Innovation Hub and Its IT Support: Architecture Model

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Abstract The paper proposes to consider the concepts of an innovation ecosystem and a digital platform for an innovation hub. The analysis of world experience in terms of innovative hubs contributing to the accelerated implementation of innovations is presented. The basic requirements for the digital platform were formed. The purpose of this paper is to form a reference model of an industry innovation hub for the accelerated implementation of digital technologies and a reference model of a digital platform for an industry innovation hub. The methodological basis of the paper is the analysis of open sources.

Keywords Digital technologies · Innovation hubs · Innovations ecosystems · Reference model · IT-architecture

1 Introduction

The basic conditions for the introduction of new developments are government support, funding, technology, a strong scientific and technological base, as well as an appropriate culture of innovation development. Today, in working with innovations, the key role is played by a properly built and most transparent process within the company, which will contribute to the achievement of the set results. The need for innovation is driven by the challenge of economic development. Thus, importantly the basis for the stability of the progressive development is to ensure continuous generation of innovative projects. If earlier almost all companies that worked with innovations tried to find as many projects as possible, cover the entire market, collect a wide funnel of solutions, today this trend is sharply transformed into a point search for technologies that are already ready for implementation in business [1]. The main goal of this approach is to find a solution that can be quickly assessed, determine a future customer for it within the company, and launch it into a separate dedicated project for yourself or in cooperation with partners in the market [2]. The creation of

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ecosystems and innovation hubs for the dissemination of digital innovations seems to be an expedient form of organizing the interaction of the participants in the innovation process, which will allow achieving a synergistic effect from the integrated efforts of the participants and will contribute to the accelerated digital transformation of the state. Innovation hubs are becoming popular with executives looking to support local economies and boost employment. But for the effective development of innovations special conditions are needed [3, 4].

Innovation hubs are increasingly becoming an integral part of urban planning as planners seek to revitalize economic and employment opportunities by creating an environment conducive to innovation. The scale of this environment can range from company departments or individual buildings with multiple tenants (often called incubators) to entire geographic regions called clusters. For the most part, as defined by the Massachusetts Institute of Technology, these are "dense networks of interconnected technology companies, customers and suppliers." Such an element of the innovation infrastructure will make it possible to create new products in an end-to-end cycle: from seed to a startup with its subsequent implementation. An innovative hub is believed to provide an attractive work environment and first-class infrastructure in terms of network connectivity [5].

The purpose of this paper is to form a reference model of an industry innovation hub for the accelerated implementation of digital technologies and a reference model of a digital platform for an industry innovation hub.

As a result of the research, the authors of the article want to get a generalized understanding of the interaction between the innovation hub and the digital platform of industry solutions.

2 Overview of Innovation Ecosystems and Hubs

The purpose of the innovation ecosystem is, first, to create a network community in which conditions favorable for the intensive dissemination of knowledge and the sharing of resources are provided. Under such conditions, a high intensity of interaction will be ensured through trusting relationships, contributing to the dissemination of knowledge and other resources [6].

Analysis of information about the established, generally recognized, and effectively operating global innovation ecosystems and hubs made it possible to formulate the main goals of creating an innovation ecosystem (Fig. 1) [7].

As for the characteristics of an innovation ecosystem, it can be considered as a complex system that has the following characteristics [8]:

- Self-organization—the ability of a system to create "order" without the participation of an external or internal leader when changes occur spontaneously or because of local interactions.

Fig. 1 Key goals of creating an innovation ecosystem

- Emergence is the property of a system to have characteristics that its elements cannot have individually—cooperation between companies leads to a result that they cannot create alone.
- Co-evolution is a process of mutual changes during the development of interrelated subjects.
- Adaptability—adaptation to changing conditions through internal changes.

Thus, it is possible to form the structure of the innovation ecosystem (Fig. 2). It is assumed that participants in the innovation ecosystem implement the entire cycle of innovation implementation.

2.1 World Experience in Creating Innovative Hubs

The USA, Singapore, Finland, Japan, and Israel are the most striking examples of the implementation of their innovative capabilities. The main global trends in innovation can be identified in four areas, presented in Table 1 below [2].

Cyber-Physical Security

In 2020, the City of New York opened a new cyber security technology hub in Manhattan. The project is being implemented in close and unique collaboration with the Israeli firm Jerusalem Venture Partners. The partnership, funded by $ 100 million, including $ 30 million from New York City authorities, will partner with companies that can offer cutting-edge cyber security solutions [9, 10].

Among other things, they will work on solutions not only for large corporations but also for small and medium-sized businesses, whose representatives often cannot afford expensive developments that guarantee high protection efficiency.

