Electronic Environment of the Scientific Library: Project Solutions to Support Modern Scientific and Educational Requests*

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Abstract

The purpose of this article is to outline the project solutions for the e-environment of Ukraine's scientific libraries and its role in addressing the modern scientific and educational needs of researchers. The primary goal of the research is to study the features of this electronic environment and its modernization, taking into account the interests of both science and education. Scientific novelty lies in the comprehensive analysis of the library's e-environment and the identification of priority tasks in satisfying researchers' scientific requests. The research methodology involves analyzing the project solutions of the electronic environment and assessing how well modern scientific and educational requests from researchers are met. Students, faculty, and researchers have the opportunity to gain valuable experience by participating in projects that involve specialized software and technologies, which contributes to the training of engineering professionals and the advancement of scientific research. At the current stage of development, several key priority areas been identified. First, the integration of the latest information technologies into the activities of scientific libraries not only introduces new types of services but also highlights unique domestic electronic resources and digital collections within a scientific e-environment. Secondly, the creation of an electronic environment promotes effective and distributed access for a wide range of researchers to scientific information search systems through cooperation with leading international aggregators of scientific and information resources.

Keywords

E-environment, project solutions, electronic resources, electronic catalog, digital collection, repositories, online services, research databases, scientific library

1. Problem formulation

Needs for information literacy, disparities in society, bridging digital divides, richness of information sources in electronic environments. To improve to access information sources and information literacy training, information behavior must be understood (i.e. all information activities). This paper conceptualizes new opportunities for information sources to researchers to supplement information literacy and behavior research [1, 2].

Vasyl Stefanyk National Scientific Library of Ukraine in Lviv (hereinafter – VSNSL of Ukraine in Lviv) is an important information-analytical and socio-cultural center. The national repository of unique handwritten and printed cultural monuments and other documents, in which the national information potential is concentrated.

Since its inception, a primary task of Ukraine's scientific library has been the optimal preservation of its entire mass of documents and collections. Concurrently, the library aims to provide the widest possible access to its resources for all categories of researchers with scientific, research, cultural, and

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educational needs. The global pandemic of COVID-19 and the full-scale invasion of the russian federation on the territory of Ukraine prompted the scientific library to increase the representation of its activities in the interactive e-environment. Thus, it is worth emphasizing that a comprehensive decision of the issue of use in in the work processes of VSNSL of Ukraine in Lviv, electronic information technologies and electronic resources are quite important and relevant [3, 4].

2. Formulation of article's objective

The purpose of the article is to highlight the project solutions of the science library e-environment and its role in the implementation of modern scientific and educational requests of researchers. This includes: assessment of the current state of the electronic environment of the scientific library; determination of the basic needs of researchers in the context of access to information and information resources; description of effective project solutions of the electronic environment of the scientific library to support scientific research and educational processes [5, 6].

3. Scientific novelty of the research

The scientific novelty of the article consists in a comprehensive analysis of design solutions for the creation and development of the electronic environment of a scientific library as a tool for supporting modern scientific and educational needs. For the first time, a systematic approach to the integration of the latest information technologies, specifically microservice architecture, UI/UX design, metadata management, cloud services, and digital collections, into a single electronic infrastructure of the library, is presented. The proposed solutions aimed at ensuring sustainable and distributed access of scientists to electronic resources, as well as at supporting engineering training through access to specialized scientific databases, repositories, and digital archives. The uniqueness of the approach consists in the combination of technical and content components in the context of modern challenges, such as the COVID-19 pandemic and the full-scale war, which leads to a new level of digital transformation of library activities. Thus, the electronic environment of a scientific library emerges not only as a tool for preserving and accessing information but also as an active platform for supporting science, education, and academic mobility in the context of global changes.

4. Own experience

The scientific libraries own electronic environment includes the library's official website: Available at: https://www.lsl.lviv.ua [7].

