The Use of Serverless Technologies to Support Data Processing within the Open Learning and Research Systems

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Abstract: The article highlights the promising ways of providing access to cloud-based tools using serverless solutions to support data processing within the open learning and research environment. It is emphasized that the implementation of serverless technologies is a current trend in the development of modern ICT open learning and research systems. The concept of the hybrid serverless cloud is considered. The analysis and evaluation of the existing experience of using different types of cloud-based solutions to data processing support are considered and evaluated. The example of the wave files processing using the lambda-function is examined. The issues of integration of different services within the open systems of learning and research are covered. A concept of the cloud-based open learning and research university environment involving the use of the serverless cloud-based components is considered. The reasonable ways of tools selection are evaluated and the prospects for their use within the cloud-based open learning and research environment are described.

1 INTRODUCTION

The formation and development of a cloud-based learning and research environment, taking into account the principles of open science is an important area of modernization of the educational process in higher education, the leading trend in the development of pedagogical systems of open education within the European Research Area (ERA, 2015). Thanks to the use of cloud technologies there is an opportunity to build more convenient, flexible, scalable systems for access to electronic resources and services in the process of learning and research, creating conditions for teamwork with software applications along with the removal of geographical and time constraints, providing mobility of all subjects (Bondarenko et al., 2019; Bykov and Shyshkina, 2018; Bykov et al., 2020). This creates a basis for the implementation of the principles and technologies of open science for a wider range of users, the creation and operation of virtual research teams, improving scientific communication processes, access to data in the research process, implementation of their results, interaction with society (www.fosteropenscience.eu, 2019). Cloud computing tools and services form an information technology platform of the modern educational and scientific environment, becoming a network tool for the formation of this environment (Bargmann, 2018; Hevko et al., 2021; Markova et al., 2015; Mazorchuk et al., 2020; Munk et al., 2020; Roberts and Chapin, 2017). Thus, it becomes relevant to analyze trends in the implementation of cloud data processing services into the activities of a scientist and also the research or educational institution.

2 THE RESEARCH RESULTS

2.1 The Background Issues

Cloud computing in several kinds of available models, such as IaaS, PaaS and SaaS, plays an important role in facilitating learning and research data processing. Providing abstraction of resources and simple automation tools, modern cloud platforms simplify most routine tasks such as installation, maintenance,

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backup, security, and more (Bykov et al., 2020; Svetsky et al., 2017). Moreover, today, the concept of open science deals with open data and big data processing. To fit the requirements of open science systems design large amounts of data are to be available for users access and joint processing. Thus the cloud computing platforms may serve as a reasonable framework to support open learning and research processes both in terms of maintaining and processing a large amount of data and also to make it available for the community of scientists for joint processing, retrieving and evaluation (Bykov et al., 2020).

The computing capacity becomes crucial for large amounts of data processing and retrieval, as this kind of activity is needed at most stages the research process, such as data collecting, representation, visualization, analysis, interpretation and discussion. The possible way to save resources and to provide flexible use of the cloud-based infrastructure is using lambda-function within the serverless settings. This leads to the notion of Function-As-A-Service (FAAS) as a promising available cloud-based model (Roberts and Chapin, 2017; Bargmann, 2018; Jonas et al., 2019; van Eyk et al., 2018).

The serverless computing applications in different areas and their estimation are among the most current issues considered nowadays, for example for machine learning (Kurz, 2021), network functions virtualization (Aditya et al., 2019), geospatial architectures (Bebortta et al., 2020). Casale et al. (Casale et al., 2020) propose the platform for decomposition and orchestration for serverless computing. Ortiz (Ortiz, 2019) present architecting serverless microservices on the cloud with AWS and also issues of instructors training to use these technologies. Still the area of educational application of serverless technologies to provide better use and implementation for learning and research within the university sector is poorly investigated and needs further research. There is a need to consider methodological issues and possible ways of serverless technology application within the open learning and research university environment.

The article aims to consider and evaluate a hybrid cloud-based serverless architecture as the possible open learning and research platform to support data processing and research collaboration. The main idea is that design and development of learning and research environment due to the proposed approach will result in more efficient use of the cloud-based resources, better access to learning and research data and collaboration support. The case study of the sound signal processing as possible example of serverless approach application for learning and research is considered.