Medicine Industry

The modern pharmaceutical industry is unthinkable without innovations, including digital ones, and global pharmaceutical giants play an important role in their search,

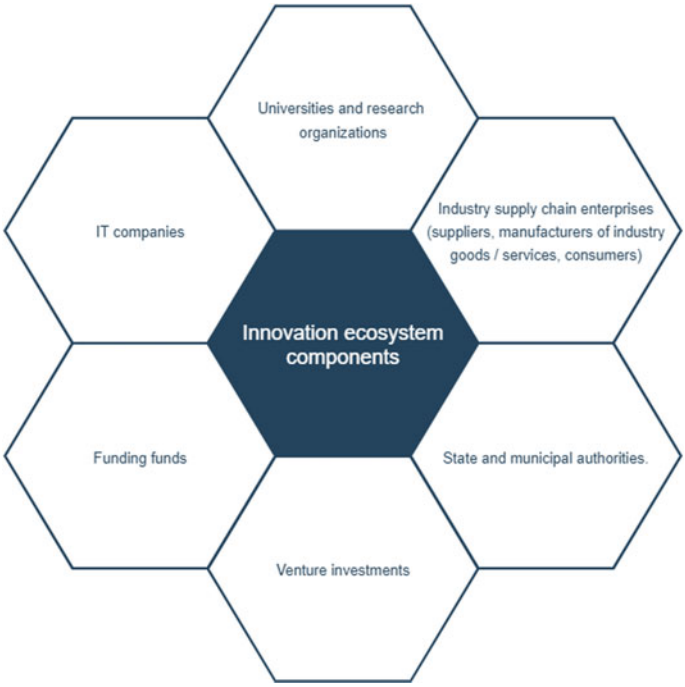

Fig. 2 Detailed structure of the innovation ecosystem

Table 1 Key trends in innovation

Name	Description
System crisis venture investing	• Reduction of investments at the initial stages of innovative projects • Increasing the distance between entrepreneur and venture capitalist fund • Increased competition between foundations and business angels
Strengthening the role states as customer innovation Edge Analytics	Asian, Israeli, and Finnish models are built entirely on state participation
Crisis of the existing system of intellectual property protection	• Monopolization of certain segments (biotechnology and IT) and oligopoly on others (music) • Creation of barriers to technological development in individual regions by large corporations
Democratizing the innovation process	• Expansion of investment in terms of geographic expansion and involvement of more people in this process • Starting entrepreneurship while still at university

support, and then implementation. Among them is the international biopharmaceutical company AstraZeneca, operating in more than 100 countries around the world and known for its drugs in the field of cardiology, oncology, nephrology and metabolism, and respiratory diseases. As part of supporting innovation, the company has deployed a global health innovation hub system or Health Innovation Hubs. In Russia, such a hub iDream was opened in 2018 in cooperation with the Skolkovo Foundation; today the company has eight hubs in emerging markets, including Singapore, India, and China [11].

Ecosystems for the development of innovation generally work to improve the health system. Thanks to the cooperation of all partners, from business to government agencies, we can all solve problems of the state, industry, and patients faster and more efficiently. We can say that health care of the future will become patient-centered. The industry has already formed a clear trend toward the transition from quantity to quality, from a fragmented approach to the development of innovation and the integration of all players. Digital technologies are the core of the new system. Building a fully integrated ecosystem of patient data is essential to advance science and technology and build the most efficient healthcare systems.

Enel Company Experience

Enel has created a global network of ten innovation hubs. Innovation hubs are in Brazil (Rio de Janeiro), Chile (Santiago), Israel (Tel Aviv), Italy (Milan, Catania, Pisa), Russia (Moscow), Spain (Madrid), and the USA (Boston, San Francisco) to find startups with great potential in terms of technologies and business models relevant to Enel's operations.

Since 2015, when Enel introduced the Open Innovation approach, focusing on development from external sources, the company has received about 10,000 cooperation proposals, 6,500 of which were sent by startups. In total, about 650 projects have been implemented during this time, of which about 250 are startups. Thanks to Enel, over 50 startups have been scaled to a global level. Among the many areas of such cooperation, the most significant are energy storage, big data, energy management, smart homes, electric transport, the Internet of things, preventive maintenance of equipment, artificial intelligence, intelligent technologies, and robotics [12, 13].

French Innovation Hub

A French innovation hub has already been set up in New York and Tokyo, and Moscow has become the third capital in the world to support the expansion of French Tech outside of France. In Russia, the French Tech community began to form in 2014, together with the arrival of new innovative companies: AT Internet, Blablacar, Cegid, Criteo, Generix, and others. The creation of such a community has three goals: facilitating the exchange of experience between members, popularizing French projects among large companies, increasing the attractiveness of the French Tech label among members of the Tech community, investors, and Russian media [14].

