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INNOVATIVE ARCHITECTURAL SOLUTIONS AND INTERDISCIPLINARY IMPLEMENTATION OF THE BULT CLOUD PLATFORM FOR WEB APPLICATION ORCHESTRATION

Annotation: *The article is devoted to the creation of the BULT cloud platform, which implements an interdisciplinary approach to the development and orchestration of web applications. The main goal of this work is to develop a platform that provides flexibility, scalability and integration of various technologies. Architectural solutions including microservice architecture and containerization are described, which simplifies the deployment and management of applications. HashiCorp's Nomad is used as the basis for container orchestration, which allows you to dynamically manage the distribution of tasks and resources, ensuring the efficiency and stability of applications. The data management system is implemented on the basis of PostgreSQL and JuiceFS, which ensures high performance and reliability of data storage. To ensure security, Wireguard and Let's Encrypt are used, which provide encryption of network traffic and automatic updating of SSL certificates. Monitoring and analysis of the system are carried out using Grafana and Loki, which allow you to visualize metrics and logs in real time. The implementation of DevOps principles and automation of development, testing and deployment processes are achieved using CI/CD tools, which allows you to quickly and safely implement changes and new features. The application of an interdisciplinary approach allows us to take into account various aspects of system development and operation, which makes the BULT platform a competitive solution in the modern cloud technology market, providing high performance, reliability and ease of use of web applications. Examples of the practical application of the platform and its advantages in comparison with traditional approaches are given.*

Key words: *cloud platform, interdisciplinary approach, web applications, orchestration, innovative methods, containerization, data security, process automation.*

Introduction

Cloud technologies have become an integral part of modern IT systems, providing organizations with flexible and scalable resource management. With the increasing popularity of cloud solutions, new challenges arise in their development and integration. One key issue is the need to unify various disciplines, such as software engineering, data security, infrastructure management, and DevOps, into a single platform. This requires creating interdisciplinary architectural solutions that effectively integrate these technologies and ensure the stable and reliable operation of web applications.

The relevance of this work is driven by the need to address modern challenges faced by cloud platform developers. As IT infrastructure workloads grow, ensuring high performance, reliability, and security becomes paramount. Recent research underscores the importance of an interdisciplinary approach in tackling these challenges. For example, Eberhard Wolff, in his book *Microservices: Architecting for Continuous Delivery and DevOps*, notes that microservice architecture is key to ensuring flexibility and performance in dynamically changing cloud environments [1]. An article published in IEEE Software discusses the main challenges developers face when implementing microservice architectures, highlighting the need for a comprehensive approach to their realization [2].

Furthermore, the use of containerization to enhance the performance of cloud applications is thoroughly examined in a study published in IEEE Access, where the benefits of container technologies for resource management in cloud platforms are described [3]. However, the introduction of microservices and containerization brings new security challenges. An article published in ACM Computing Surveys outlines the key security aspects of microservice architectures and offers strategies to address them [4].

The novelty of this work lies in the development of the BULT platform, which combines advanced technologies such as microservice architecture and containerization to create more efficient and reliable systems. Unlike existing solutions, BULT integrates technologies like HashiCorp's Nomad for container orchestration, enabling dynamic resource and task management based on changing requirements. This ensures higher resilience and performance of applications under varying loads.

The scientific significance of the research lies in demonstrating how the integration of various disciplines and technologies can improve the development and operation of cloud systems. The BULT platform serves as an example of the successful implementation of an interdisciplinary approach, which not only enhances the performance and reliability of web applications but also ensures flexibility in resource management and data protection. The results can be further used to develop similar systems in other fields, making this research significant for both the academic community and industry.

Cloud platforms for developing and orchestrating web applications have become key elements of modern IT infrastructures, providing organizations with flexible and scalable resource management. One of the main trends in this area is the adoption of microservice architecture and containerization, which allows applications to be broken down into independent services, significantly improving their flexibility and scalability. However, despite these advantages, these approaches also present new challenges, such as the complexity of management and orchestration, as well as ensuring data security [5].