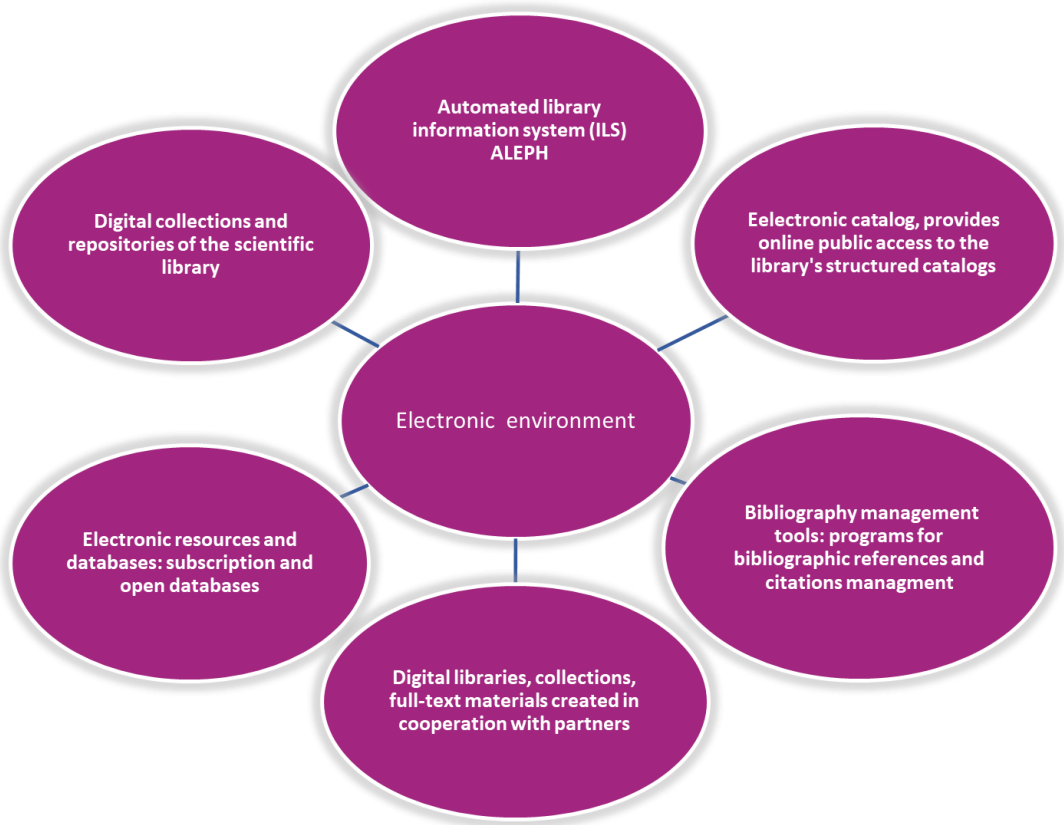

Figure 1: Structure of electronic environment of the scientific library.

If the above steps 3-6 fail, check the procedure at https://www.partitionwizard.com/disk-recovery/cant-install-fonts-windows-10.html.

Various methods and approaches covering both technical and organizational aspects used during the development of the project for the creation of an informational e-environment. Here are the main methods:

1. *Methods of developing the architecture of the web environment, which involve the use of Modular architecture, Microservice architecture, Single-page applications (SPA).*

Development uses individual components or modules that easily integrated and can reuse. The e-environment consists of independent services that can perform specific tasks. This allows the system to scale by adding new features without modifying the core code. This approach characterized by interaction that takes place on one web page with dynamic content updates, which increases speed and convenience for users.

2. *User interface design methods (UI/UX), including User-Centered Design (UCD), Responsive Design, Design Thinking.*

The first covers the analysis of user needs and the construction of an interface according to their expectations. This allows you to create intuitive and convenient e-environments. The second provides adaptation of the interface to different screens (mobile, tablet, PC) for a better user experience. The third approach focuses on user empathy, prototyping and testing solutions to create the best web experience.

3. *Content management methods, including Content Management Systems (CMS), Semantic Markup Methods, Metadata Management Methods.*

The use of CMS (for example, WordPress, Joomla) made it possible to simplify the process of creating, managing and publishing information on a web resource. Use of standardized markup languages (HTML5, XML) and semantic tags to ensure correct structuring and understanding of information. Metadata management techniques are important for improving information retrieval and search engine optimization (SEO). Different schemes used for tagging and categorizing content.

4. *Data management and storage methods, including relational and non-relational databases, Caching, Cloud storage and CDN (Content Delivery Network). Application of relational (SQL) and non-relational (NoSQL) databases for information storage and management.*

The choice of methods depends on the data type and scalability requirements. Implementing caching mechanisms (e.g., Redis, Memcached) ensures faster data access, which significantly enhances the performance of the electronic environment. Distributed storage and content delivery methods accelerate webpage loading times and reduce server load.