Financial and Technical Hubs

One of the world's largest financial and technical hubs is located in California's Silicon Valley. Projects like Affirm, Stripe, Lending Club, Prosper, SoFi, Square, and many more have formed the Silicon Valley Unicorn Club. This is a unique place where any innovative project is put to the test. Customers are spoiled for technology because they get the opportunity to be the first to try any technology solution. Nevertheless, even though the top ten US startup accelerators are located in California, there is one snag—it is not a fact that a project that has become successful in Silicon Valley will become successful beyond its borders [15].

New York is becoming another center of innovation. This is where the comprehensive guidelines for walking the digital currency Bitcoin and accepting this cryptocurrency to pay parking bills took shape. New York has become a promising region for established investors and companies hunting for innovative fintech startups. Potential investors include Bain Capital Ventures, JPMorgan Chase, FinTech Innovation Lab, New York Digital Health Accelerator, and NYC Seed.

London is still considered one of the world's financial-technical centers. Unicorns such as Klarna, iZettle, Adyen, Funding Circle, TransferWise, and POWA Technologies came from Europe as proof of the significant role of the European market in the global fintech arena. In Q2 2014, European startups raised over $2.8 billion from venture capitalists [16].

India, Singapore, and Hong Kong are fueling Asian fintech, making it globally competitive. Leading financial group DBS, with some 280 subsidiaries operating in 18 global markets, announced at the end of last year that it will invest $7.1 million in initiatives that can support the startup ecosystem in Singapore. Japanese internet giant Rakuten has launched a $100 million fintech fund. The fund will focus on fintech projects that are either in the early or mid-stage of their development [17, 18].

3 Results

3.1 Ideality Diagram of an Innovation Ecosystem

Within the framework of this paper, the authors introduce the concept of the ideality of the innovation ecosystem, based on the best world practices described in paragraph 2. Figure 3 shows a diagram of the ideality of the innovation ecosystem in the Spider Diagram format. This diagram reflects the key properties of the ecosystem using angles. Each of the lines of development of the ecosystem has its beginning and end, and the entire path of the ecosystem from inception to "ideal state" along a specific line can be taken as 100%. Analyzing the existing stage of ecosystem development for each line, the expert can give each line a quantitative expert assessment [19].

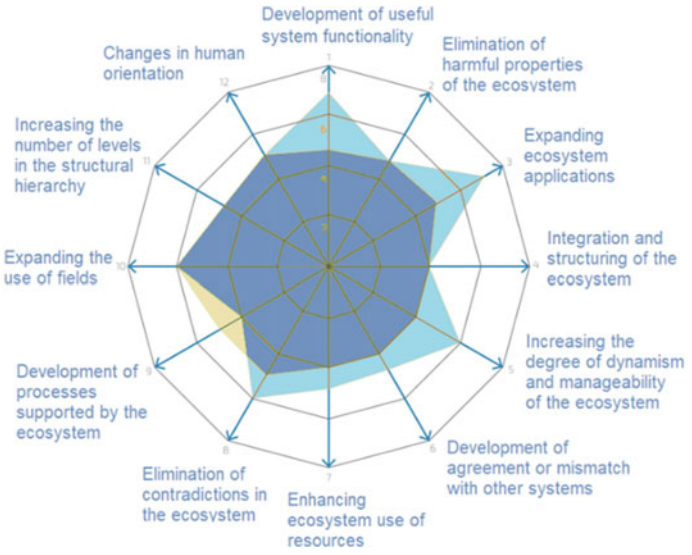

Fig. 3 Ideality diagram of an innovation ecosystem

3.2 A Reference Model for an Industry Innovation Hub for Accelerating Digital Adoption

In Fig. 4, the authors propose a general reference model for an industry innovation hub. When we talk about the common center of the so-called congestion of the flow of companies, people, we should focus on three key components of our ecosystem: community, data, and digital platform.

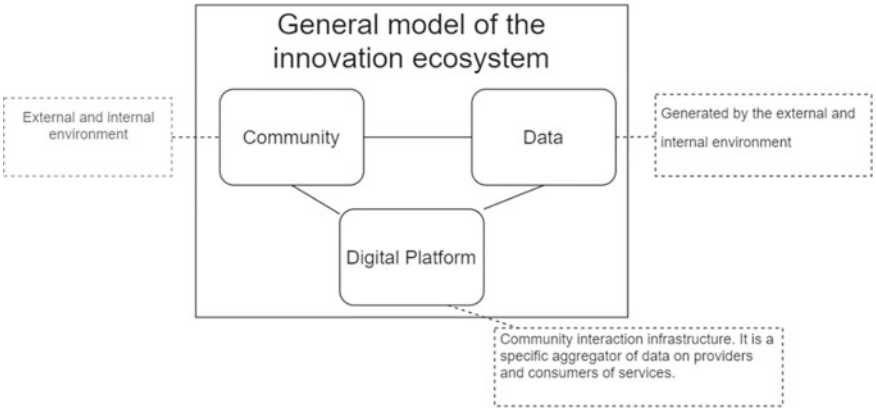

Fig. 4 General reference model of the innovation ecosystem

If we detail the model into components and show their interconnection, we get the following diagram in Fig. 5:

Block "Science, Universities"—is the main source of technological developments for commercialization as well as engineering and technical personnel.

