing reference model for DIHs. In particular, it has been developed in the context of the Access to I4MS (XS2I4MS) proposal (a support action to advance the I4MS ecosystem) and it is actually used in all the DIHNET.eu [8] projects. The three categories composing the ETB model have been elaborated based on the experience of DIHs stakeholders and also from the experimented researches in the frame of several projects from the EC I4MS calls. The ETBSD model extends it to the particular domain of Embedded and Cyber-Physical Systems (ECPS) [7]. The ETBSD reference model is grounded on five main macro-classes (Fig. 1), representing the main context in which the DIH can operate, delivering services to its stakeholders. Data and Skills *macro-classes* of services have been introduced since the ETB classes belonging to the previous configuration were not able to cover them fully and exhaustively. Indeed, these two new classes represent core components of the new digitized domain where can intervene paradigms such as the I4.0, comprising up-to-date technologies such as CPS and Artificial Intelligence (AI). Indeed, a major role DIHs must play is to raise the awareness of European manufacturing companies' decision makers (especially of SMEs, start-ups and mid-caps) about the opportunities that the digitization can bring to their company. DIHs should not only transfer and drive technology in their ecosystems in an accessible way but also provide to their stakeholders the consistent staff with adequate skills to utilise and exploit digital technologies. This follows the objective of dedicating at least 10–20% of the efforts employed in application experiments devoted to skills development [4]: these services would not only empower people working in European companies but also enhance the daily working processes and contribute to the digitization of portfolios and business models. For this reason, a special heed has been dedicated in the ETBSD reference model to the Skills and Data *macro-classes*, introducing services able to provide companies with new skills to manage new technologies and to exploit the data connected to them.

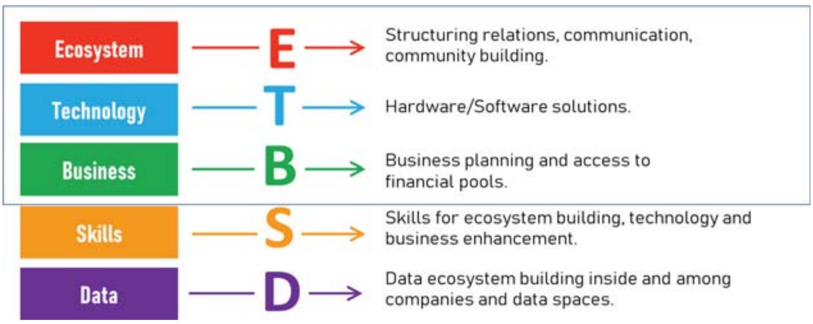

Fig. 1. Extension of the ETB model to the ETBSD reference model

Each one of the five *classes* considered in the proposed ETBSD reference model can be declined in several *types* of services, as shown in the Fig. 2 below. The *types* of services represent the main categories of services provided by the DIH to its stakeholders in each of the five specific macro-*classes*.

Furthermore, each *type* of service can be further detailed in different *classes* of services to be provided by the DIH.

The first *macro-class*, Ecosystem, is aimed at creating, nurturing, expanding and connecting the local SME constituency, involving in the SME digital transformation process different stakeholders as technology providers, technology users, competence centers, education and training hubs, market development experts, regional development associations. Its three main *types* of services are declined in several *classes* of services:

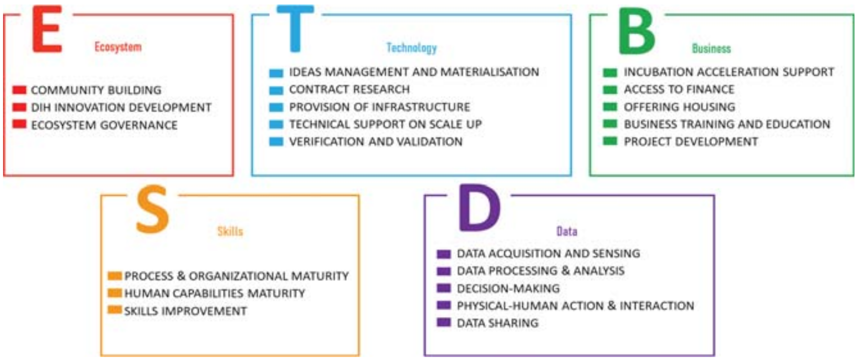

Fig. 2. Types of services in the ETBSD reference model

1. Community building:

   - SME and people engagement & brokerage: creating a community around the DIH that connects the members of the innovation ecosystem;
   - Innovation incitation, awards, challenges:
     a. Stimulating/rewarding collaborative innovation & problem solving;
     b. Offering innovation spaces to encourage ecosystem members to interact and share ideas as well as spaces for experimentation and pilot manufacturing (including data ecosystem and spaces);
        - Technology scouting: for companies seeking innovative technologies to incorporate into their portfolio (define customer + needs + ecosystem);
        - Communication:
     a. Sharing best practices experiences,
     b. Inviting business/experts to give talks and interact with (potential) customers and partners (study visits and roadshows);