Building an information e-environment necessitates a comprehensive approach that integrates various methods. Each method addresses specific aspects of the web system, including architecture, usability and security, performance, and system integration.

Microservices architecture enables the development of self-contained units, each of which can designed, deployed, and scaled independently. This modular approach supports the creation of flexible and dynamic systems that can seamlessly adapt to evolving requirements and demands. Each microservice operates autonomously, containing its own database or interacting with other components via APIs. This structure allows for localized updates or modifications within a single service without influencing the broader system. Microservices typically optimized for specific tasks, such as user authentication, image processing, or customer data management, which allows for task-specific optimization.

Since microservices are independent, they can individually scaled based on workload demands. The e-environment of a research library is inherently modular, facilitating the addition of new features without rewriting or altering existing code. New functionalities can developed as separate microservices and integrated with the system through APIs. These services may employ diverse programming languages, frameworks, and technologies tailored to the specific requirements of each task, allowing for optimal tool selection.

The independence of microservices simplifies system maintenance and updates. Developers can update, modify, or resolve issues within individual services without having to shut down necessitating a system-wide. This architecture minimizes interdependencies between system components, ensuring that failures in one service do not critically influence the operation of others.

Webpages within the e-environment provide structured access to information about the library's operating hours, activities, history, virtual exhibitions, and other tools that enhance service delivery and provide access to scientific resources. The core components of a scientific library's e-environment encompass automated library information systems (ILS) like ALEPH, which automate key library processes including cataloging, acquisitions, circulation, and inventory management. Online public access catalogs (OPACs) enable remote searches for books, articles, and other resources. Digital collections and repositories provide access to digitized versions of printed materials, including books, manuscripts, periodicals, and newspapers. Subscription-based and open-access databases, such as PubMed, Web of Science, Elsevier, Research4Life, Scopus, and ScienceDirect, offer access to scientific articles, journals, books, and other materials. Finally, bibliography management tools like EndNote and Mendeley facilitate the creation and management of bibliographic references and citations [8].

The integration of these tools effectively enables scientific libraries to meet user requirements. Providing remote access to a wide range of resources and supporting modern forms of teaching and research, as well as offering opportunities for students and academic project leaders to gain valuable experience in engineering profession [9].

5. Main material

The development of the Library's electronic environment began with the creation of an electronic catalog. Initially, bibliographic descriptions of documents converted to the electronic catalog, and retrospective cataloging of the card file performed. This included work on a portion of the card alphabetical catalog (documents dated before 1990). The first step toward creating a digital version of the card alphabet catalog involved scanning catalog cards and forming the so-called Image Catalog. Currently, the Image Catalog, containing 4,240,000 bibliographic records, is available for remote users and forms an integral part of the e-infrastructure of the VSNSL of Ukraine in Lviv. Additionally, the Library's electronic catalog comprises over 717,458 bibliographic records corresponding to 1,329,957 document copies, while the authoritative records database contains more than 30,000 entries.

As part of international collaboration, users of VSNSL of Ukraine in Lviv provided with access to electronic resources from partner libraries. These include online catalogs of digital collections from institutions such as the Hill Museum & Manuscript Library, the Ossolinski National Institute in Wroclaw, the Silesian Digital Library, and the Municipal Public Library in Sanok. These collections feature digitized manuscripts, rare editions, and periodicals from the Library's holdings.

Project initiatives for presenting library collections and their digital copies realized through partnerships. These include platforms such as the Ossolinski National Institute's "Katalog zbiorow cyfrowych," the Silesian Digital Library, and the Hill Museum & Manuscript Library repository for the Library's archives and rare documents.

At present, digital collection, projects actively integrated into the scientific library's electronic infrastructure. These include problem-oriented databases and sub-collections designed using the ILS ALEPH system for categories such as electronic resources, periodicals, archives, and mixed-content electronic book publications.

To fulfill contemporary scientific and educational demands, the library provides registered researchers with online access to eleven problem-oriented databases (digital collections). These digital collections and sub-collections, developed and organized using the ILS ALEPH platform, encompass electronic resources, electronic versions of periodicals, electronic archives and archival documents, and electronic book publications of diverse content and formats.

