



**COLLEGE OF ENGINEERING
AND COMPUTER SCIENCE**
FLORIDA ATLANTIC UNIVERSITY

Announces the Ph.D. Dissertation Defense of

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for the degree of Doctor of Philosophy (Ph.D.)

“Models and Implementations of Online Laboratories; A definition of a Standard Architecture to Integrate Distributed Remote Experiments”

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ABSTRACT OF DISSERTATION

Models and Implementations of Online Laboratories; A definition of a Standard Architecture to Integrate Distributed Remote Experiments

Remote laboratories have been under development for more than 20 years and are part of a bigger category called online laboratories, which includes also virtual laboratories. Remote laboratories use real physical laboratories which are capable of being accessed through a network. The instruments can be accessed, monitored and controlled at distance. In comparison, virtual laboratories are basically simulations which mimic the behaviors of real laboratory artifacts. The results of the virtual experimentation process should be similar to those obtained in a real laboratory, but results are mostly based on calculations and mathematical formulas. Most advanced virtual laboratories include in the data processing information of previous experiments made in real laboratories to create a more realistic and reliable environment that considers behavior of real components. Development of remote laboratories in academic settings has been held back because of the lack of standardization of technology, processes,

operation and their integration with formal educational environments. Remote laboratories are used in educational settings for a variety of reasons, for instance, when the equipment is not available in the physical laboratory; when the physical laboratory space available is not sufficient to either set up the experiments or permit access to all on-site students in the course; or when the teacher needs to provide online laboratory experiences to students taking courses via distance education. Centers around the world have been developing platforms that grant remote access to a collection of physical experiments that provide alternatives to educational institutions to reduce budgets of not only equipment purchases but also other expenses, such as, people, space, maintenance, and electricity consumption.

This thesis proposes a new approach for the development and deployment of online laboratories over online platforms. The research activities include: The design of an architecture of a system for Smart Adaptive Remote Laboratories (SARL) integrated to educational environments to improve the remote laboratory users experience through the implementation of a modular architecture and the use of context information about the users and laboratory activities; the definition of a design pattern for Remote Laboratory Management System (RLMS); the definition of Smart Laboratory Learning Object (SLLO) capable of being integrated in different educational environments; the definition of a reliability model to detect and report failures and possible causes and countermeasures applying ruled based systems; a prototype implementation of the architecture and remote labs demos that have been used as a proof-of-concept by the IEEE P1876 Networked Smart Learning Objects for Online Laboratories Standard and the Actionable Data Book (ADB) presented at the 2017 Frankfurt book fair in Germany.

BIOGRAPHICAL SKETCH

Born in Caldas, Antioquia - Colombia

B.S., EAFIT University, Medellin, Antioquia - Colombia, 2010

M.S., EAFIT University, Medellin, Antioquia - Colombia, 2013

Ph.D., Florida Atlantic University, Boca Raton, Florida, 2019

CONCERNING PERIOD OF PREPARATION & QUALIFYING EXAMINATION

Time in Preparation: 2015 - 2019

Qualifying Examination Passed: Spring 2016

Published Papers (Online Laboratories):