Block "Venture capital"—plays in the ecosystem the role of a provider of not only financing but also business competencies for startups.

Block "Innovation projects/Startups"—are implemented innovative and technological projects. The main result and indicator of the efficiency of the functioning of the national innovation ecosystem and all its elements.

Block "State Development Institutions"—close gaps in the ecosystem (especially at the initial stage of development) and concentrate resources on accelerated breakthrough areas.

"Business" block is the main consumer for innovative projects.

Block "Infrastructure (including Digital Platform)"—is of a supporting nature (general services and industry services).

The development of an innovative project is linear and includes four steps:

- Basic research
- Applied research
- Product development
- Product distribution.

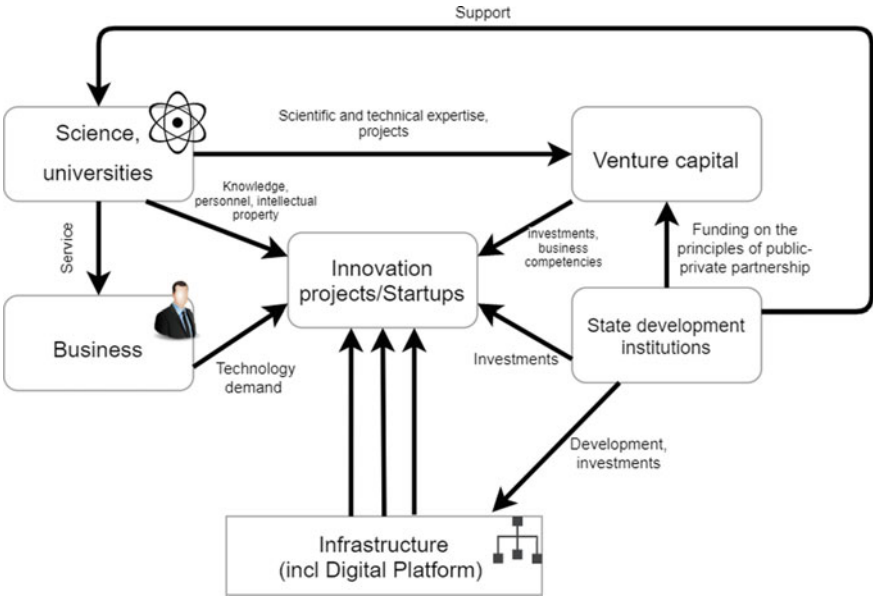

Fig. 5 Scheme of combining the innovation ecosystem components

Moreover, we can talk about the discrete nature of the innovative project, which allows us to identify five main steps. Figure 6 proposes a reference model for an innovation ecosystem based on a discrete definition of an innovation project.

At each stage of its development, an innovative project can only participate in generalized competitions, the conditions for participation in which it meets at the time of participation. If we consider the innovation ecosystem from the point of view of a startup, it turns out that there is no single ecosystem, but a set of ecosystems for each stage of development. At the same time, if we consider the situation from the point of view of external beneficiaries of successfully implemented projects (investors, government, and corporations), then the entire ecosystem works as one global super competition, the winners of which are successful projects, due to which the existence of the entire ecosystem pays off. This circumstance is also well modeled within the framework of the proposed approach since a sequence of several generalized competitions is also a generalized competition in accordance with our definition.