2. DIH Innovation Development:

   - Communication and trend watching: providing information on the trends in the market, assessment of market potential (business model), use of trend intelligence platforms and development of trend reports;
   - Visioning and strategy development: supporting start-ups and SMEs in shaping their vision and strategies as well as large corporates requiring fresh thinking to remain relevant and competitive in the marketplace;

3. Ecosystem Governance:

   - Services impact assessment: assessment of performed services (KPIs);
   - Ecosystem management: engagement rules, statute, governance structure. Facilitation of relationships both within the DIHs ecosystems and between DIHs of the network.

As well, the Technology macro-*class* is aimed at following the whole lifecycle of digital technologies from conception and idea generation, through design and proof of concept, up to minimum viable product prototyping and commercialisation. They can be interpreted from the technology providers viewpoint and from the technology users viewpoint, through the steps of access-experiment-experience spiral model. Five main *types* of services have been detected and declined in more detailed *classes* of services:

1. Ideas management and materialization:
   - Ideas generation, assessment. feasibility study: collecting innovation ideas, refining and targeting them in a collaboration environment; preliminary feasibility analysis;
   - Technology readiness assessment: DIHs conduct technology readiness assessments on products/solutions developed by start-ups and SMEs
2. Contract research:
   - Strategic and Specific R&D: strategic perspective: collaborative R&D projects to support the translation of innovative ideas into demonstrable concepts. Applying technological innovation to develop new products/services or improving existing ones;
   - Technology concept development/Proof of Concept (PoC): planning and defining new business services solutions and demonstrating the feasibility of an idea or project through its temporary realisation;
3. Provision of infrastructure:
   - Access to infrastructure and technological platforms: provision of a large range of services (e.g. renting equipment, providing platform technology infrastructure, lab facilities, support to low rate production);
4. Technical support on scale up:
   - Concept validation: developing minimum viable products that can be validated with real customers and/or in an industrially relevant setting;
   - Prototyping: designing prototypes to explore ideas and emerging technologies before going into production by also considering potential opportunities offered by small series production;
5. Verification and validation:
   - Product qualification and certification: support in certifying that the product has passed functional, performance and quality assurance tests;
   - Product demonstration: promotion showrooms and demo-cases in which a product is demonstrated in front of clients.

The third *macro-class*, Business, intervenes in more advanced scenarios (with higher TRL solutions), identifying, modelling and sustaining viable business models, including also fund raising services (e.g. private matchmaking or access to public funding opportunities). It can be declined in five *types* of services detailed in several *classes* of services:

1. Incubation acceleration support:
   - Basic facilities: providing access to physical infrastructure (offices, café, meeting rooms, laboratories, co-working areas, libraries, etc.);
   - Specialized facilities: providing access to telecommunication infrastructure, HPCs, video conferencing, labs and data ecosystem;
   - Business development: coaches and mentors, entrepreneurs in residence, dedicated programs to assist entrepreneurs in the process of business development (funnel, SMEs use case communication and assessment);
   - Guidance: offering technical/fiscal/legal advice, regulatory assistance.
2. Access to finance:
   - Financial engineering: providing support in addressing financial issues and/or advise on innovative financial products;
   - Connection to funding sources: facilitating access to different funding sources (EU, national, regional, and private) aiming at achieving an effective mix of funds (conversation, lobbying, projects);
3. Business training and education:
   - Methods and tools, business operations modelling: providing training and development in business skills and entrepreneurship (e.g. formal courses, workshops, seminars) and influence academia;
   - Secondment: facilitating the exchange of personnel (e.g. researchers) and core competences among organizations, including IPR;
4. Project development:
   - Identification of opportunities: support in the identification of new business opportunities through strategic analysis and trend watching;
   - Creating consortia: encouraging cooperation and collaboration among organizations for exploiting common opportunities (e.g. business, research, funding, match-making, open innovation);
   - Development of proposals: providing technical assistance in the proposal development process to comply with specific proposal requirements (e.g. for project funding).

