SERVICE APPROACH TO THE DEVELOPMENT OF ONLINE EDUCATIONAL PRODUCTS IN THE NATIONAL GEOINFORMATION CENTER OF BULGARIA

Dr. Todor Branzov
Assoc. Prof. Dr. Krassimira Ivanova
Prof. Dr. Velichka Milousheva
Institute of Mathematics and Informatics at the Bulgarian Academy of Sciences, **Bulgaria**

ABSTRACT

The paper presents our findings during the adoption of e-learning in the National Geoinformation Center of Bulgaria (NGIC). It details the approach used to build a set of functionalities that produce and deliver online educational products to the customers of NGIC. The Center is a consortium of the national providers of Earth observation data with a purpose to design and co-develop integrated information products. NGIC's information system is being developed since 2019. It is built adopting the IT service management practices of ITIL 4 and implementing an original service-microservice architecture. Three dimensions of the proposed solution of the problem – business, technological, and technical are presented. The business process of integrated educational product (IEP) development in NGIC is specified and described within two BPMN models – from the idea for a particular IEP, through its review process by NGIC management to provisioning with resources, actual production, and deployment to the customers as an online or product with blended nature. Two services that support the implementation of the processes in NGIC are detailed – the Authoring service and the Public online education service. The service relationship management and the blending in the architecture of the Center are reviewed. Various specifics of the system engineering and the software modules integration in the system of NGIC are explained. The paper concludes with a discussion over some opportunities provided by that implementation of the service approach – such as ease of employment of a third-party expert domain knowledge and the resources of the virtual community.

Keywords: Software Information Systems Architecture, Information Systems Applications, E-learning, Service Oriented Architecture, Information Technologies Service Management

INTRODUCTION

The National Geoinformation Center (NGIC) is a recently founded Bulgarian national scientific infrastructure. It is a consortium of otherwise independent national providers of Earth observation data, data products, services and software (DDSS). Its main purpose is to link these resources into a network with a strategic goal of design and co-development of multidisciplinary, integrated data products (IDP), which can be of use to a wide range of users such as government structures, local authorities, businesses, and the public. NGIC is intended to provide infrastructure for solving complex national and international

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tasks related to the prediction and prevention of natural and anthropogenic risks and disasters.

A particular area of interest and part of the mission of NGIC is education on the various aspects of nature-related hazards. Target audience is a broad group of citizens, state agencies officers, affiliated and independent researchers, companies, and other organizations employees. NGIC has some unique advantages – it has access to virtually all Earth observation data available through various agreements to its participating partners and the joined expert knowledge of the Bulgarian geoscience scientific community. Harnessing these advantages and the available resources (geodata and expertise) to produce educational products was described in the planning documentation of NGIC. It was suggested that gradually building educational capabilities is one of the strategic goals that have to be pursued in NGIC.

While analyzing the current state of development of national and global geoinformation centers, we identified several notable trends that we adopted as high-level user stories in education capabilities design. Also, an opportunity was noted – provisioning with live observation data instead of using static sets of data. We are suggesting that would be an innovation, would increase interest for the replayability of various knowledge checking exercises and may even lead to some new types of educational products. The paper presents an approach to develop educational capabilities within service-microservice architecture. We are using the Bulgarian NGIC as a case study, with an assumption that it may be used as a reference for systems with similar design and purpose.

CURRENT STATE AND DEVELOPMENT TRENDS

The national and quasi-national geoinformation centers proved to be successful in providing a very close to the practice, but also a safe environment for education to various categories of users – starting with the art and science of reading and understanding the outputs of the information systems up to an advanced level training in data processing for the next generation of researchers [1][6]. Along with already classic approaches as self-paced or teacher-driven online courses, an analysis of the current state of development of 11 of the leading geoinformation centers (GIC) and programmes [2] identified some notable trends.

Various initiatives aim to develop a *research infrastructure in schools that is concurrently used for collecting observation data*. Significant progress in the process of integrating education with Earth research has been made in Australia by a series of projects within the National Collaborative Research Infrastructure Strategy. The projects AuSIS [3] and AuGPS have placed earthquake-measuring seismometers and location-finding GPS units in schools across the nation, and then record the data online. Thus, they combine practical learning experiences within schools by collecting useful data for researchers. In addition to the physical infrastructure, the project teams have developed curriculum-aligned educational packs that provide materials to teachers.