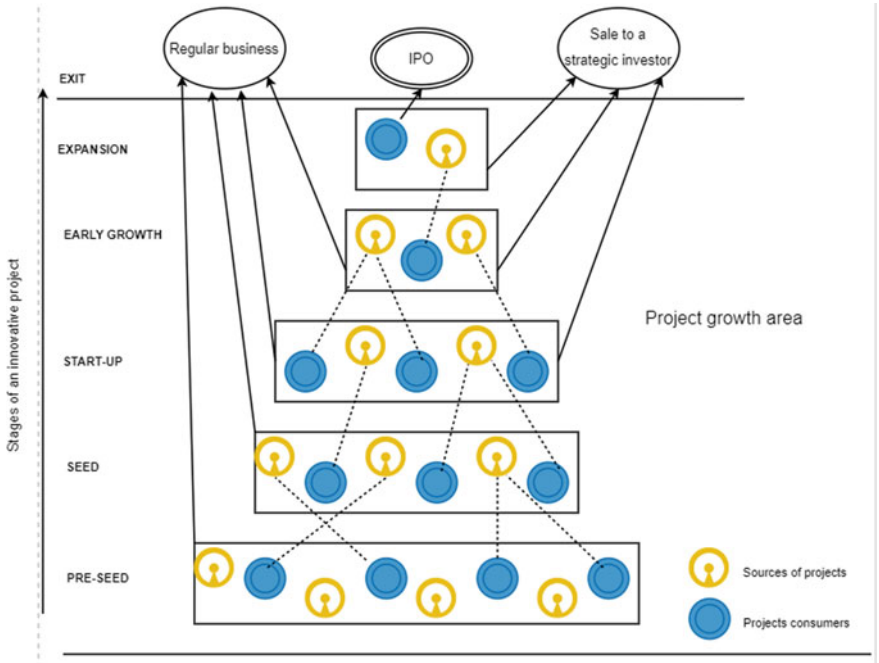

Fig. 6 A reference model for an innovation ecosystem based on a discrete definition of an innovation project

3.3 Innovation Hub Architecture

General Architecture of the Innovation Hub

Figure 7 shows the overall architecture of the innovation hub. The innovation hub architecture defines the overall structure and functions of systems (business and IT) across the entire ecosystem (including partners and other organizations that form the so-called "real-time enterprise") and provides a common framework, standards, and guidelines for architecture the level of individual projects. The shared vision provided by the enterprise architecture creates the possibility of a unified design of systems that are adequate in terms of meeting the needs of the organization, and capable of interoperability and integration where necessary [20].

Four architectures are considered as the main levels (layers) of enterprise architecture [21]:

- Business architecture (business architecture).
- Data architecture.
- Application architecture.
- Technological architecture (infrastructure).

Business Architecture

Business architecture describes how a business works. The most significant elements in this area are "processes and information," "organization," and "productivity." The element "processes and information" is most important as it describes and classifies the business structures, business processes, and activity streams that make up

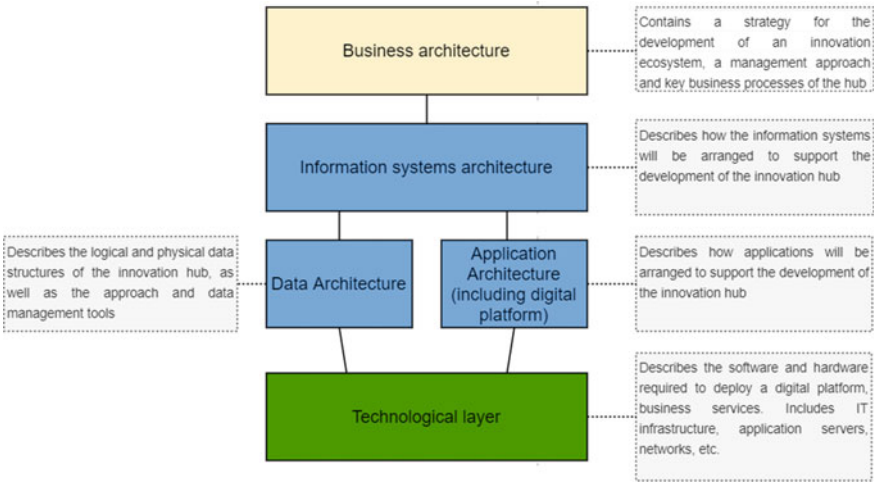

Fig. 7 General architecture of the innovation hub

the organization's business model. The element "organization" describes the organizational structure and methods of work, the products, and services that the business produces, the business units, their location, etc. The element "performance" describes the indicators that measure the efficiency of the enterprise (productivity, business risks, etc.).

Data Architecture

Data architecture describes the data used by an enterprise. It is customary to distinguish four key groups of data architecture requirements [22]:

- Requirements for the data structure.
- Requirements for data transfer.
- Requirements for data management.
- Requirements for data security.

The data structure, in turn, consists of classifiers and data characteristics. Four types of data are distinguished: master data, metadata, transactional, and historical data.

When integrating and replacing software applications, it becomes necessary to transfer data. The requirements for data migration shape the data architecture. Also, at this architectural level, the data transformation and cleaning systems needed to represent data in a format that meets the requirements and constraints of the target application should be defined. It is this element of the data architecture that is responsible for data quality.

Data management requirements describe the resources that an enterprise must carry out data transformations. First, these are:

- structure—organizational structure and standardization bodies for data transformation management;
- people—the skills and roles required to transform data;
- data management systems throughout their life cycles.

Data security requirements can be defined as maintaining data integrity, confidentiality, and availability properties. This element of the data architecture describes the requirements for different categories of data.