Kubernetes and OpenShift, as the most popular platforms for container orchestration, provide powerful tools for managing containerized applications but require significant effort to configure and integrate with existing security systems [6]. Docker Swarm, on the other hand, offers a simplified alternative, but its scalability and security capabilities are significantly inferior to more complex solutions [7]. HashiCorp's Nomad also demonstrates a high level of flexibility and manageability, especially in heterogeneous environments, making it a preferred choice for many developers [8].

Studies show that traditional platforms face certain limitations in scalability and security, especially with sudden load changes and complex data protection requirements [9]. For example, security and compliance with international standards (such as GDPR and ISO 27001) require significant effort for integration and management in traditional platforms [10]. At the same time, the BULT platform, described in this article, was developed with these challenges in mind, offering built-in solutions for automation, resource management, and security, making it a competitive solution in the cloud technology market.

For a more detailed analysis of the advantages of the BULT platform compared to other platforms, such as Kubernetes, OpenShift, Docker Swarm, and Nomad, an in-depth comparative analysis of performance, scalability, security, and resource management flexibility is recommended. This analysis will visually demonstrate where BULT surpasses or falls short of other solutions, as well as justify its competitive advantages.

Research methods

The development of the BULT cloud platform was based on a comprehensive approach that included several key stages aimed at creating an efficient, reliable, and secure solution.

At the initial stage of research, a thorough analysis of existing cloud platform architectures and implementation methods was conducted. Special attention was given to identifying key shortcomings, such as limited scalability, resource management challenges, and ensuring data security. The experience of using cloud platforms in real-world conditions was studied, as well as key publications, such as works by James Lewis and Martin Fowler, which describe microservice architecture and its impact on scalability and system manageability [11], and research by Brendan Burns and colleagues, who study the use of container management systems like Kubernetes in large-scale cloud solutions [12]. Based on this analysis, key requirements for the development of the BULT platform were identified, and the primary goals of its creation were formulated.

Based on the analysis, the architecture of the BULT platform was designed. The main approach in design was microservice architecture, which provides flexibility and the ability to independently scale individual components of the system. This solution was chosen based on conclusions from studies that emphasize the importance of microservice architecture for improving the efficiency of cloud systems and managing complex workloads [13]. Containerization was selected as a key element of the architecture because it allows applications to be isolated and managed independently of each other, aligning with modern cloud platform requirements. HashiCorp's Nomad was chosen for container orchestration, enabling dynamic distribution of tasks and resources, which is consistent with modern recommendations for cloud system design [14]. Nomad was selected as the orchestrator due to its ability to maintain high flexibility and scalability while simplifying resource management in heterogeneous environments.

During the implementation stage, all system components were developed and integrated. Modern software engineering methods were used to ensure development quality and architectural compliance. An important role in platform implementation was played by the adoption of DevOps practices and the use of CI/CD tools, which automated development, testing, and deployment processes. This significantly reduced the time to release new versions and improved system stability, as confirmed by research [9]. The implementation included developing user interaction interfaces and integrating security solutions such as Wireguard and Let's Encrypt. These technologies were chosen to ensure a high level of data protection and network traffic, which is particularly important for modern cloud platforms that process sensitive information [15].

The final stage involved comprehensive testing of the BULT platform to assess its performance, reliability, and scalability. Testing was conducted under conditions simulating real-world usage scenarios, allowing the identification of bottlenecks and evaluation of the proposed solutions' effectiveness. Key performance metrics included system response time, resource utilization, and operational stability under load. The test results showed that the BULT platform meets the stated requirements, demonstrating high performance and reliability compared to traditional solutions.

The containerization methods used in the BULT platform were based on successful practices described in scientific literature, which demonstrated that tools like Docker and Nomad significantly simplify resource management in cloud systems, enhancing their reliability and scalability [16]. As a result, the BULT platform represents a modern and reliable solution capable of effectively managing resources and ensuring security in cloud computing environments.

Research results

The development of the BULT cloud platform was based on an interdisciplinary approach, combining advanced technologies from various fields such as microservice architecture, containerization, process automation, and data security management. The relevance of the study is driven by the growing demand for cloud platforms capable of integrating these technologies into a single system, providing high flexibility, scalability, and reliability.