A number of examples are noted of organizations that are employed as *additional (third-party) geoscience educational sources in GIC*. E.g., Geoscience Australia, which is the Australian government technical advisor on all aspects of geoscience, and custodian of the geographical and geological data and knowledge of the nation, uses a range of educational strategies to promote geoscience awareness in the community. They cover three distinct groups – teachers, students and online resources for self-paced education.

At least two of the reviewed centers are *using observations data as a resource in the educational process*. Bhuvan – the Geoportal of Indian Space Research Organisation – is a gateway to Indian Earth observation data products and services [4]. The portal School-Bhuvan provides map-based learning with the goal to bring awareness among the students about the country's natural resources, environment and their role in sustainable development. The e-learning courses are self-paced and learner-centric and targeted to professionals, academia and research community to enhance their knowledge in remote sensing and geospatial technology using online simulated learning contents. Data used in the educational environment, proposed by Bhuvan, can be placed in two major groups: observed (i.e., topographic data) or prognostic (like models of monsoon development).

The project LeanEO! is an Earth observation education project of the European Space Agency (ESA). It aims to increase the understanding of satellite data from ESA missions and show how these can be used to tackle environmental problems in the real world [5]. The project offers a set of lessons using LeanEO! deployed applications. The infrastructure provides access to observation data, software for data and image processing for educational use, a resource library with extra information and tools, as well as technical support for lesson writers and lesson users.

Although several other practices were noted, we assume that they are universal for online educational systems. Thus, we stress only on the above that we presume to have specific relevance for geosciences.

Another finding was that almost all of the simulators, knowledge checking or gamified products use static sets of data. In our opinion, this restricts the interest in replayability by the users. Especially when the goal is training with tools for data processing and modeling, as well as visualizing and interpreting the results it would be an improvement if the trainee has a different set of data with each instance of an exercise or scenario.

DEVELOPMENT OF EDUCATIONAL CAPABILITIES IN SERVICE-MICROSERVICE HYBRID SYSTEM

The design proposed in this article is based on the current trends in online education systems, along with the specific directions we reviewed above. A key innovation is the supply of educational products with live data. We use a blended approach to design, with modeling each of the three dimensions of the solution within the enterprise architecture – business, technological (information system architecture) and technical (software and hardware infrastructure) [7].

NGIC's information system architecture is used as a reference and the system is used for the approbation of the models, implemented solutions and the approach itself. The system has been developed since 2019. It adopts IT service management practices of ITIL 4 and implements an original service-microservice architecture (Fig 1.).