- *Key Components of the Digital Collections.* Electronic Book Editions. Scientific publications of VSNSL of Ukraine in Lviv. Collections such as Stefanikiana, Yaroslav Dashkevich's collection, Dmytro Buchynskyi's collection, Rehabilitated Book, and The Shevchenko Scientific Society Heritage (1874–1913);
- *Electronic Resources.* Open-access digital libraries and repositories from Library partners;
- *Electronic Periodicals.* Ukrainian and Polish periodicals published between 1848–1939, including digital issues and yearbooks;
- *Archive of the Shevchenko Scientific Society* from the National Library of Poland in Warsaw and "Archives of the Shevchenko Scientific Society from the Ossolinski National Institute in Wroclaw", with descriptions and digitized archival files;
- *Incunabula Collection.* Rare book collections of VSNSL of Ukraine in Lviv [10].

Between 2019 and 2023, problem-oriented databases enriched with 2,088 new bibliographic descriptions and over 4,000 digitized documents in PDF format. During this period, 99,655 researchers utilized the Library's electronic resources, resulting in 231,657 online sessions. The digital collections alone engaged 54,568 researchers, with 77,194 work sessions recorded.

Access and Usage.

The Vasyl Stefanyk National Scientific Library of Ukraine in Lviv provides free access to its digital resources through its official website. The "Electronic Resources" page consolidates access to open-access sources, global electronic catalogs, library science journals, and institutional repositories.

Remote access to a wide range of resources enables academic libraries to effectively deliver information services and support modern education and research. This includes facilitating valuable experiences in engineering profession for students, faculty, and academic project leaders. These experiences encompass access to engineering databases, scientific articles, and patents; participation in seminars on the use of engineering software and technologies; and support for student projects.

Since 2018, the Library has secured agreements to provide access to scientific databases and platforms, including Elsevier, Research4Life, and Clarivate Analytics. During the full-scale war initiated by the Russian Federation, publishers like Elsevier and Research4Life granted Ukrainian researchers free access to scientific resources.

Supported Platforms and Resources.

Elsevier and Clarivate Analytics: Tools: *Researcher Discovery, Researcher Academy, PubMed, Mendeley*; Resources: *ScienceDirect* (e-books) and the scientometric platform *Web of Science Core Collection.*

Research4Life Portal. Access to materials from publishers like *Springer Nature, Taylor & Francis, Cambridge University Press,* and others.

EBSCO Information Service. Products: *Academic Search Complete and Energy & Power Sources.*

Specialized Archives. Full-text archives of Ukrainian historical periodicals *LIBRARIA* and digital media collections via the *Goethe-Institut Onleihe* Electronic Library.

Between 2018 and 2023, users of the *Web of Science Core Collection* platform conducted 1,670 searches across various disciplines, including the arts, humanities, and social sciences. 678 total studies and 300 subsessions reported.

Usage Statistics of Key Platforms and Databases.

The activity on the "Elsevier" platform, particularly the bibliographic and abstract database Scopus, reflects significant engagement. Detailed metrics are as follows:

- Scopus platform (Scopus.com) number of regular searches: 1,096; total number of studies: 1,250; number of views: 1,128.
- Total number of users of the Scopus platform for 2020: number of regular searches 92; total number of studies is 120; number of views in Scopus is 103.
- Total number of users of the *Web of Science Core Collection* platform for 2018–2023: the number of regular searches is 1,670; the total number of studies is 678, subsessions – 300.
- EBSCO Energy platform (2018-2020), incorporating databases such as *Academic Search Complete, Image Collection and Energy & Power Source*, recorded: total number of requests is 470; total number of searches is 101 [11].

The "Electronic Resources" webpage also facilitates access to additional domestic and international databases, open electronic resources, and open-access libraries.

Library Usage Metrics (2019–2024).

Over the past five years (2019–2024), the number of sessions conducted with the Library's online scientific reference database complex reached 154,463. This figure forms a critical part of the broader indicator representing user interaction with the electronic environment of the Vasyl Stefanyk National Scientific Library of Ukraine in Lviv.

Specialized Information Resources.