Application Architecture

Application architecture (application architecture) describes the applications that automate the organization's activities (business architecture) and process information flows (data architecture). First, the application architecture is described through classes and types of applications without being tied to specific solutions and technologies. Application classes are stable and do not change too much over time, while implementation technologies for dedicated application classes can change rapidly [23].

Technological Architecture

A technology architecture describes the physical implementation of an enterprise IT infrastructure and relies on the requirements derived from the application architecture description. There are various ways to categorize technologies. According to Gartner, the technology architecture has six elements [24]:

- data services (DBMS, data warehouses, etc.);
- application services (mail, collaboration systems, development tools, etc.);
- middleware (application servers and other integration tools);
- computing infrastructure (server and user equipment, storage systems, etc.);
- network services (local and global network infrastructure and access technologies);
- security services.

After analyzing the methods of modeling the architecture of an enterprise, explaining in detail each of its components, the authors of the paper propose a model of the upper level of the architecture of an innovation hub that promotes the introduction of innovations considering the integration of a digital platform (Fig. 8).

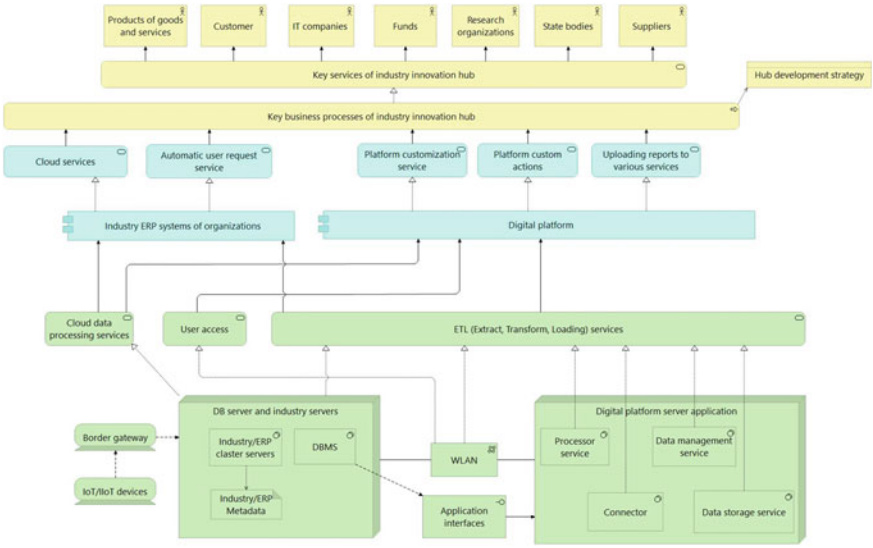

Fig. 8 Top-level architecture of the innovation hub

3.4 Digital Platform of the Industry Innovation Hub

Requirements for the Digital Platform of the Innovation Hub

The construction of a digital platform is based on the principles of ontological models. The architecture of the digital platform provides for the principles of constructing the BEOM (Business Entity Ontological Model) matrix for both individual enterprises and the industry as a whole:

- Structured solutions for industry challenges.
- Data on stakeholder interaction.
- Description of objects of activity (for example, digital twins).
- Organization of relationships (relationships) for all participants in the ecosystem.
- Geo-referencing for objects and processes.
- Structured data storage for analysis of temporary changes as well as the ability to monitor processes online.

Digital Platforms can associate needs with resources (product service providers to consumers, etc.) through different interaction formats: people-to-people, people-to machines, machines-with-machines "(machines-to machines). The concept of a digital platform includes both the technological structure itself and the platform business model and ecosystem. The platform as a business model is a model of providing through a technological platform for direct interaction and the implementation of transactions between entities using new methods and forms of interaction, value creation, and pricing.

The development process of digital platforms can be divided into three blocks:

- Structures and stages of formation of digital platforms.
- Platform Business Aspects.
- Challenges and opportunities for integration into ecosystems.

The interaction of these blocks leads to an understanding of the value of using digital platforms in innovative hubs.

The digital platform of the innovation hub allows:

- perform scenario calculations of the development of the technological direction;
- map value chains, providing market participants with a holistic picture of economic ties;
- design optimal "Supplier–Consumer" relationships;
- identify promising areas of development (growth drivers) for the creation of new businesses, products, and services;
- to formulate justifications for investment projects for the production and launch of products and services on promising markets.

To achieve economies of scale and focused market launch of new products, the digital platform helps organize the structured work of a team of experts to develop the supplier/consumer network and identify and develop technologies that are priority for the entire supply chain.

Using a digital platform allows you to reduce the risks of investment projects, attracting a network of international partners to create a new product for target foreign markets. The digital platform is formed in two stages (Fig. 9). The first stage includes building a model of the value chain and includes two sub-stages, the second stage is aimed at Building digital models of market supply (value proposition) in promising areas (growth drivers) and consists of four sub-stages.