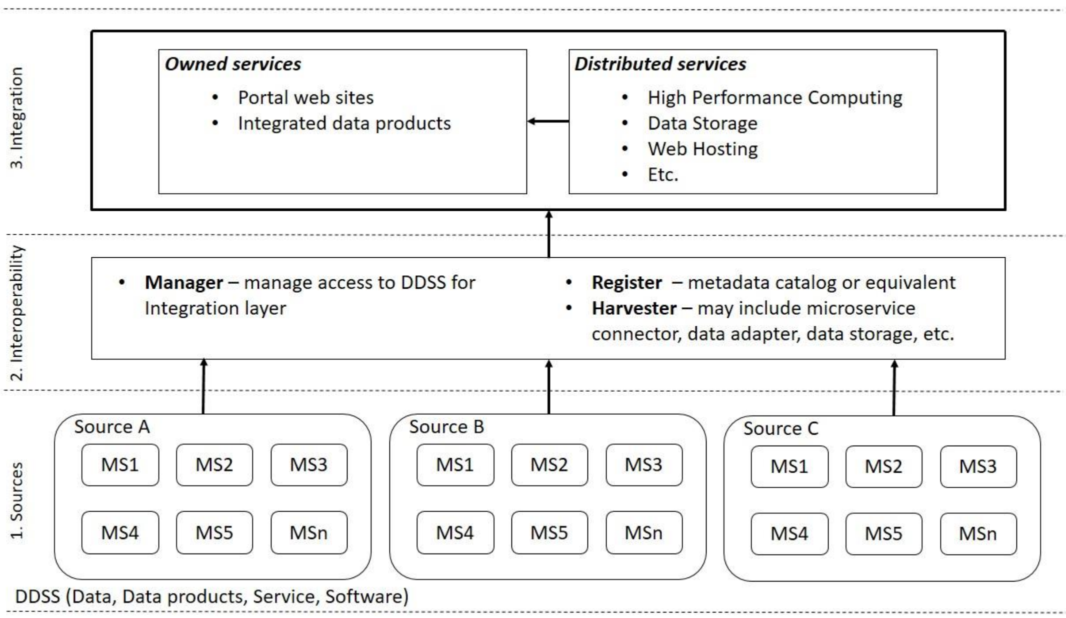

Figure 1. Basic service-microservice model of NGIC

The "Sources" layer contains the providers of Data, Data products, Services and Software (DDSS) that are used by the system to produce advanced integrated products. "Interoperability" layer includes components that are mentioned in three abstract categories: "Manager," which regulate the access to the DDSS in "Sources" layer; "Register," which provide automation of discovery and selection of DDSS; and "Harvester," which includes advanced automated subsystems for data collection from the sources (like data harvesters, data adapters, storages for data buffering, etc.). The "Integration" layer produces integrated data products (IDP). This layer employs service architecture built around two groups of services – owned services and distributed services. The access to IDP is provided by own services, while the preparation of IDP itself can use combinations of owned and distributed services, delivered by the ICT support providers within the consortium or third-party providers that are not partners in NGIC[2]. The integrated educational product (IEP) is a type of IDP.

The business-level modeling of the proposed process of educational product development (also employed in NGIC) is split into two phases presented here with two BPMN models. The first phase (Fig. 2) represents the IEP proposal review process.

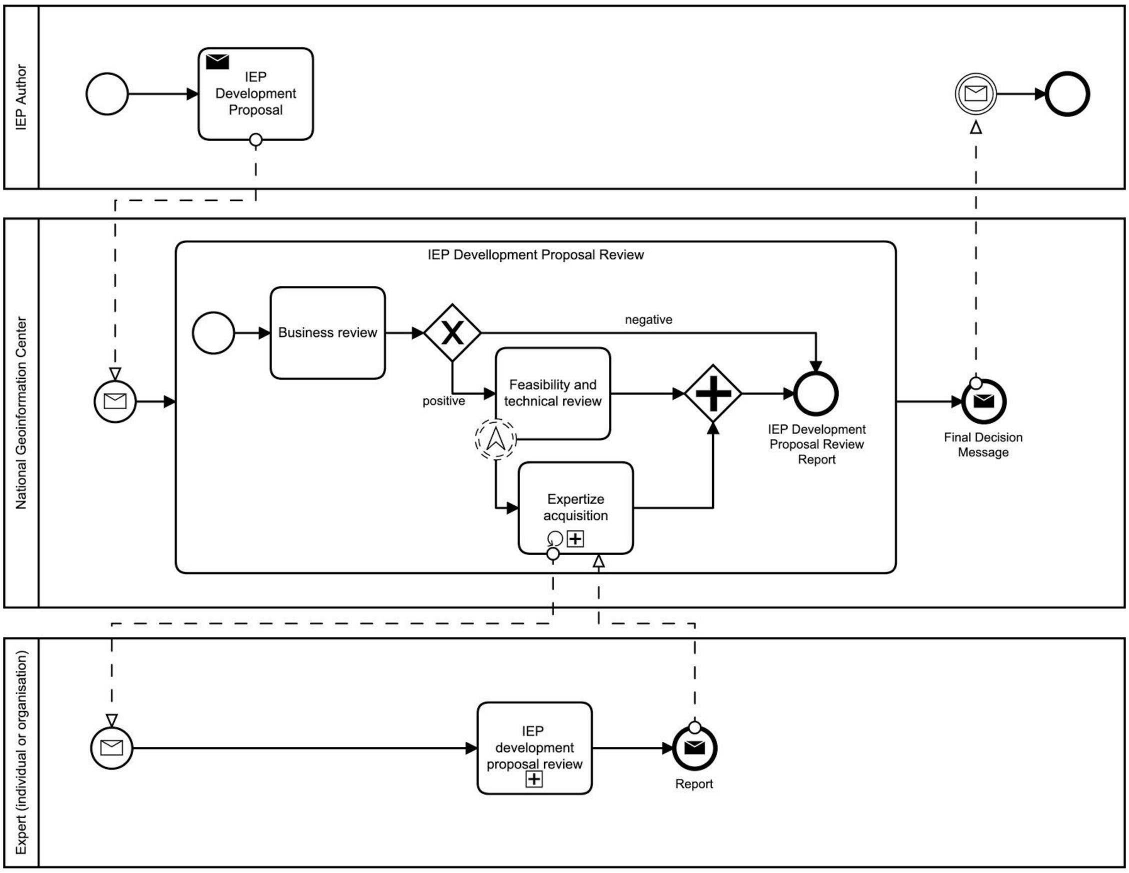

Figure 2. A model of the proposal review phase of the business process of integrated educational product development used in NGIC