2.2 The Conceptual Basis

The conceptual and terminological body of investigation and the main principles of designing and developing university cloud-based learning and research environment such as the principles of open science, open education, as well as the specific principles inherent in cloud-oriented systems are considered by Bykov and Shyshkina (Bykov and Shyshkina, 2018).

The cloud-based learning and research environment (LRE) of a higher education institution is the environment in which the virtualized computer-technological (corporate or hybrid-based) infrastructure is purposefully built for the realization of computer-procedural functions (such as content-technological and information-communication functions) (Bykov and Shyshkina, 2018).

Serverless technologies are used to build applications that are hardly predictable as for the amount of the computer capacities necessary for their processing. The serverless hybrid cloud architecture is designed to deploy the lambda-functions (aws.amazon.com, 2019).

The lambda-function is a cloud-based service model when the computing is fulfilled within the cloud-based infrastructure of a provider on user demand and the user needn't create and manage the server architecture.

2.3 The Model and Approach

In figure 1, the configuration of the serverless application architecture is shown.

The overall approach is to access Lambda-function trough API Gateway, avoiding server management as Lambda-function returns the values into the static HTML format, the data retrieved on S3-basket, that may be outputted and processed.

In this case, a user refers to certain electronic resources and a computing capacity set on a hybrid serverless architecture from any device using the Internet connection.

The advantage of the proposed approach is that, in learning or research processes, it is necessary to use computing capacities for special purposes that may appear eventually due to the current need. In particular, in the course of the experimental research, big data processing may be needed that require much computer capacity for a short period. It may be redundant to maintain and manage the cloud server for these purposes. At the same time, there is a possibility of designing special lambda functions so the