In the following, the two additional *macro-classes*, Skills and Data, are fully detailed. Concerning the Skill *macro-class*, it has a twofold aim. The first is to assess the status quo of the companies that want to approach digitization, in terms of both process/organization and skills maturity, and to set an adequate roadmap to empower it. The second is to support the skill empowerment through not only educational programs, up-skilling and re-skilling training but also sharing channels, structure contacts and collaborations for scouting and brokerage aimed at knowledge-transfer. Three main *types* have been declined in the following *classes* of services:

1. Process & organizational maturity:
    - Maturity assessment: assessment of company readiness for I4.0 (tech, organizational, and ecosystem readiness);
    - Maturity strategy development: definition of a roadmap starting from the characteristics of the single enterprise or part of it;
2. Human capabilities maturity:
    - Human skills maturity: support in capabilities screening through on-site visits, interviews, etc. Definition of actual level of I4.0 skills maturity;
    - Skills strategy development: gap analysis between the AS-IS and the desired level of skills, action plan definition/support to implementation;
3. Skills improvement:
    - Human up-skilling, re-skilling training: life-long training on technical and soft skills at corporate, operational and technology specific level;
    - Educational programs: attracting and skilling next generation talents, forming I4.0 employees and workers;
    - Scouting and brokerage: support in identifying channels, structure contacts and collaborations intended to knowledge-transfer, etc.

The last *macro-class*, Data, is pivotal for adequately exploiting digital technologies potentialities through services dealing with different phases of the data lifecycle: from data acquisition and sensing, through data processing & analysis, up to decision-making and data sharing, not neglecting aspects as physical-human action & interaction. It includes five *types* of services, detailed in the following service *classes*:

1. Data acquisition and sensing:
    - Data acquisition: data in motion models and services for Industrial IoT;
    - Data protection: data anonymization, confidentiality, encryption and privacy preservation services;
2. Data processing & analysis:
    - Data storage: data spaces, data lake, linked data, distributed storage, knowledge representation services;
    - Data analytics: semantic analysis, data discovery, advanced data analytics (edge analytics, cloud analytics) services;
3. Decision-making:
    - Cognitive big data architectures: configuration and deployment architectures for big data;
    - Decision support and development: cognition, prediction, prescription, simulation, machine learning, reinforcement, DNNs, formal logics;

4. Physical-human action & interaction:
   - Collaborative intelligence: human-machine interface, human-robot interaction, human-data interaction, multi-lingual AI;
   - User experience: navigation, user experience, exploration;
   - Feedbacks loop: control/actuation, cognitive mechatronics;
5. Data sharing:
   - GDPR and data sovereignty compliance: consultancy services for personal and non-personal data sharing and exchange business processes modelling, rules of governance and contracts;
   - Data spaces: data models/ontologies for trusted secure data exchange;
   - Data platform: HW/SW architectures/components, connectors services.

4 Discussions, Conclusions, and Future Work

This paper has the aim of introducing the conceptual ETBSD reference model. It has the paramount aim of supporting the configuration of the services portfolio that a DIH should provide to support companies in adopting digital technologies, grouped under the umbrella of I4.0, with a special focus on CPSs. The ETBSD reference model could be a good reference model for modelling collaborative networks 4.0 in which DIHs will be one of the pillars because of their "by-design" innovation skills. It could also be considered a strategic tool designed for several scopes:

- to classify their extant services (as-is), identifying overlaps and gaps;
- to identify new services (to-be) to be provided in the future (maybe imitating and replicating initiatives of other DIHs in a pan-European ecosystem);
- to identify opportunities for collaboration among DIHs and their stakeholders to-be-joint in a pan-European DIH of three types:
  - Joint provision (more stakeholders put together existing services);
  - Joint development (new services jointly created, putting together skills);
  - Joint matchmaking (for stakeholders looking for partnerships and specific assets in the DIH network).

In particular, the ETBSD reference model will be tested in the DIH4CPS project [9]. DIH4CPS is a EU project aiming at consolidating a pan-European DIH, coordinating the different smart specializations of its poles. DIH4CPS poles are regional/national DIHs with their members (competence centres, technology providers, technology users). Specific services of each pole can be concretely provided by one of its users. However, it is the pole itself that disseminates and communicates the event and creates the audience, trying to sell it wherever, or to create a new service together with the user (based on a cross-fertilization process). This is done under the DIH4CPS network's supervision, which discovers overlaps, competitions and gaps to be filled thanks to the use of ETBSD reference model.