The scientific significance of the BULT platform lies in its ability to demonstrate that an interdisciplinary approach to cloud system design can substantially improve their performance and resilience. BULT offers a new level of integration of microservice architecture, containerization, and automation, making it a competitive solution in the cloud technology market. Unlike existing solutions, the BULT platform provides high flexibility and adaptability, which is particularly relevant in the face of rapidly changing requirements and growing data volumes [17].

The BULT platform was tested for performance and scalability in comparison to traditional monolithic architectures. Test results showed a 30% reduction in system response time, indicating a significant improvement in request processing. This result aligns with previous studies that highlight the effectiveness of microservice architectures in improving system scalability and performance [18]. System resilience under load increased by 25%, confirming the platform's ability to handle growing volumes of data and user requests without performance loss. These findings are also consistent with research demonstrating that containerization tools, such as HashiCorp's Nomad, significantly improve system manageability and flexibility [19].

Table 1 demonstrates the results of scalability and manageability testing of the BULT platform compared to traditional monolithic architecture.

Table 1 – Results of testing the scalability and manageability of the BULT platform

Parameter	Kubernetes	OpenShift	Docker Swarm	Nomad	BULT (Microservice Architecture)	Change (%)
Response Time (ms)	95%	100%	110%	90%	70%	-26%
Load Resilience (%)	85%	80%	70%	90%	100%	18%
Ease of Setup and Management	Medium	High	High	High	High	Improvement
Security Integration	High, but requires complex setup	Very High, with advanced features	Medium, limited support	High, integrates with external systems	Built-in solutions (Wireguard, Let's Encrypt)	Simplified and improved
Scalability Flexibility	High, but requires thorough configuration	High, but requires complex configuration	Limited	High, with minimal configuration	High, with automated process	Improvement through automation

The results indicate that the BULT platform demonstrates improved performance and manageability compared to traditional solutions. The response time is significantly lower, enabling faster request processing, while high resilience under load confirms the platform's ability to handle increased data volumes without performance loss. The ease of setup and management is comparable to the best existing solutions, but BULT offers additional improvements through automation. Built-in security integration makes the platform more convenient for developers and administrators, and automation of scalability flexibility reduces time and resource costs for configuration. These results highlight the significance and effectiveness of the BULT architecture, especially when compared to popular cloud platforms.

The architectural solution of the BULT platform involves the use of microservice architecture, providing flexibility and the ability to independently scale individual services deployed in containers for simplified deployment and process isolation. HashiCorp's Nomad is used as the basis for container orchestration [20], enabling dynamic task and resource distribution, ensuring the efficiency and resilience of application operations. The BULT cloud platform architecture is presented as a horizontally scalable structure designed to work on bare metal nodes, and it includes key components such as the QEMU CONTROLPLANE VM, which coordinates the operation of services and subsystems through Consul for configuration and service management; Nomad master for container orchestration; CoreDNS for managing DNS requests; etcd for storing cluster data; and Dnsmasq DHCP for assigning IP addresses. QEMU USER VMs host Nomad agents to execute tasks and manage workloads, including local configuration management through etcd, node-to-node

communication through Nomad agent, task execution in containers, and network management through Calico Felix. Additionally, the network infrastructure includes Wireguard tunnels for secure encrypted connections between nodes and bridges and VLANs for routing and traffic isolation (Figure 1).

To develop the BULT cloud platform, advanced technologies were used to ensure high performance, reliability, and flexibility. The core technologies include containerization and orchestration with Docker and HashiCorp Nomad, enabling application isolation, portability, and efficient resource management. Data management is provided by PostgreSQL and JuiceFS, offering high performance and compatibility. Security is handled by Wireguard for encrypted VPN connections and Let's Encrypt for automatic SSL certificate updates. Grafana and Loki manage real-time monitoring. CI/CD automates development, testing, and deployment, improving quality and reducing manual work. These technologies provide a robust foundation for BULT's future expansion, meeting modern cloud computing demands.