The key notion to the development of IEP is to provide NGIC capabilities to the "author" role – i.e any party that has the expertise and motivation to participate in elaboration of high-quality online educational products in the geoscience domain. Some possible actors in that role could be the partnering organizations in NGIC, invited lecturers, universities, etc.

The "IEP Author" expresses its interest in the development of IEP with an "IEP Development Proposal" sent to the NGIC. The business and technical feasibility of the proposal is reviewed by an expert committee and a proposal review report is prepared and presented to the governing committee of the NGIC. The final decision of that committee is communicated to the Author.

A key part of the review process is the option to acquire external expertise for the feasibility and/or technical review of the proposal. Although not mandatory, it is assumed that one of the scenarios is that the external experts would be sourced from the partner organizations in NGIC. This provides an early option to the partners to evaluate their eventual participation in the future IEP development – as a data provider, as a distributor, or anything that will add value to the product. Also, third party experts that own and may eventually provide specific skills, i.e., legal or marketing, may be included in the evaluation.

The second part of the development process is the actual production of the IEP (Fig. 3).

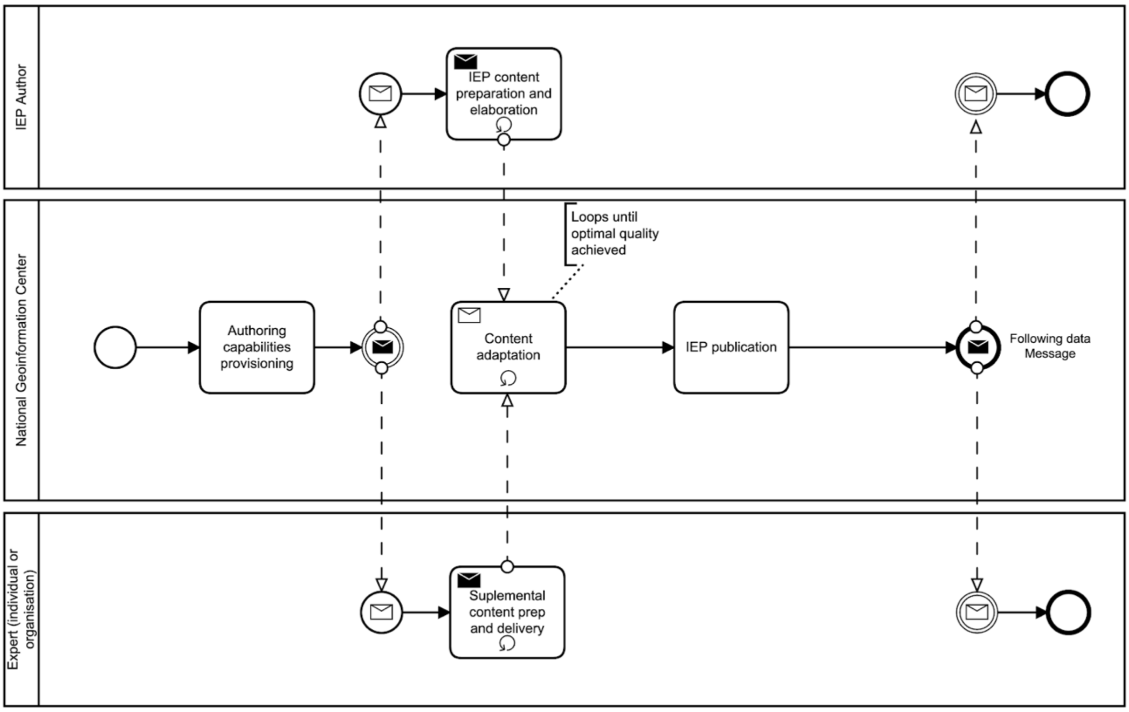

Figure 3. A model of the production phase of the business process of integrated educational product development in NGIC

NGIC team provides authoring capabilities, i.e., user profile with access to the learning management system, any specialized tools and instructions to use to the "IEP Author" and external "Experts." The provided capabilities may vary between various authors or between authors and experts according to the specific needs.

