Abstract
This short paper presents research and development of a cloud computing application for water resources based on open source software and open standards using hybrid deployment model of public - private cloud, running on two separate virtual machines (VMs). The first one (VM₁) is running on Amazon web services (AWS) and the second one (VM₂) is running on a Xen cloud platform. The cloud application has three web services for 1) data infrastructure (DI), 2) support for water resources modelling (WRM), 3) user management. The presented cloud application is: available all the time, accessible from everywhere, it is scalable, works in a distributed computer environment, it creates a real-time multiuser collaboration platform, the programing languages code and components are interoperable, and it is flexible in including additional components. This research demonstrate the capability to scale and distribute the cloud application between several VMs. The cloud application was tested on the Zletovica river basin case study with concurrent multiple users. The tests confirmed that the presented cloud application works and can be used as a foundation for development of specialized geospatial application in the water domain.

Keywords
Cloud computing, water resources, open source, application development.

1 Introduction
Presently, most of the existing software for water resources is desktop-based, designed to work on a single computer. This represents a major limitation in many ways, starting from limited computer processing, storage power, accessibility, availability, etc. The only feasible solution lies in the web and cloud. There are various examples of web applications (Choi, Engel, & Farnsworth, 2005; Delipetrev, Jonoski, & Solomatine, 2014; Delipetrev, Mihajlov, Delipetrev, & Delipetrov, 2010; Horak, Orlik, & Stromsky, 2008; Reed, Bills, Anderson, Ketchum, & Piasecki, 2010), cloud web services (Bürger, Kollet, Schumacher, & Bösel, 2012; Quiroga, Popescu, Solomatine, & Bociort, 2013) and mobile applications (Jonoski et al., 2012) in the water domain.

The cloud application for water resources is continuation of previous research (Delipetrev et al., 2014) that presents the development of a web application for water resources based on open source software. The cloud application enhancement are the following:
1. The web application is distributed/deployed on two VMs. The VM₁ is running as a micro instance of Amazon web services (AWS) public cloud, and the VM₂ is running on a Xen cloud platform at the University Goce Delcev in the Republic of Macedonia.
2. The web service for support of WRM that runs on VM₁, and the DI web service that runs on VM₂, are communicating with WFS-T (Web Feature Service - Transactional Protocol) XML messages over the internet, demonstrating distributed computer environment.
3. Hybrid cloud design is presented, where VM₁ is part of the AWS public cloud, and VM₂ is running in the private cloud. The advantage of this distributed computer environment is that the data security and protection can reside in the private cloud (VM₂), while the web services can be in the public cloud (VM₁).

The cloud computing application was tested using data from the Zletovica river basin located in the northeastern part of the Republic of Macedonia. The application url www.delipetrov.com/his/ provides video presentation and explanation of the system components, guides how to use the services etc.

2 Design and implementation

The main enhancement compared to the web application is the scalability. The design and implementation demonstrate that the cloud application can support seamlessly unlimited number of users. The web services that are shown in Figure 1:
1. DI.
2. Support of WRM.
3. User management.

*Figure 1: Design of the cloud computing application for water resources.*

The DI web service is composed of two components 1) HMak database created in PostgreSQL and PostGIS and 2) GeoServer application. The HMak stores
geospatial data, including topographic, hydro-geological, rivers, roads, municipal, etc. The HMak stores six geospatial vector layers: rivers, canals, reservoirs, users, inflows, and agriculture land, and their attribute tables, which are used by the web service for support of WRM.

The web service for support of WRM is intended to provide a web interface for creating and editing geospatial water resources elements just like in classical desktop applications. The main difference between the web service for support of WRM and desktop interfaces is that the web service for WRM is accessible by multiple users simultaneously over the internet using a web browser.

The web service for support of WRM is developed using PHP, Ajax, JavaScript and OpenLayer library that supports OGC standards. The OpenLayer library creates WFS-T communication between the web service for support of WRM user interface running on VM1, and the geospatial data stored in HMak where the GeoServer acts like a middle tier running on VM2. The WFS-T communication provides a framework to create, update, and delete geospatial data over the internet.

The web service for users’ management is simple with a main purpose to control the cloud computing application access. Each user receives its own login and password to access the cloud application and monitoring the time spent on the system.

Important milestone is the deployment of the cloud application between the two VMs running on separate physical servers. The first VM1 is a micro instance on the AWS, and the second VM2 is running on the Xen cloud platform. The VM1 has 8 GB HDD, 1 GB RAM and Ubuntu 13 as an operating system. The VM2 has 30 GB HDD, 1 GB RAM and Fedora 16 as an operating system. The VM2 is running on a physical server IBM x3400 M3 with four-core Intel Xeon E5620 2.40 GHz with 12 MB of cache per processor.

3 Preliminary results and tests

The cloud computing application was tested on river basin Zletovica that is located in the north-east of the Republic of Macedonia. The river basin main challenges are flood and drought protection. Figure 2 shows the hydro system Zletovica model that is created by the web service for WRM by multiple collaborating users. The hydro system contains the reservoir Knezevo, river network, canal network, towns as users and agricultural areas. The towns and reservoir titles are added additionally and are not part from the web service.
4 Discussion

Concerning service models, the presented cloud application belong to software as a service (SaaS). Users with a web browser access the cloud application and do not care about underlying cloud infrastructure. The current deployment model is hybrid of public - private cloud because the VM$_1$ is running in public cloud AWS, and VM$_2$ is on private Xen cloud platform. The cloud application is scalable, interoperable, and accessible from everywhere and available all the time.

The most valuable cloud application feature is its real time collaboration platform capabilities. Multiple users using only a web browser can jointly work with the web services and collaborate in the same working environment. When a user saves the current work, all other distributed users with just a web browser refresh can see the changes (new/modified rivers, users etc.). All of the data and models are stored in HMak and users do not have to be concerned about hardware and software support infrastructure.

Another important concern in implementing cloud solutions is the data protection and safety. This prototype cloud application makes an elegant solution, residing the web services in the public cloud, while the data is stored in the private cloud. If for instance an attack happens to protect the data, the private cloud VM$_2$ can be disconnected from the public cloud AWS VM$_1$. Another key point is that data resides inside the institution, and only the web services are “outsourced.” This concept can be applied in many organizations where the data needs to be stored internally.

5 Conclusions

The presented cloud application is developed using open source software and standards and prototype code. The application is deployed on two VM creating hybrid cloud solution. The cloud application is a state-of-the-art web geospatial collaboration platform for water resources modeling. The presented solution is a prototype and can be used as a foundation for developing specialized web geospatial applications.
References