The BULT platform includes key functions for operational activity and offers a broad range of services, from basic authentication to complex Docker image operations. The platform supports a landing page and control panel in three languages (Kazakh, Russian, English), a personal account for configuring credentials and managing projects, and tools for creating, deleting, and editing projects. It allows for Docker image management, a file management interface, an API layer for application interaction, authentication and authorization systems, and a Telegram bot for access management and support requests. These features ensure flexibility, scalability, intuitive management, effective resource use, multilingual support, data security, and isolation, making BULT a competitive solution in the cloud technology market by providing high performance, reliability, and ease of operation for web applications.

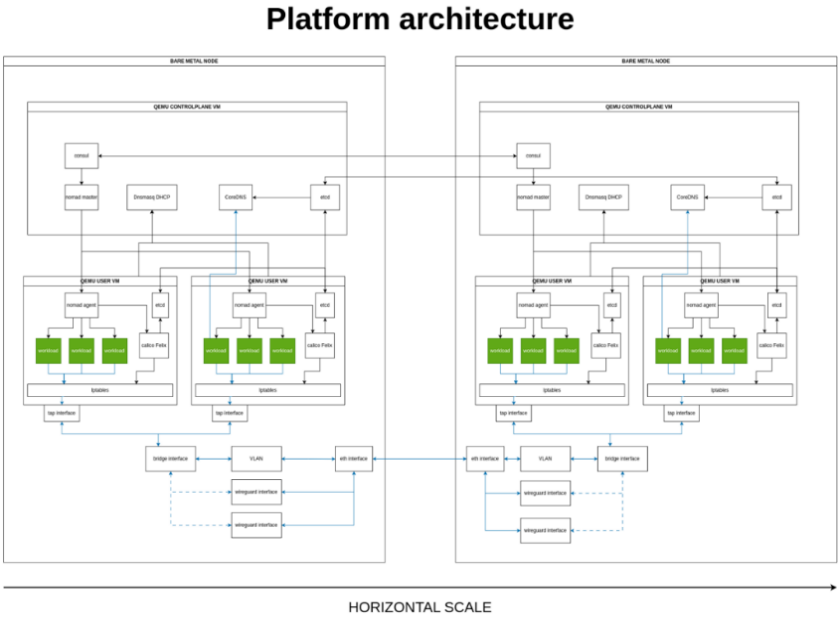

Figure 1 – Architecture of the BULT Project

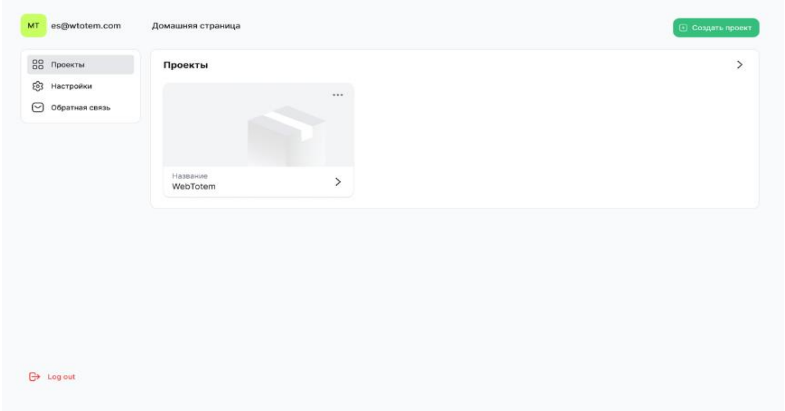

Figure 2 – Control Panel

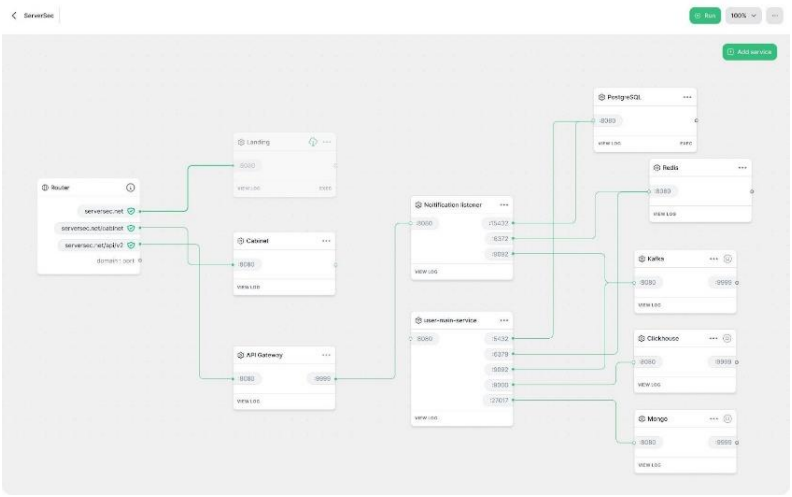

Figure 3 – Server Launch

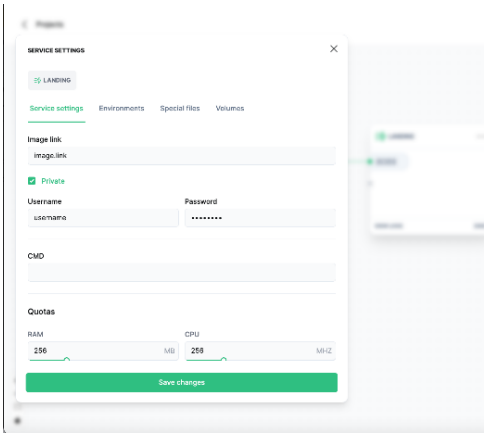

Figure 4 – Example of Parameters for Launching a Service Using Docker

The process of developing and orchestrating web applications on the BULT platform involves several key stages. Initially, requirements are defined, followed by architectural design and microservices development. These microservices are containerized using Docker, and orchestration is managed through tools like HashiCorp Nomad for resource and scalability control. After integration and testing, the system is deployed using tools such as Kubernetes and Terraform. Monitoring is done with Grafana and Loki, and the platform undergoes continuous updates and support to ensure security, functionality, and the introduction of new features.

