



# Deusto

Facultad de Ingeniería  
Ingeniaritza Fakultatea

Reviewer

Prof. Ing. Javier García-Zubía, PhD.

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## **Review of Doctoral Thesis**

**Pavel Beňo, MSc.**

**Cloud computing solutions and security of EU remote  
interactive laboratories network**

**Cloudcomputingové riešenia a bezpečnosť siete vzdialených  
interaktívnych laboratórií EU**

**Supervisor:**

**Prof. Dr. František Schauer, DSc.**



I am writing this review on the basis of appointment as opponent by the letter of dean of Faculty of Applied Informatics, Tomas Bata University in Zlin, Czech Republic.

## **Content**

The Doctoral Thesis has 142 pages, 45 figures, 7 tables, 94 bibliographic references, a list of acronyms and a list of 14 author publication.

The present dissertation is organized in 8 chapters. The work is clear and comprehensive, it includes figures and tables to describe and analyse in a correct way the stated problems in the thesis. The text is well written and edited.

After the abstract, the thesis presents, in chapter 1, the state of the art in the remote laboratories field. Chapter 2 addresses the remote laboratories management systems, and based on this analysis Chapter 3 presents the goals of the thesis. Chapters 4-6 design, implement and analyse the proposed system in the thesis. The thesis ends with the conclusion and outlook.

## **Current topic**

The motivation of thesis is clearly stated and it is interesting for the research community. The remote laboratories is an active research field, and in this area the results and quality level of RemLabNet, in which is based this PhD thesis, are well known.

## **Goals of the PhD thesis**

The remote laboratories and the remote experimentation are broad research fields that include hardware design, software design, pedagogical design, etc. A remote laboratory has at least two parts: the remote experiments and the management system. This PhD thesis is focused in the management system,



RLMS (Remote Lab Management System). A RLMS is a crucial pillar in a remote lab because it assures the accessibility, the universality and the security.

The main goals of the PhD thesis are focused in the software design of the RLMS:

1. Create virtualized cloud environment, using progressive cloud solutions for hosting Remote Laboratories Management System - REMLABNET.
2. Design and provide the virtualized cloud environment with corresponding security precautions. For this purpose, carry out software security penetrating test of REMLABNET to ascertain its overall security resistance.
3. Model the University network failure and ascertain the limit of its spreading and ways for its effective suppressing and elimination.
4. Design the virtualized cloud interface environment for easier building, servicing and maintenance of remote laboratories embedded in the cloud.

### **Comments and questions**

Cloud, Security and Federation are the three keywords of the PhD thesis. They are described and connected in detail in chapters 4 and 5. The proposed solutions are CC-RemLabNet TC-RemLabNet and RemLabGRAB, all of them implemented and tested to deploy the RemLabNet-Cloud.

In Chapter four the PhD thesis explains in detail what is security and cloud for the RemLabNet and how it was analysed using a commercial tool. Then five new services are explained in detail: IaaS, PaaS, SaaS, RaaS/PLaaS and SaaS.

In chapter five, after the technical discussion of chapter four, the design and test of new functionalities are addressed. The main objective is to “move” a remote lab, the RemLabNet, into the cloud to promote security, performance, federation and other characteristics.





In 5.1.2 there is a previous analysis to see if cloud technologies are suitable for RL. I think that this is correct way: not use a technology without a previous analysis.

The security problem is faced in 5.2 section (30 pages). Different situations are tested and measured. Data are correctly provided to the reader and the conclusions are clear.

In 5.3 section is described how RemLabNet is implemented into the cloud. This task is a complex task and it is described with detail, i.e, see Figure 33 in page 96. Also see figure 45 in page 116.

In 5.4 section the federation of RemLabNet is explained. RemLabNet is federated in Go-Lab project, SCOPE project and Graasp platform. But it is not clear if a different remote lab can be federated using RemLabNet.

Questions:

- During this time, has the RemLabNet had a security problem like a DoS attack? How was it solved? How is the situation in TBU?
- The IEEE Std 1876 - Networked Smart Learning Objects for Online Laboratories, <https://site.ieee.org/sagroups-edusc/>, has been developed by IEEE coordinated by Hamadou Saliah with researchers like Denis Gillet, Pablo Orduña, etc. Do you know it? Can you explain the relation between this IEEE standard and the PhD thesis?
- Reading the PhD thesis it seems that the federation of RemLabNet into GoLab and Graasp was made using SmartGateway, can you explain this?
- Is the Faculty of Applied Informatics using a federation of remote labs with other institutions?
- In page 108, federation and interoperation are described, can you explain better what is interoperation with RL?