A dedicated section within the Library's electronic infrastructure is the "Full-Text Materials" webpage. Available at: https://www.lsl.lviv.ua/index.php/uk/povnotekstovi-materialy/). Here, users can access full-text electronic publications such as:

- *Annotated Bibliographic Index of Literature on Library Science, Bibliography, and Bibliography Issues.*
- *Bibliographic Index of Publications on Library Science, Bibliography, and Bibliography Issues (2004–2024).*

Leading staff from the Department of Library Science moderate and develop the content for these resources. These indexes feature annotated analytical descriptions of articles covering topics such as the history of librarianship, contemporary challenges in the field, and the organization and preservation of Ukraine's cultural heritage during martial law. The full-text version of these indexes is updated biannually and made available as part of the Library's "Full-Text Materials" electronic resource.

Remote access to the library's electronic resources, including scientific articles, patents, and scientometric databases, is critically important for the development of modern forms of education, especially in technical fields. This initiative creates a dynamic learning platform where students, faculty, and researchers can gain valuable practical experience. Participation in seminars and projects that involve the use of specialized software (SaaS, IaaS) and technologies significantly enhances their digital competence and readiness for professional activity. This directly contributes to the training of highly qualified engineering professionals who possess the skills to work with modern tools, and it accelerates scientific research that meets global standards. The implementation of these systems allows the library to effectively meet user needs, provide wide access to resources, and support modern educational and research methodologies. Thus, the library's electronic environment strengthens its function as an indispensable resource for the academic and research community, transforming it from a traditional repository into an interactive information resource. To achieve this goal, advanced technologies that form the core of the digital infrastructure are applied: Microservice Architecture: Instead of a monolithic system, the electronic environment consists of independent services that interact via APIs. Each service is responsible for a specific function (e.g., electronic catalog management, user authentication, resource usage analytics). This approach ensures flexibility, scalability, and resilience, as the failure of one service does not affect the operation of the entire system. New features can be added without a complete code rewrite, which significantly accelerates development. Cloud services and CDN (Content Delivery Network): The use of cloud platforms (e.g., AWS, Google Cloud) allows the library to host its resources and applications, ensuring high availability and reliability. CDN technologies distribute static content (digital copies of documents, images) across geographically distant servers. This minimizes delays and speeds up web page loading for users from different regions, significantly improving their user experience (UX). Access and user experience optimization. The digital transformation of the library covers not only internal processes but also user interaction, which requires the implementation of effective UX/UI solutions: User-Centered Design: The development process begins with a deep analysis of user needs (students, faculty, researchers). Based on this analysis, an intuitive and functional interface is created that allows for quick retrieval of needed information. A/B testing and regular user feedback help to continuously improve the interface. Responsive Design: The website and all its components automatically adapt to the screen size of the device, whether it is a smartphone, tablet, or desktop computer. This ensures a unified, seamless experience of accessing resources, regardless of where and from which device the user is working. Semantic markup and metadata management: The use of standardized metadata schemes, such as Dublin Core or MARC, allows for structuring information so that it is understandable not only to humans but also to machines. This significantly improves SEO (search engine optimization) and makes the library's content visible in external search engines, such as Google Scholar. The library's role in supporting engineering education and research. A modern scientific library becomes not just a source of information but an active partner in the

scientific and educational process. It provides access to scientometric platforms: access to Scopus and Web of Science allows researchers not only to access publications but also to analyze citations, track trends, and evaluate the effectiveness of their research. This is critically important for scholars who aspire to publish in international journals with a high impact factor. Specialized engineering databases: The library provides access to resources containing patents, preprints, and reference technical materials [12]. This enables engineering students to work on projects based on real data and develop innovative solutions. Scholar support services: The library offers seminars on the use of bibliographic managers (e.g., Mendeley, Zotero), training on academic integrity, and combating predatory journals. This shapes a culture of scientific work that meets international standards. The electronic environment of the Vasyl Stefanyk National Scientific Library of Ukraine in Lviv is a striking example of a successful digital transformation that has turned a traditional institution into a flexible and effective digital ecosystem hub. The implemented project solutions, based on a modern technological architecture and focused on user needs, have not only expanded access to resources but also improved the quality of scientific and educational services. This ecosystem ensures sustainable operation and is an indispensable tool for supporting the scientific and educational community of Ukraine, adapting to current challenges and opening up new opportunities for development.