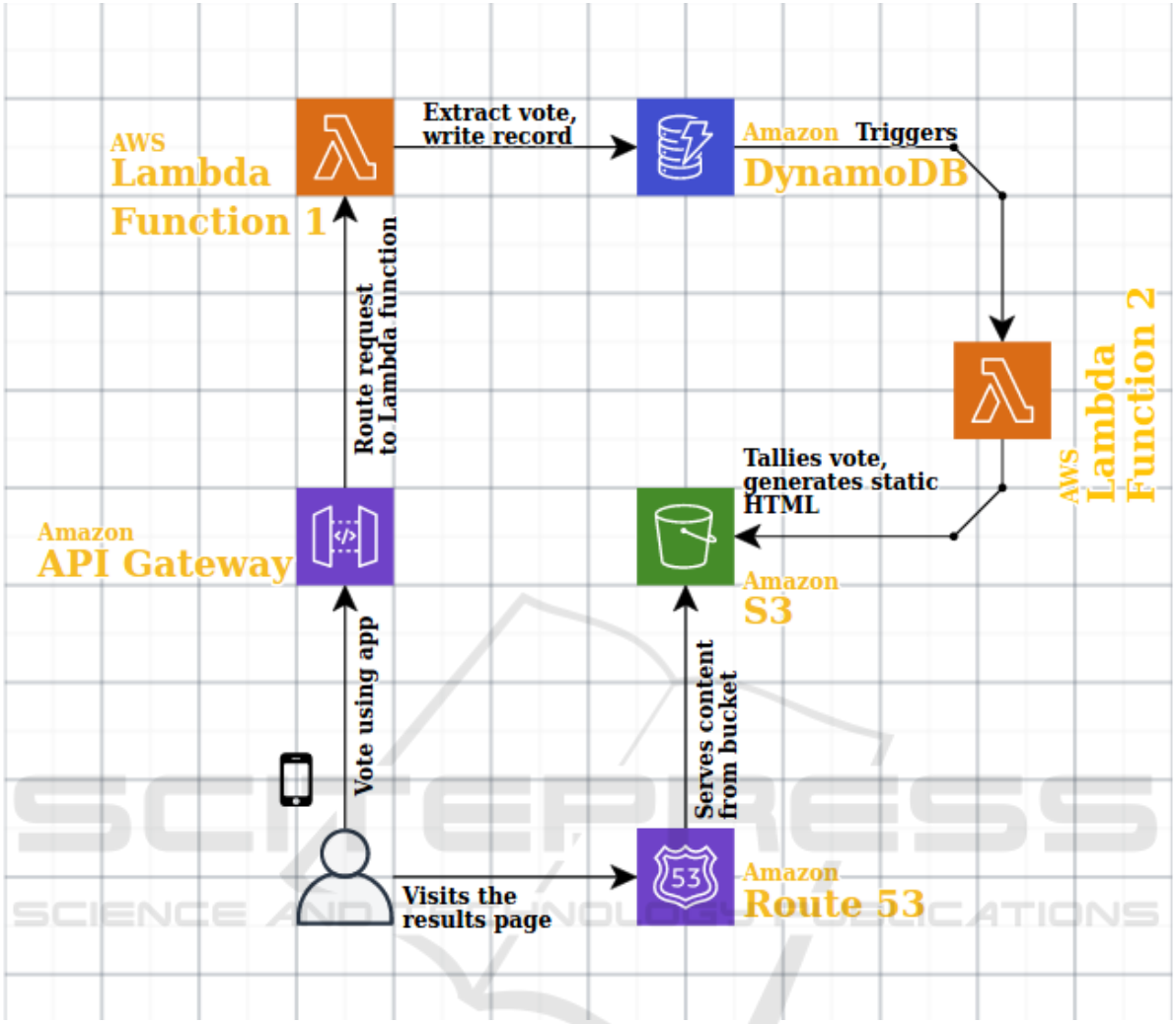

Figure 1: The serverless application architecture (retrieved from https://app.cloudcraft.co/).

learner or researcher can access them via the Internet and use the server with the powerful processing capabilities without deploying it any time as the function is needed. The necessary resources can be supplied more flexibly on demand.

2.4 Current Developments and Implementation

The cloud-based LRE was implemented at the Institute for Digitalisation of Education of the National Academy of Educational Sciences of Ukraine in the course of research projects and pedagogical experiments conducted during 2012–2017. During that period, cloud-based services for open education and open science support were introduced in the research and educational process (Bykov and Shyshkina, 2018).

In 2018 the V4+ Academic Research Consortium Integrating Databases, Robotics and Language Technologies was established, which aimed to address regional issues related to EU ICT research priorities. The BOX Cloud shared work-space – the shared work-space for all partners was built on the IBM BOX Cloud for storage and transfer of documents that networked researchers' computers. Virtual machine with Windows 10 – this virtual machine is simply a shared computer with Windows 10 in the form of a remote desktop was used to support open learning and research collaboration (Bykov et al., 2020).

The cloud-based components that had been elaborated and tested within this period of research were implemented in the learning process. The learning course "Cloud Computing Technologies" was developed and introduced in National University of Life and Environmental Sciences of Ukraine for train-