The authors prepare any original content that is needed and the experts provide supplemental content. The NGIC adapts and optimizes the content to the abilities of its software information system. If some agile development approach is adopted in IEP development, all needed iterations (loops) are executed until the optimal quality of the product is achieved.

The "IEP publication" task is executed after the content adaptation concludes. It makes publicly available the product and the NGIC fires a message both to the author and external expert with any follow-up data, i.e., additional access to the system, user tracking data, etc.

Again, the case that requires special attention is when "the expert" is a partnering organization that produces original data or even any provider of such data. That may provide some unique capabilities like provisioning with live data that may be used in the development of knowledge checks, graded tests, or more complex tasks for the users of IEP. Another particular case is when the IEP is one of the popular online course forms. In that case, the teacher and the students follow the topics of the course syllabus and there is active two-way communication. The teacher is usually the author; however, the model also includes the alternative cases, assuming that the teacher may also be an "expert" and firing variations of the follow-up message accordingly.

With that model of the business dimension of a solution, we have three distinctive roles employed in the business model. We have defined the consumers of the services that could be used as a foundation of technological solutions based on an IT service management framework. However, we propose fusing that results along with a top-to-bottom analysis in the service design process, i.e., determination of various contact surfaces of the services. We found that design of two customer-facing services (services that are seen by the customer [8]) – one, oriented to the users of IEP and second, oriented to the authors of IEP – is sufficient to implement the described business processes (Fig. 4.)

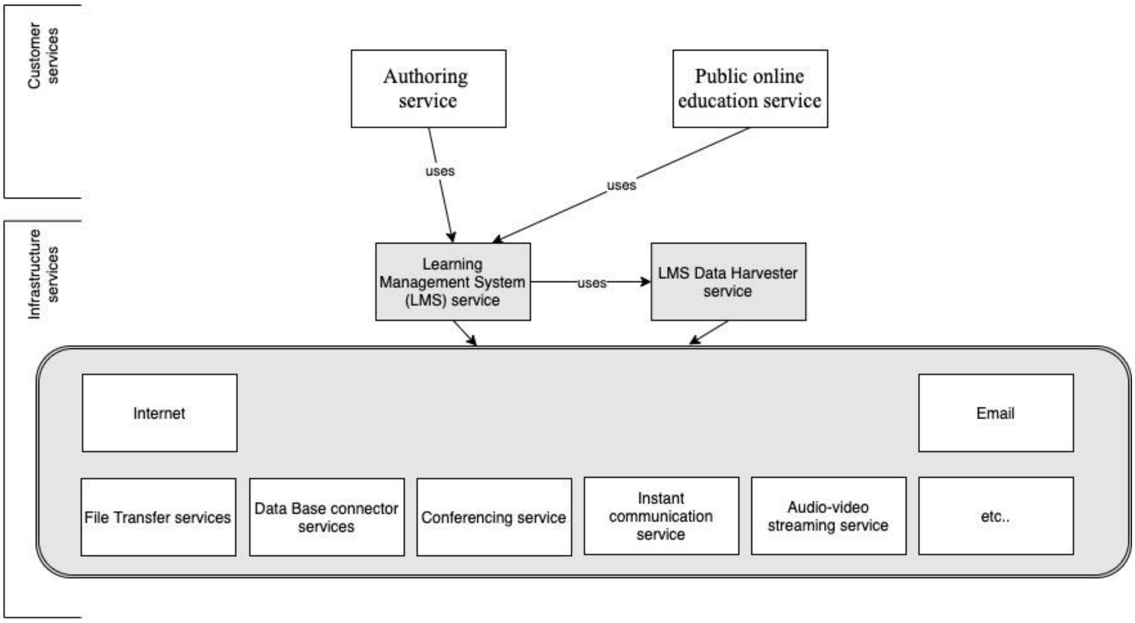

Figure 4. Example implementation of the business processes into the service portfolio

The "Authoring service" is oriented towards all parties that create and elaborate content into an educational product. That service contains the mechanisms that implement the entire IEP proposal review phase and all tasks of the production phase until the "IEP publication" task. The service is consumed by the authors and experts. The possible variations of quality and content of services needed by the authors and the third-party experts are described in two or more Service Level Agreements (SLA).