Suggestions for future work:

- There is a new topic in remote experimentation: deferred experiments (ultra concurrent experiments). In this case the sessions are recorded and after and offered to the users Using the RemLabNet cloud, would this be possible?
- Using the cloud in RemLabNet the system is recording all the actions made by users, is running a Learning Analytics approach in RemLabNet? Is this possible in future?
- RLaaS- RemLabGrab (page 96) can be used for creating adaptive learning experiments, have you thought on it?

Comments:

- The bibliographical references are not written in a common way. This should be avoided in a PhD. Thesis.
- I would like to know if there are plans for publishing in JCR journals the results of the PhD thesis. I think that it can be done and it would increase the value of the PhD thesis.
- In some figures the legends are not close to the figure.

### **Final evaluation and recommendations**

The thesis and its contents are of the high standards required for a Ph.D. candidate. **I recommend it for presentation and for acceptance as the Ph.D. thesis in partial fulfillment of the requirements of the Ph.D study in the field of Engineering Informatics. I also highly recommend with pleasure to award Ing. Pavel Beno the Ph.D. degree in the mentioned field of study.**

Bilbao, 11.11.2019

Dr. Javier García-Zubía

Opinion of the Dissertation theses:

# Cloud Computing Solutions and Security of EU Remote Interactive Laboratories Network.

**Author of Dissertation Theses:** Pavel Beňo, MSc.

**Opponent:** prof. Eng. Karel Vlček, PhD.

**Opinion:** Eng. Pavel Beňo's dissertation topic – entitled Remote Interactive Network Measurement Solutions is a current issue. The proposed measurement systems provide new methods and ensure that the measurement process is easier and more objective. The measurement process approach corresponds to current practice requirements. This contribution's concept on the practical performance of measurement tasks provides several advantages. The first is the possibility of comparing the results of tasks under selected conditions.

On the other hand, every approach may also be accompanied by disadvantages and complications. Remote Laboratories - (RLs), are run at remote locations and the client (who orders these measurements), has no way of influencing the experiment, nor do they have the ability to influence the course of the measurement process, or - the ability to influence the measurement results. Everything happens through a transmission channel, which includes the transmission circuits and – on the other hand, are reception circuits. All of these electronic components have an effect on interference of transmission paths. Specific interference sources are created during the digitisation of the measured quantities, (including time - which is understood as an independent variable).

The general RL scheme - shown in Figure 2 on page 13 of the thesis, does not contain any time correction in the course of the measurement process. Is it possible that this correction, carried out by a program that controls the measurement process, is correct? And is this possible? Please explain this problem. Please provide a solution to this problem during the measurement process.

The physical instruments that make up the measuring equipment and which are used and which are shown in Figure 8, are the solution to the problem? Or is it necessary to resolve a time mismatch at a remote location? Can the contracting authority influence this situation by modifying the parameters of other devices?

The Remote Laboratory System, which is used for the above-mentioned experiments, is mentioned in theses. I am sure that it ensures all of these functions, that it is the best solution for the project submitter in terms of measurement process quality. Communication between RL servers, which have the function of data centres here, assure the communication channels that are responsible for providing the diagnostics of individual devices.

The important action is the whole communication with the client. The client can observe the measurement process, and he proceeds the experiment via the communication server as well. During these conditions, it is the access to measurement experiment, and it is possible to managing it, by means of the Content Management System (CMS).

These conditions allow to provide not only the laboratory equipment, but it give the opportunity for interconnection of an extraordinary facilities, and to design the virtual cloud interface environment for easier building servicing and maintenance of remote laboratories embedded in the cloud.

The important aspect of the solution is data protection. These steps are solved in duties, which are in regulations of the European Union which was edited as the replacing of existing law about personal data protection. This aspects were respected in the law 69/2018 Z. z. "Law about cyber security" of the Slovak Republic, which was even more stringent that one of European Union. It was expressed, how to process personal data of clients, fulfilling during the system REMLABNET is in function.