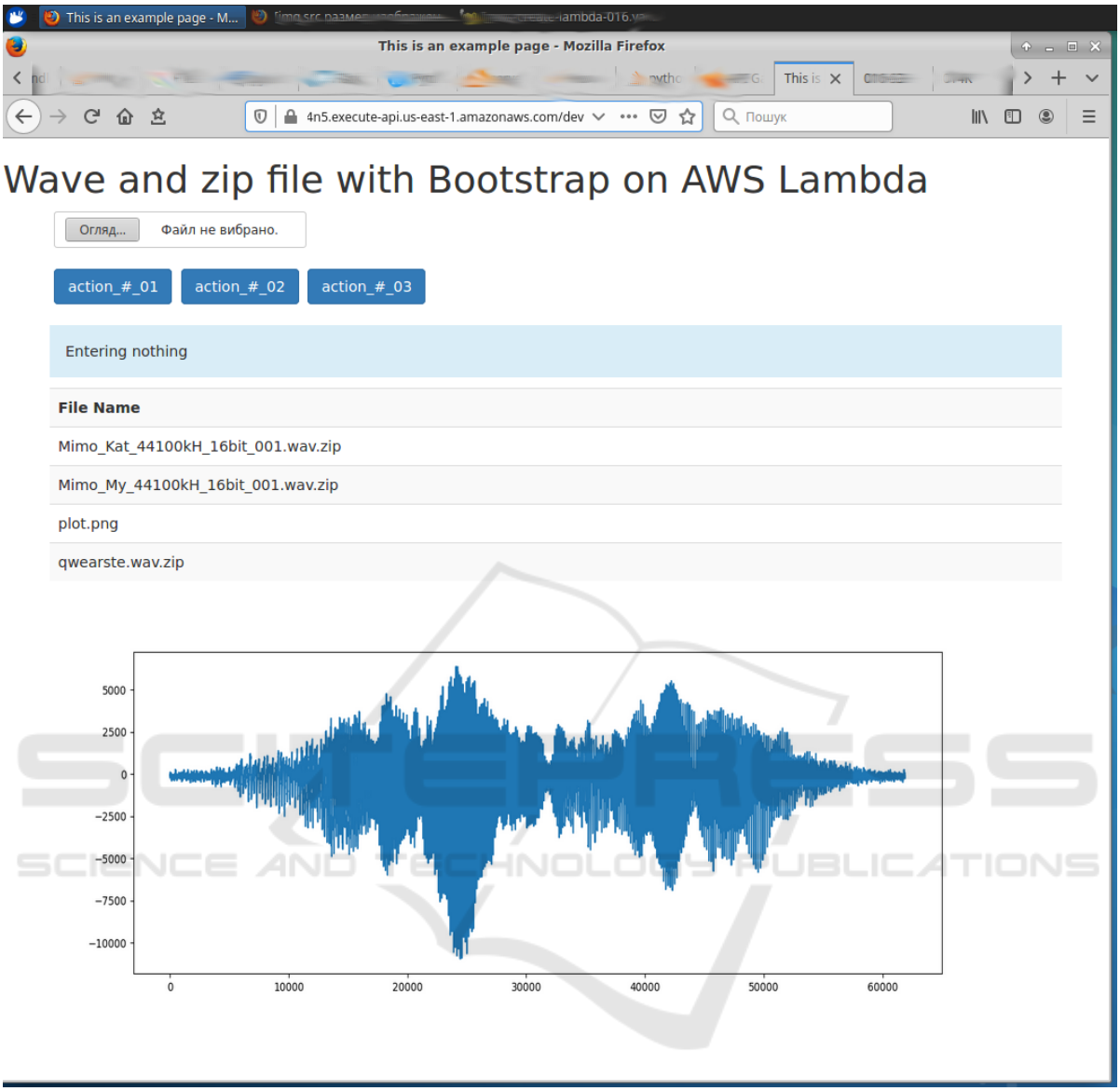

Figure 2: The result of the lambda-function processing the wave file.

ing computer science bachelors. The students were trained to build cloud-based components on virtual machines using AWS and Azure platforms. The methodology of open learning and research platform implementation proved to be useful.

The next step of the research was the creation of the serverless hybrid cloud architecture to support collaborative research with Kyiv Glushkov Institute of Cybernetics of NAN of Ukraine. The script was used for uploading and output of the sound signal oscillogram using Python programming language with the library Matplotlib within the framework Flask. The lambda-function was used to build the sound signal oscillogram and make the image (figure 2).

The serverless environment was used for the solving of tasks of wave rows analysis:

1. A Python-based Internet application tested on localhost using the Flask framework was created.
2. In the AWS console, a user account with necessary permissions to protect future applications was created. On this user account, an S3 bucket and an EC2 server were created. On S3 the working folder with the script in Python (or another working language for AWS Lambda might be used) was upload.
3. To provide the processing, it was necessary to attach one or more layers with the environment li-

braries installed. The virtual environment with the libraries was installed on the EC2 server. An additional layer was formed from this environment. Also, AWS Lambda may contain additional freely distributable layers. They can also be included in future applications.

4. The electronic table of available resources in the YAML format was formed using CloudFormation tool. The YAML script creates a separate role for working with the future application.
   4.1. Using the role, a Lambda-function was created, its codes were downloaded from the zip file created on the previous step in S3.
   4.2. Using this role a Gateway API was created allowing to call the Lambda-function from a browser.
5. Debugging was fulfilled.

Using this sequence of steps the hybrid environment with lambda-function was created and tested. Using the proposed architecture the problem of sound signal processing was solved.

3 CONCLUSIONS AND DISCUSSION

Pedagogically balanced and expedient introduction of cloud technologies in the educational and research process of higher education institutions, formation and development of the learning and research environment on this basis are factors of expanding access to electronic educational resources, increasing the effectiveness of ICT infrastructure. The use of serverless technologies to provide cloud services of data processing, visualization and retrieve is a relevant and promising area of development and modernization of the university open learning and research environment.

This experience can be used for the development of new cloud-based components for educational and scientific purposes based on the proposed architecture of the hybrid cloud-based environment with Lambda-function.

This approach still needs further implementation and evaluation.

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