The "Public online education service" is oriented towards the audience of users of the educational product. That service contains the means for distribution of the products to the audience. Various SLAs could be created according to chosen distribution models, i.e., free, freemium, paid, etc.

Two major sets of functionalities have to be added to NGIC: (1) a kind of learning management system to provide NGIC with e-learning production and deployment capabilities and (2) mechanisms that would allow datasets to be obtained from a partner or third-party source and to be implemented as a part of an IEP. Both solutions are wrapped in services – "Learning Management System service" and "LMS Data Harvester service." Those services are supporting (infrastructure) services and are consumed by the customer-facing services. Beyond those four services, the relations in the portfolio are determined according to the needs of the particular system. On Fig. 4, we present some of the infrastructure services used in NGIC; however, that list is neither full nor universal.

Back to the basic architecture model, both customer-facing services are placed in the "Integration layer" (Fig. 1) as part of the "Owned services" set. The reflections of the "Learning Management System service" may be either own or distributed (if SaaS solutions are used) or spread over both. The "LMS Data Harvester service" is in the "Interoperability" layer.

Two scenarios for production of IEP are available:

- The product does not have requirements for external input, i.e., live earth-observation data, during the production phase. These are a series of video or audio casts, multimedia presentation files, etc. The "Learning Management System service" doesn't need to consume "LMS Data Harvester service" in that case.
- The product has requirements for external input, i.e., live earth-observation data, during the production phase. These are products that contain dynamic tests, simulation exercises with live data, etc. The "Learning Management System service" need to consume input from "LMS Data Harvester service" in that case. The harvester service contains the means to call one or more microservices provided by one or more partners in the "Source" layer.

Although we may develop one data harvester service to cover the needs of all kind of IDP, a discrete harvester service for use only by IEP (through LMS service) would allow better service management and indirectly will provide better isolation of the data streams from sources that are used by various types of integrated data products. We stress the importance of this discretization for delivering a safe sandbox environment for the IEP users, along with covering the needs of other IDP types users.

The choice of software and hardware infrastructure products for implementation of the models is very wide, and a detailed review is out of the scope of this paper. In addition, it depends on factors such as organizational IT policies, legal and management requirement, which varies greatly. However, two suggestions need special comment. The current leading learning management systems (i.e., Moodle, Blackboard, Open EdX, etc.) are very close in functional capabilities and quality. The creation of a shortlist of potential candidates wouldn't be a hard task; however, we think that special effort has to be put in assessing ease of development and maintenance of software module extensions, which may prove critical for the implementation of the models. The second suggestion is regarding the microservices maintained by the sources – the architecture uses a very broad definition that focuses mostly on the autonomy of the sources and agility to the requirements towards communication interfaces [2]. In this sense, even some venerable mechanisms such as FTP locations should be acceptable and assimilable by the system.

DISCUSSION AND CONCLUSION

The paper presented an approach that we used to build educational capabilities in a system with a well-determined business domain. The mission of the NGIC identifies the target audience of its educational center - students and doctoral students, researchers, volunteers and professionals in civil protection, all citizens curious in the field of geoscience.

The thematic scope may include: training on various aspects of natural and anthropogenic risks; on specific geological, water and meteorological processes; mastering knowledge on how to use resources (DDSS) to design and create IDPs and interpret results. The special power of the NGIC educational center is that its architecture allows provision of the IEP with real, pseudo-real and/or historical data - live and up to its needs and specifics. The sources of data may be either partner in the consortium or third-parties. Those capabilities provide opportunities for the development of unique products - such as knowledge checking exercises, always using unique sets of data, or to greatly enhance some of the existing types of products, i.e., online competitions on predicting the weather forecast or scenario simulations.

From the wider perspective of software engineering, our suggestion is that the approach and the presented models may be employed in the design process of educational capabilities in any information system with similar architecture, regardless of the business domain. The microservice concept is especially useful in organizations that use a federated or decentralized model [9] – it respects the autonomy of the participants, decreases centralized management effort, and provides an elegant mechanism for cooperation.

Another aspect that deserves further investigation is whether the potential for the development of gamified IEP, along with adequate software modules for social communication, would provoke the nascency of a virtual community around the NGIC. Among that community, potential authors or contributors could arise. Keeping in mind the mission and domain of NGIC, a virtual thrifting community is a premise and opportunity for various citizen science initiatives.

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