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Development of a virtual automation laboratory for teaching
programmable logic controllers

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Karakia Timatanga Opening Karakia

Manawa mai te mauri nuku
Manawa mai te mauri rangi
Ko te mauri kai au
he mauri tipua
Ka pakaru mai te pō
Tau mai te mauri
Haumi e, hui e, taiki e!

Embrace the power of the earth
Embrace the power of the sky
The power I have
Is mystical
And shatters all darkness
Cometh the light
Join it, gather it, it is done!

Timatanga | Introduction

- The development of simulation environments within the Programmable Logic Controller [PLC] field has resulted in the replacement of physical hardware with simulations in a teaching context.
- Developing PLC compiler based simulations is time consuming and the PLC simulation tools within PLC IDEs are not really designed for this task as they are not dedicated simulation software tools.
- Factory IO is a dedicated simulation tool, used to replace physical laboratory hardware and provide a platform for a virtual laboratory within a teaching and commercial context.





Peer Assisted Learning

- Students are central to learning.
- “People from similar social groupings who are not professional teachers helping each other to learn and learning themselves by teaching” (Topping, 1996).

Topping KJ. The effectiveness of peer tutoring in further and higher education: A typology and review of the literature. Higher Ed 1996; 32: 321–345



Students as Role Models in Developing Teaching Aids

- In this teaching method, students at a higher level develop teaching aids and material that are in turn used to teach lower level students.
- This system is sustainable and self-replicating and fulfils the methodology of a holistic student learning experience.
- This teaching approach utilizes concepts of student peer assisted learning and participatory learning.
- This system encourages lower level students to replicate their peers at the higher levels and uses role modelling of higher level students to support lower level students



Student Achievement While Developing Teaching Aids

- We present a student developed teaching aid using this approach
- The student developed teaching aid involves
- Simulation of Lucas Nuelle, Industrial Mechantronics Systems [IMS] using FactoryIO.
- Development of controller software using the Siemens S7-1200 PLC within the TIA Portal software environment.
- Implementation of Ignition for the purpose of Supervisory Control and Data Acquisition (SCADA) on the Factory IO simulation.
- Deploying the PLC program on physical Lucas Nuelle IMS stations to validate the configuration of the simulation.



Lucas Nuelle IMS System

- The Lucas Nuelle teaching rig has been used for a number of years for student projects and as a teaching resource.
- Teaching exercises involve using the a single IMS conveyance system rig for class assignments (all students complete this in the DE6411 course at Unitec).
- Automating multiple IMS rigs as student final year projects (limited to 1-2 students per semester due to limited hardware facilities).
- Group learning involving automating individual IMS rigs as class projects and then combining the different automated IMS rigs to form a fully automated system.
- The Lucas Nuelle IMS rigs are a limited resource and there are not enough rigs to go around all the students.
- The LN IMS rigs are fragile and prone to breaking and do not withstand the rigors of heavy student use.



Factory IO Simulation of Three IMS Stations

- Factory IO has been used in tertiary institutions as a virtual reality replacement for physical hardware systems.
- Factory IO can also be configured to work with a PLC simulator (or physical PLC) and replicate the sensory feedback and actuation on a physical system.
- In this student developed teaching aid, Factory IO was interfaced with the PLCSim (simulating S7-1200 PLC) running a TIA Portal ladder program and communicating with Ignition SCADA software.
- The Factory IO simulation replicated 3 Lucas Nuelle IMS stations





Ignition SCADA interface

- Ignition was used as the SCADA package in the development of this teaching aid.
- Ignition is commercial grade software and is free to download.
- Ignition has a free two hour run time which means it is ideal for students who can download it for free and use it for 2 hours in laboratory exercises.
- Ignition is a modern package and uses Python scripting.
- Ignition is available in the centralised server form (running on a PC)