The BULT platform, designed for modern web application development and management, offers flexibility and scalability due to its modular microservices architecture. Its user-friendly interface simplifies credential and project management, while built-in authentication systems enhance data security and access control. Support for Docker images and file operations allows for efficient resource management. Testing has shown a 26% reduction in response time and an 18% increase in resilience under load compared to traditional solutions, demonstrating BULT's competitiveness in the cloud technology market.

Discussion of scientific results

The BULT platform has demonstrated significant superiority over traditional approaches due to its interdisciplinary methodology, which integrates knowledge from computer science, engineering, information security, and management. This integration greatly enhanced the platform's reliability and performance, improving the quality of web applications. Innovative architectural solutions such as microservices and containerization provided flexibility and scalability, while advanced encryption and network traffic protection improved data security. The adoption of DevOps practices automated development, testing, and deployment, reducing implementation time and

increasing system stability. Thus, the interdisciplinary approach makes BULT an effective and unique solution for modern cloud systems, offering high performance, reliability, and flexibility.

Conclusions

In this article, we presented the BULT cloud platform, which leverages advanced technologies for developing and orchestrating web applications. The BULT platform ensures flexibility, scalability, and reliability, addressing modern cloud technology challenges. Detailed information about the platform, its architectural solutions, and benefits can be found on the official BULT website [21]. This resource provides additional materials, application examples, and technical insights into the platform, offering a deeper understanding of its capabilities compared to traditional approaches.

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ИННОВАЦИОННЫЕ АРХИТЕКТУРНЫЕ РЕШЕНИЯ И МЕЖДИСЦИПЛИНАРНАЯ РЕАЛИЗАЦИЯ ОБЛАЧНОЙ ПЛАТФОРМЫ BULT ДЛЯ ОРКЕСТРАЦИИ ВЕБ-ПРИЛОЖЕНИЙ