6. Verification

Analysis of the electronic environment's functioning at the Vasyl Stefanyk National Scientific Library of Ukraine in Lviv reveals significant qualitative and quantitative shifts in information resource utilization. Consistent user engagement is evident, supported by over 230,000 online sessions across five years, averaging more than 46,000 sessions annually. This dynamic confirms that the achieved level of the library's digital presence aligns with projected indicators.

Increased electronic resource utilization is apparent, as demonstrated by reader access data. Between 2020 and 2024, total accesses rose from 10,365 to 40,978, indicating a positive trend in attracting users to digital collections.

The provision of remote access to electronic resources has been a key transformative element, expanding user capabilities regardless of location. Implementation of the electronic catalog, now containing over 717,458 bibliographic records representing 1,329,957 document copies, has substantially optimized information search processes.

Project initiatives presenting library holdings and their digital copies on partner platforms have enhanced the visibility and accessibility of unique collections. The active integration of problem-oriented databases and sub-collections within the digital collections has enabled a new level of thematic access to scientific information.

Online access to eleven problem-oriented databases for registered researchers has become a crucial factor in supporting scholarly activities. The positive momentum in digital fund growth reflected in the electronic environment's active development: from 2019 to 2023, problem-oriented databases augmented by 2,088 bibliographic descriptions and over 4,000 digital documents.

Significant electronic resource user activity recorded, with 99,655 unique researchers generating 231,657 online sessions. This underscores the growing prominence of digital resources and their importance to the scientific community. Intensive use of the library's online scientific complexes, notably the Web of Science Core Collection platform (1,670 searches) and online reference databases (154,463 sessions from 2019 to 2024), demonstrates the library's effective integration into the global scholarly network.

The increase in the total number of accesses to electronic collections from 10,365 in 2020 to 40,978 in 2024 highlights the significant growth in user interest in the library's digital resources. The most popular accessed electronic collections from 2023 to 2024 include "Electronic version of the periodicals from VSNSL of Ukraine in Lviv", "Electronic resources", "Scientific editions of VSNSL of Ukraine in Lviv)" and " Archive of the Shevchenko Scientific Society from the National Library of

Poland Collections in Warsaw" (*http://aleph.lsl.lviv.ua:8991/F/...EARNTSHNBW*), reflecting current user research interests.

Overall, the presented quantitative data confirms the positive impact of creating an electronic environment on VSNSL of Ukraine in Lviv operations, ensuring greater resource availability, process automation, and improved user experience. The data validates that the library's electronic environment effectively fulfills its functional purpose by significantly enhancing access to scientific information, aligning with the article's research objectives. These mentioned changes evidence a substantial digital transformation in library activities, expanding access to information resources of VSNSL of Ukraine in Lviv, and promoting active user engagement with electronic services.

7. Conclusions

The electronic environment of the Vasyl Stefanyk National Scientific Library of Ukraine in Lviv (https://www.lsl.lviv.ua) plays a critical role in providing comprehensive access to scientific information, particularly for remote researchers. The core components of this environment include.

- ***ILS ALEPH:*** An integrated library system that automates essential library processes.
- ***Electronic Catalog:*** A structured, open-access digital collection supporting distributed and remote resource searching.
- ***Digital Collections and Repositories:*** Providing access to digital versions of books, archival documents, periodicals, and newspapers.
- ***Scientific Reference Databases:*** Open-access and project-based platforms offering an extensive range of academic resources, including articles, journals, and books.
- ***Bibliography Management Tools:*** Simplifying the creation and management of bibliographic references for academic work.

Remote access to the library's electronic resources, including scientific articles, patents, and engineering databases, facilitates the development of modern forms of education in technical fields. Students, faculty, and researchers have the opportunity to gain valuable experience by participating in seminars and projects that involve the use of specialized software and technologies. This contributes to the training of highly qualified engineering profession and the advancement of scientific research.

The implementation of these systems enables the Library to effectively meet user needs, facilitate wide-ranging access to resources, and support contemporary educational and research methodologies. Consequently, the Library's electronic environment enhances its function as an indispensable resource for the academic and research communities

Declaration on Generative AI

During the preparation of this paper, the authors used OpenAI GPT-4o for grammar and spelling checking. All intellectual contributions are the authors' own and they are takes full responsibility for the publication's content.

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