- L. F. Zapata-Rivera, M. M. Larrondo-Petrie, "The Remote Laboratory Management System (RLMS) Pattern". In Proceedings of the 2018 Latin American Conference on Pattern Languages of Program. Valparaiso, Chile. Nov, 2018.
- L. F. Zapata-Rivera, M. M. Larrondo Petrie, J. Zalewski, J. Shockley, J. Costa, J. Lalinde-Pulido, E. San Cristobal, M. Castro, M. Rodriguez A, H. Saliyah-Hassane, "Scalable, Ad Hoc, Low Cost, Mobile, Online Laboratories". In Proceedings of LWMOOC V, Learning with MOOCs 2018 MOOCs for All – A Social and International Approach. Madrid, Spain. Sep 26 – 28, 2018.
- L. F. Zapata Rivera, M. M. Larrondo-Petrie, "xAPI-Based Model for Tracking On-line Laboratory Applications". In Proceedings of the IEEE Frontiers in Education Conference (FIE). San Jose, CA, USA. Oct 3 – 6, 2018. DOI: 10.1109/FIE.2018.8658869
- T. L. Barbosa, L. F. Zapata Rivera, M. M. Larrondo-Petrie, "Implementation of Basketball Multiplayer Remote Game for Education". In Proceedings of the 16th LACCEI International Multi-Conference for Engineering, Education Caribbean Conference for Engineering and Technology, "Innovation, Education, and Inclusion". Lima, Peru. Jul 18 - 20, 2018.
- L. F. Zapata Rivera, J. Minkoff, S. Fortinsky, M. M. Larrondo-Petrie, "Practical Color-Matching Remote Laboratory, Integration and Experimentation". In Proceedings of the 16th LACCEI International Multi-Conference for Engineering, Education Caribbean Conference for Engineering and Technology, "Innovation, Education, and Inclusion". Lima, Peru. July 18 - 20, 2018.
- L. F. Zapata Rivera, T. Nguyen, V. Huynh, G. Kveton, L. Koester, M. M. Larrondo-Petrie, "Implementation of a Student Lab Kit Case to Allow Interfacing with Online Laboratory Systems". In Proceedings of the 16th LACCEI International Multi-Conference for Engineering, Education Caribbean Conference for Engineering and Technology, "Innovation, Education, and Inclusion". Lima, Peru. July 18 - 20, 2018. DOI: 10.18687/LACCEI2018.1.1.559.
- L. F. Zapata Rivera, M. M. Larrondo-Petrie, "Design of a Rule-Based System to Support the Failures and Recovery Management". In Proceedings of the 15th International Conference on Remote Engineering and Virtual Instrumentation (REV). Dusseldorf, Germany. Mar 18 - 20, 2018. ISBN 978-3-319-95678-7
- L. F. Zapata Rivera, M. M. Larrondo-Petrie, "Models and Smart Adaptive Interfaces for the Improvement of the Remote Laboratories User Experience in Education". In Proceedings of the 14th IEEE International Conference on Remote Engineering and Virtual Instrumentation (REV). New York, USA. Mar 15 - 17, 2017. ISBN 978-3-319-64352-6
- L. F. Zapata Rivera, M. M. Larrondo-Petrie, L. Ribeiro Da Silva, "Implementation of cloud-based smart adaptive remote laboratories for education". In Proceedings of the IEEE Frontiers in Education Conference (FIE). Indianapolis, IN, USA. 2017. DOI: 10.1109/FIE.2017.8190473.
- L. F. Zapata Rivera, M. M. Larrondo-Petrie L. Ribeiro Da Silva, "Smart Adaptive Remote Laboratories for Education (Implementation of a prototype)". In Proceedings of the 15th LACCEI International Multi-Conference for Engineering, Education Technology. Boca Raton, FL, USA. Jul 19 - 21, 2017.
- L. F. Zapata Rivera, M. M. Larrondo-Petrie, "Models of Collaborative Remote Laboratories and Integration with Learning Environments". International Journal of Online Engineering (iJOE). Vol. 12, No. 09, 2017. ISSN: 1861-2121 pp 14-21. DOI: 10.3991/ijoe.v12i09.6129.
- L. F. Zapata Rivera, and M. M. Larrondo-Petrie, "Models of remote laboratories and collaborative roles for learning environments". In Proceedings of the IEEE 13th International Conference on Remote Engineering and Virtual Instrumentation (REV). Madrid, Spain. Feb 24 - 26, 2016. DOI: 10.1109/REV.2016.7444517. **Best Student Paper Award**
- L. F. Zapata Rivera and M. M. Larrondo-Petrie, "Design of a Latin American and Caribbean remote laboratories network", In Proceedings of the IEEE Frontiers in Education Conference (FIE). Erie, PA, USA. 2016, pp. 1-5. DOI: 10.1109/FIE.2016.7757581.

- L. F. Zapata-Rivera, T. Nguyen, V. Huynh, G. Kveton, L. Koester, M. M. Larrondo-Petrie. "Dynamic Hybrid Online Laboratory Systems in Distance Learning. IEEE RITA Journal. 2019 (Submitted).
- L. F. Zapata-Rivera, P. Weinthal and M. M. Larrondo-Petrie Generation of Multiple interfaces for Hybrid Online Laboratory experiments based on Smart Laboratory Learning Objects. IEEE Frontiers in Education Conference (FIE). 2019 (Submitted).