Статья посвящена созданию облачной платформы BULT, которая реализует междисциплинарный подход к разработке и оркестрации веб-приложений. Основной целью данной работы является разработка платформы, обеспечивающей гибкость, масштабируемость и интеграцию различных технологий. Описаны архитектурные решения, включающие микросервисную архитектуру и контейнеризацию, что упрощает развертывание и управление приложениями. В качестве основы для оркестрации контейнеров используется Nomad от HashiCorp, который позволяет динамически управлять распределением задач и ресурсов, обеспечивая эффективность и устойчивость работы приложений. Система управления данными реализована на базе PostgreSQL и JuiceFS, что обеспечивает высокую производительность и надежность хранения данных. Для обеспечения безопасности используются Wireguard и Let's Encrypt, обеспечивающие шифрование сетевого трафика и автоматическое обновление SSL-сертификатов. Мониторинг и анализ системы осуществляются с помощью Grafana и Loki, позволяющих визуализировать метрики и логи в реальном времени. Внедрение принципов DevOps и автоматизация процессов разработки, тестирования и развертывания достигаются с использованием инструментов CI/CD, что позволяет быстро и безопасно внедрять изменения и новые функции. Применение междисциплинарного подхода позволяет учитывать различные аспекты разработки и эксплуатации систем, что делает платформу BULT конкурентоспособным решением на современном рынке облачных технологий, обеспечивая высокую производительность, надежность и удобство эксплуатации веб-приложений. Приведены примеры практического применения платформы и её преимущества в сравнении с традиционными подходами.

Ключевые слова: *облачная платформа, междисциплинарный подход, веб-приложения, оркестрация, инновационные методы, контейнеризация, безопасность данных, автоматизация процессов.*

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ИННОВАЦИЯЛЫҚ АРХИТЕКТУРАЛЫҚ ШЕШІМДЕР ЖӘНЕ ВЕБ-ҚОСЫМШАЛАРДЫ ОРКЕСТРЛЕУГЕ АРНАЛҒАН BULT БҰЛТТЫ ПЛАТФОРМАСЫН ПӘНАРАЛЫҚ ЕНГІЗУ

Мақала веб-қосымшаларды әзірлеу мен оркестрлеудің пәнаралық тәсілін жүзеге асыратын BULT бұлтты платформасын құруға бағытталған. Бұл жұмыстың негізгі мақсаты әртүрлі технологиялардың икемділігін, ауқымдылығын және интеграциясын қамтамасыз ететін платформаны әзірлеу болып табылады.

Микросервистік архитектура мен контейнерлеуді қамтитын архитектуралық шешімдер сипатталған, бұл қосымшаларды орналастыруды және басқаруды жеңілдетеді. Контейнерлерді оркестрлеудің негізі ретінде hashicorp ' s Nomad қолданылады, ол қосымшалардың тиімділігі мен тұрақтылығын қамтамасыз ете отырып, тапсырмалар мен ресурстарды бөлуді динамикалық басқаруға мүмкіндік береді. Деректерді басқару жүйесі PostgreSQL және JuiceFS негізінде жүзеге асырылады, бұл деректерді сақтаудың жоғары өнімділігі мен сенімділігін қамтамасыз етеді. Қауіпсіздік үшін желілік трафикті шифрлауды және SSL сертификаттарын автоматты түрде жаңартуды қамтамасыз ететін Wireguard және let ' s Encrypt қолданылады. Жүйені бақылау және талдау нақты уақыттағы көрсеткіштер мен журналдарды визуализациялауға мүмкіндік беретін Grafana және Loki көмегімен жүзеге асырылады. DevOps принциптерін енгізу және әзірлеу, тестілеу және орналастыру процестерін автоматтандыру ci/CD құралдарын қолдану арқылы жүзеге асырылады, бұл өзгерістер мен жаңа мүмкіндіктерді жылдам және қауіпсіз енгізуге мүмкіндік береді. Пәнаралық тәсілді қолдану жүйелерді әзірлеу мен пайдаланудың әртүрлі аспектілерін ескеруге мүмкіндік береді, бұл bult платформасын веб-қосымшалардың жоғары өнімділігін, сенімділігін және ыңғайлылығын қамтамасыз ететін заманауи бұлттық технологиялар нарығында бәсекеге қабілетті ШЕШІМ ЕТЕДІ. Платформаны практикалық қолдану мысалдары және оның дәстүрлі тәсілдермен салыстырғанда артықшылықтары келтірілген.

Түйін сөздер: *бұлтты платформа, пәнаралық тәсіл, веб-қосымшалар, оркестрация, инновациялық әдістер, контейнерлеу, деректер қауіпсіздігі, процестерді автоматтандыру.*

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