The goals of thesis are introduced on the page 25. I can pronounce, that there are fulfilled. I recommend the theses for defense.

In Zlin, 28<sup>th</sup> November, 2019.



prof. Eng. Karel Vlček, PhD.,

Opponent

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Faculty of Mechanical Engineering  
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## Review of Doctoral Thesis

Author: **Pavel Beňo, MSc.**  
Thesis: **Cloud computing solutions and security of EU remote interactive laboratories network**  
**Cloudcomputingové riešenia a bezpečnosť siete vzdialených interaktívnych laboratórií EU**  
Degree program: **Engineering Informatics P3902**  
Degree course: **Engineering Informatics 3902V023**  
Supervisor: **Prof. Dr. František Schauer, DSc.**  
University: **Tomas Bata University in Zlín**

The opponent's report was prepared on the basis of the appointment of the opponent, by letter dated 5.11.2019 from the Dean of the Faculty of Applied Informatics, Tomas Bata University in Zlín.

### Content of the doctoral thesis

Scope of work: 142 pages, 45 pictures, 7 tables, 94 bibliographic references, the list of acronyms and abbreviations and the list of 14 author's publications.

The dissertation thesis consists of eight chapters. There are thanks, abstract and content in the introductory part. In the first chapter, the author deals with remote laboratories - state of the art; in the second chapter, there is the remote laboratory management system. The dissertation theses are in the third chapter. Chapter four and five address the design and safety of remote laboratories on the basis of the submitted thesis. At the end of the thesis there is discussion of results, assets of the thesis for science and experience, conclusion and references.

The work is clear, analyzed problems are explained in detail and logically ordered. Formally, the work is processed in high quality.



### **Topicality of the thesis**

The dissertation thesis solves a very interesting and highly current issue of REMLABNET remote laboratories from the technical point of view. The solved problems belong to the study program Engineering Informatics.

### **Fulfillment of goals PhD thesis**

The dissertation thesis solves theses that were designed to accept the results of previous research related to Remote Laboratories Management system - REMLABNET. The dissertation theses are defined in the third chapter - design and visualization of cloud environment with respect to the safety and maintenance of remote laboratories built into the cloud. The dissertation theses thus include the obligation to integrate the study of theoretical context and practical experience as well as to infer own and original results. I can say that this thesis of the dissertation has been fulfilled.

### **Processing methods**

The dissertation thesis deals with the current problems of cloud computing solutions, security and reliability of networks from remoted interactive laboratories. Remote laboratories significantly improve communication, not only within the scientific and academic community, but also enable students to improve their knowledge. In order to optimize the security and reliability of the REMLABNET system, penetration testing has been used to examine the reliability of special cloud functions. This was applied in seven steps, which is explained in detail in the present work. Advanced cloud computing services were described in detail, needed for advanced TC-REMLABNET, RLaaS - for grant RLs clients, GaaS - which serve to harvest information from RLs, TCaaS - where thin client was used instead of classic PC, STaaS - for sharing and storing measured values.

### **I have the following questions:**

1. What is the best way for a client to reach remote laboratories?
2. You have done system security and penetration testing. How do you see the importance of the steps you took?
3. At work you mentioned interception on optical fiber. Where and how did you come across it?
4. How do you see the future of REMLABGRAB and what are its biggest advantages over other remote laboratory systems?

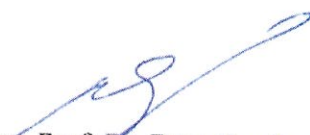
**Conclusion:**

In conclusion, the dissertation thesis is topical and corresponds to the study program Engineering Informatics. The dissertation has the required level and the obtained results are beneficial for the development of the given field.

On the basis of studying the dissertation, I can state that the author has mastered scientific research methods and has mastered theoretical knowledge in the given field, which he can apply in solving scientific research and tasks solved for practice.

The thesis fulfills the content, material and formal conditions at the required level and therefore I recommend it to accept it for defense and at the same time, after successful defense, I propose that the academic degree (Ph.D.) will be awarded to the doctoral student Pavel Beňo, MSc. in the field of Engineering Informatics.

V Košiciach, 28.11.2019



Assoc. Prof. Dr. Peter Frankovský