After analyzing the world experiences of countries and companies in the creation and implementation of innovative hubs, the authors of this paper propose to form a map of requirements for a digital platform. The authors identified seven key requirements required to implement the digital platform of industry innovation hubs (Fig. 10):

- General functional system requirements
- Reliability requirements
- Performance and hardware requirements
- Security requirements
- Requirements for the modes of functioning, diagnosis, and monitoring of the system
- System interface requirements
- Requirements for the composition of information, volumes, methods of its organization, and life cycle.

If we talk about the general requirements for a digital platform, the following several points can be distinguished:

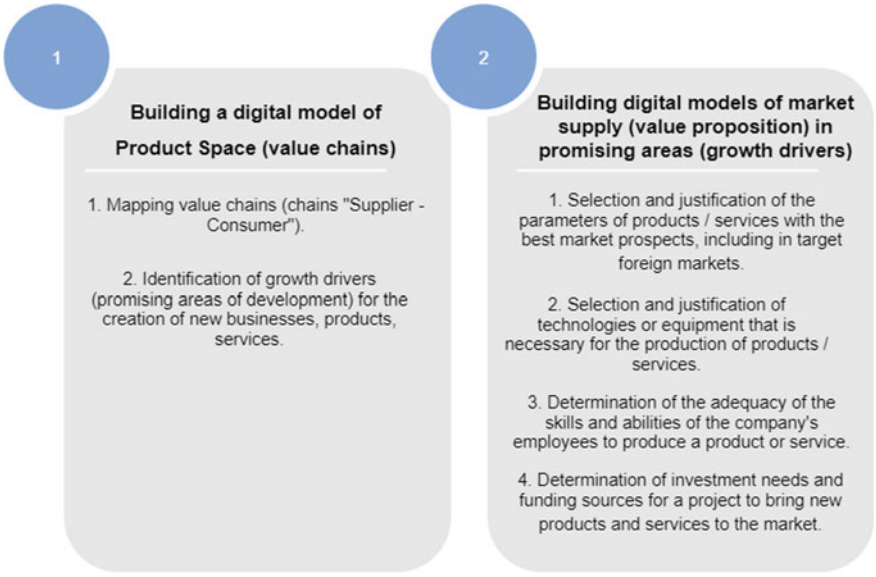

Fig. 9 Stages of creating a digital platform for an innovation ecosystem

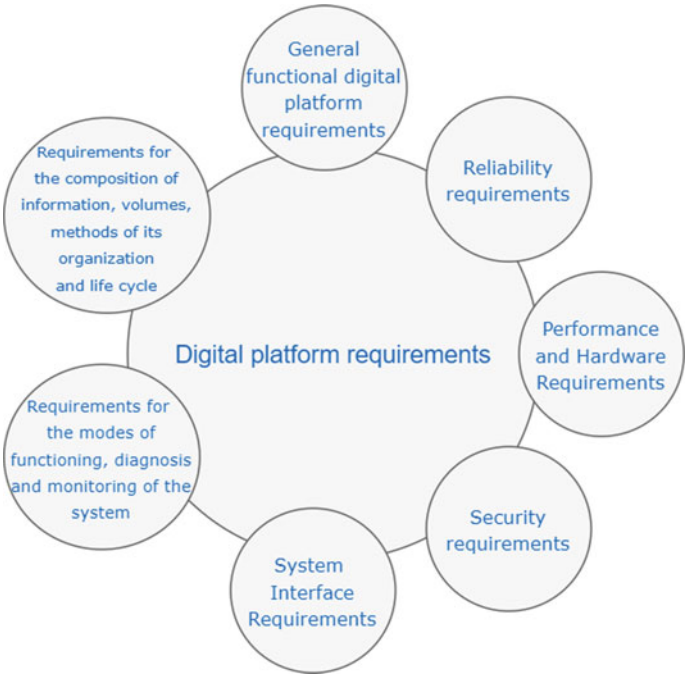

Fig. 10 Digital Platform Requirements Map

1. Automated loading of data from information systems-sources in the established format.
2. Integration of all platform participants.
3. Support for the platform in real time and considering the workload of its attendance.
4. Availability of high-level technical characteristics and sufficient capacity for multi-channel user work.

A Reference Model for an Industry Innovation Hub for Accelerating Digital Adoption

Figure 11 presents a digital platform reference model showing the influences and interconnections of key participants in the innovation hub.

Digital Platform Architecture

Based on the description of digital platforms and the formation of a system of requirements for them, it is possible to analyze the architecture of the digital platform (Fig. 12).