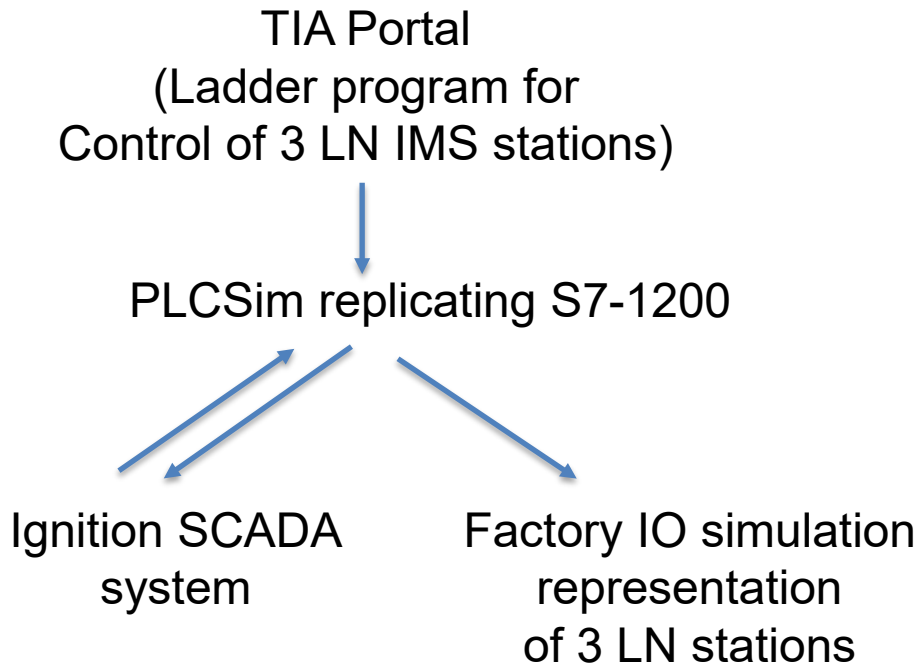
or

in a Cloud based form

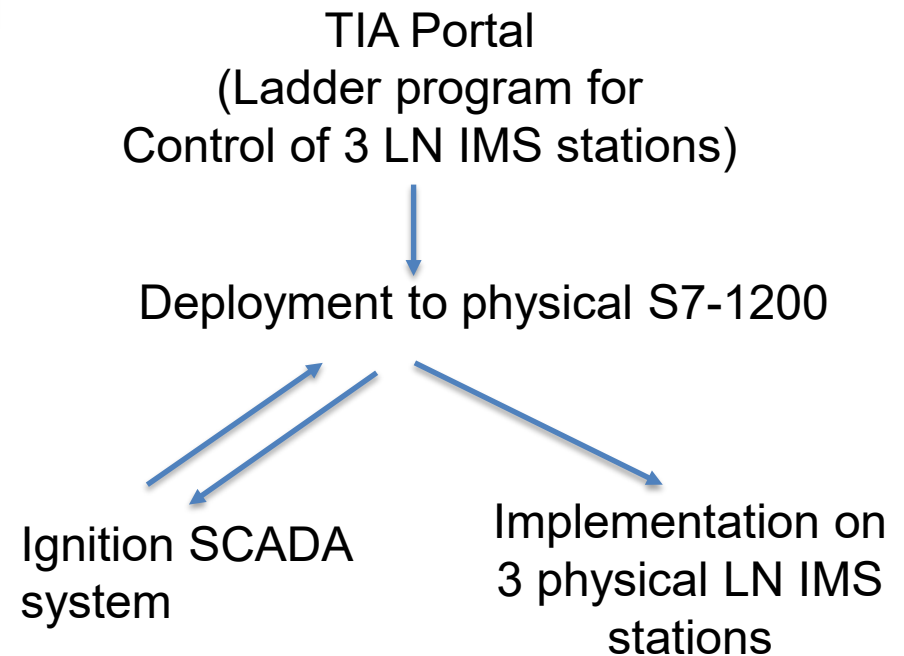


Teaching Aid Development Methodology

Simulation approach



Physical hardware approach





Results

- PLCSim requires TIA Portal V15, V16, V17 in order to simulate S7-1200.
- The student developed teaching aid successfully integrated TIA Portal, PLCSim, FactoryIO and Ignition to achieve a code for code replacement of 3 physical LN IMS stations.
- The 3 LN IMS station virtual reality system is still quite clunky and requires quite a high level of user ability which limits its deployment to capable higher level students and will require exemplars and additional resourcing to make it viable in a class setting.
- Bandwidth and computing power are issues as these are very large software packages.
- The class laboratories involving 1 LN IMS profibus conveyance station can be completely replaced with Factory IO, as this is much simpler to implement in a class situation.
- This will increase the teaching capacity presently limited to 2 physical IMS conveyance stations to an unlimited number of virtual reality simulations.



Acknowledgement

I would like to acknowledge Sam Loveridge, the L6 NZDE student who put together the Factory IO simulations described in this presentation. These simulations will serve as the foundations of a virtual reality laboratory simulation and this will replace physical hardware based LN IMS stations used by future students in laboratories and future lecturers who teach DE6411.



Q & A



Te Karakia Whakamutunga | Closing Karakia

Ka wehe atu tātou
I raro i te rangimārie

We are departing
Peacefully

Te harikoa

Joyfully

Me te manawanui
Haumi ē! Hui ē! Taiki ē!

And resolute
We are united, progressing
forward!