Among the potentialities of this reference model, it has to be highlighted the opportunity of generalization provided by it. Indeed, the reference model is made of classes while an instance of the reference model is "the model" of a specific DIH providing specific services belonging to the reference classes. While the ETBSD reference model has been presented at "class" level, the expected actual services to be provided by DIHs should be declined at the "instance" level (e.g. for Ecosystem macro-class – Community building type - SME and People Engagement Service Class, the Service instances could be DIH Annual Community Event, Industrial events, Academic conferences and workshop). Indeed, a further declination of the service classes is needed. Each service class should need to be characterized with:

- specific service instances,
- the service provider (pan-European DIH, DIH pole, technology provider, academic partner),
- the service customers (technology user, DIH pole, technology/solution provider, academic partner),
- the service output (e.g. events, scouting, funding, training, assessment, consultancy, sharing of assets and ideas, etc.),
- classification of service (networking, skills and training, test before investing, access to funding).

Concerning the service provider, the ETBSD reference model deals with services offered by DIHs to its local/regional ecosystem (perhaps actually provided by some members). Often, the DIH services are sold by them but provided by other users. In this sense, the business model inside the DIH is very important.

Among the limitations, we would underline that the ETBSD reference model could lack of a mechanism to allow its evolution in a sustainable way. Regarding this, it has been planned to validate the presented conceptual version of the reference model and to further improve it through a survey to be run with a twofold approach. The first, top-down, will be submitted to the regional DIHs belonging to the DIH4CPS pan-European network for defining the related as-is services portfolios. The second, bottom-up, will be submitted to the SMEs belonging to the same network for grasping and realising which are the services needing more heed in the ECPS domain.

A limitation of this paper is the application of the reference model to only one of the areas of SAE, Embedded and Cyber-Physical Systems: this concurrently gives evidence to the possibility to extend the adoption of the reference model to all the four areas. Concerning this point, a strong compatibility of the ETBSD reference model has been found with the white paper discussing services that DIHs can provide in the IoT domain, redacted by an EC initiated DIH network in IoT (AIOTIDIHN) [10]. The AIOTIDIHN services portfolio can help to further refine, differentiate, extend or validate the ETBSD reference model: a comparison with it is planned after the run of the survey. Finally, a combination of the ETBSD with the ECOGRAI model [11] can be relevant to measure the sustainability of the DIH ecosystem with adequate KPIs.

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References

1. World Economic Forum: Digital Transformation of Industries. Demystifying Digital and Securing $100 trillion for Society and Industry by 2025 (2016). https://reports.weforum.org/digital-transformation/wp-content/blogs.dir/94/mp/files/pages/files/wef1601-digitaltransformation-1401.pdf. Accessed 16 Jan 2020
2. Sassanelli, C., Rossi, M., Terzi, S.: Evaluating the smart maturity of manufacturing companies along the product development process to set a PLM project roadmap. Int. J. Prod. Lifecycle Manag. **12**(3), 185–209 (2020)
3. Lasi, H., et al.: Industry 4.0. Bus. Inf. Syst. Eng. **6**(4), 239–242 (2014). https://doi.org/10.1007/s12599-014-0334-4
4. European Commission: Smart Anything Everywhere - Digital Innovation Hubs - Accelerators for the broad digital transformation of the European industry (2018). https://ec.europa.eu/digital-single-market/en/news/communication-digitising-european-industry-reaping-full-benefits-digital-single-market. Accessed 04 Feb 2020
5. European Commission: Digitising European Industry. Reaping the full benefits of a Digital Single Market (2016). https://ec.europa.eu/digital-single-market/en/news/communication-digitising-european-industry-reaping-full-benefits-digital-single-market. Accessed 04 Feb 2020
6. European Commission: Digital Innovation Hubs in Smart Specialisation Strategies. Early lessons from European regions (2018). https://doi.org/10.2760/475335
7. I4MS. https://i4ms.eu/about. Accessed 06 May 2020
8. DIHNET.eu. https://dihnet.eu/. Accessed 30 July 2020
9. DIH4CPS – Digital Innovation Hub for Cyber-Physical Systems. http://dih4cps.eu/. Accessed 09 May 2020
10. IoT Digital Innovation Hub (AIOTIDIHN): Mission and Activities of IoT Digital Innovation Hubs Network (2019). https://aioti.eu/wp-content/uploads/2019/10/AIOTI-WG2-White-Paper-DIH-Network-Activities-Published.pdf. Accessed 30 July 2020
11. Vallespir, B., Ducq, Y., Doumeingts, G.: Enterprise modelling and performance - part 1: implementation of performance indicators. Int. J. Bus. Perform. Manag. **1**(2), 134–153 (1999). https://doi.org/10.1504/IJBPM.1999.004434