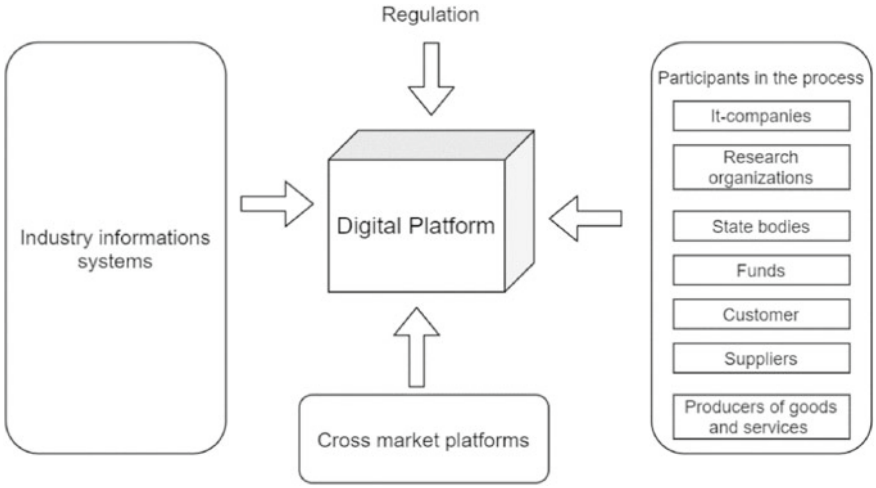

Fig. 11 A reference model for an industry innovation hub for accelerating digital adoption

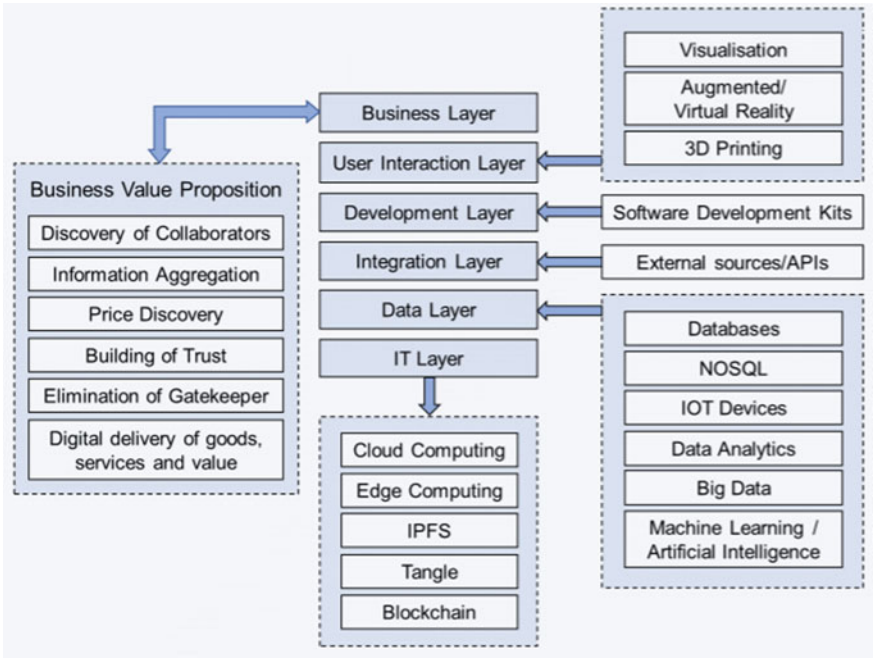

Fig. 12 Digital Platform Architecture

4 Discussion

The results of such studies will serve as a basis for identifying end-to-end technologies for the key sectors of the economy discussed in this paper. Based on this, it is proposed to build reference models of industry innovation hubs, depending on the specifics of the industry, to provide an effective digital environment for individual industries. This will allow technology to develop in accordance with the requirements of stakeholders in a particular area. In the future, the authors plan to come to the development-specific industry solutions of the innovation hub model. It is also planned to develop an integrated architecture of the digital platform and formulate requirements for its services.

5 Conclusion

In this paper, the key concepts of an innovation ecosystem and a digital platform for an innovation center are presented. The analysis of the world experience in creating innovative hubs that contribute to the accelerated implementation of innovations is carried out. The authors suggested the ideality diagram of an innovation ecosystem, which reflects the key properties of the ecosystem using angles.

The basic requirements for the digital platform were formed in map view. Stages of creating a digital platform for an innovation ecosystem were described.

Reference models of the industry innovation hub were formed for the accelerated implementation of digital technologies. Moreover, a reference model for an innovation ecosystem based on a discrete definition of an innovation project was proposed. Also, the authors suggested the reference model of the digital platform for the industry innovation hub.

One of the research results is the formation of the general architecture of the industry innovation hub. The high-level architecture of the innovation hub using the ArchiMate modeling language was proposed. Based on the description of digital platforms and the formation of a system of requirements for them the architecture of the digital platform was proposed.

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