Introducing Industrial Computer Networks into the Curriculum through a Partner Informed Case Study

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Abstract

Today an increasing number of systems and devices are being interconnected. The popular perception of this Internet of Things is of domestic appliances existing in comfortable or air conditioned environments connected to the Internet. However many systems that need to be interconnected exist in harsh environments such as extremes of temperature or in hostile environmental conditions, for example railway trackside equipment, utility plants or even at the bottom of an ocean. The network devices employed in these systems must operate in such harsh conditions. Westermo Data Communications manufactures networking equipment of this nature, for what we might refer to as the field of Industrial Networking. There is increasing demand for personnel with the experience and expertise in the design, implementation and management of these industrial networking systems. This represents an opportunity for the future employability of students enrolled on the computer networking degree programme at Southampton Solent University. Westermo has partnered with the University to help develop the unique industrial networking skills required by this sector through

means of a case study based on a real world industrial networking scenario. This paper discusses how students developed solutions to the case study based on research supported by practical experience with Westermo equipment and informed by supporting material from their own teaching programme. Students also have the opportunity to gain Westermo certification to provide supporting evidence of expertise in this area.

Keywords: internet of things, industrial networking, case study

1.0 Introduction

1.1 Industrial Networking and Rationale for Partnership

Advances in technology and the Internet have allowed a growing number of devices to be interconnected around the World, driving the demand for information gathering and remote management of systems and has given rise to the Internet of Things (IoT) [1]. It offers a means for connecting domestic systems over the Internet as well as the ability to remotely manage and monitor industrial systems, for example power generation plants, railways or marine and offshore installations [2]. Until recently many of these systems were managed on site as autonomous systems, however today there is a rising need for their interconnection and remote management [3]. Therefore there is a demand for engineers with the technical skills to implement and manage the new technologies required to enable these systems to be interconnected. Hence Industrial Networking is becoming an increasingly important dimension of the computer networking subject area. Industrial Networking devices are often expected to operate in harsh environmental conditions from extremes of temperature to extreme humidity [4]. This has required the design and manufacture of specialist networking equipment for this purpose. One company manufacturing and supporting this type of equipment is Westermo Data Communications. Southampton Solent University (SSU) have sought to form a partnership with Westermo to enrich the curriculum of the Computer Networking Degree programme, piloted in an existing unit within the programme. A case study, based on a typical Westermo customer, served to aid the learning strategy in the chosen unit.

1.2 Industrial Networking Partner

Westermo was named after the village where it was born, Västermo, Sweden, in 1975 and was established by a pioneer of Industrial Data Communications, Tore Andersson. In 1995 Alan Bollard, currently the Managing Director, developed Westermo UK. Alan has positively influenced the company and helped develop the organisation’s growth within the UK [5]. From where Tore began, Westermo now

employs over 200 people and has 11 other sales and support offices around the world (including the UK) and thousands of industrial based customers. The products are still produced in Sweden to this day and are arguably a global competitor in the field of Industrial Ethernet Switches.

Westermo started to notice that within the industrial network sector a knowledge gap was developing. People were retiring and removing important skill sets from the ever-developing industry, whilst the skillsets required are constantly evolving. In 2014 Westermo embarked on a new challenge. They wanted to introduce a new member of staff to the Technical Support team at the UK Headquarters near Southampton, although they had some difficulty finding a suitable candidate. In August, a graduate fresh from Southampton Solent University applied for a job with the company, although with no relevant industrial networking experience, but a degree in Computer Networking that proved to be the a deciding factor in their employment. Westermo wanted, with the assistance of their recent graduate, to create this new affiliation with the university.

Westermo is actively helping to educate students at SSU by running guest lectures, donating relevant equipment and providing technical advice to students, including email support. Westermo want to find the future employees for their customers and more importantly help to bridge the knowledge gap of the industrial data communications sector.

Working in collaboration with Westermo, SSU has seen development in a sector that is often overlooked in the typical model of teaching in the field of computer networking technology. SSU envision students gaining vital experience from the collaboration with Westermo therefore leading to improved employability and enhanced career prospects.

2.0 The Case Study

2.1 Background to the Case Study

The University has a Computer Networking Degree programme. The topic of the Internet of Things had been introduced into the programme over time to keep up to date with current and future technology trends, however prior to the discussions between the course team and Westermo there was little content relating to Industrial Networking in the programme. There were two possibilities for introducing this emphasis in the curriculum. The course could be re-organised and revalidated to incorporate more industrial networking or the subject area could be introduced into an existing unit. There will be opportunities to look at the whole programme in the future, but revalidation would be time consuming. However a suitable undergraduate final year networking unit proved to be eminently suitable

for incorporation of this theme into the curriculum. The unit outcomes were related to employability which is seen as key to graduate employment. The unit involved student centred learning, which is seen as an effective way to engage students in the learning process by means of active learning [6,7]. Employers are seeking graduates with soft skills, such as team working, communication, presentation, and technical skills such as research and practical experience, so the unit was designed to provide opportunities to develop these [8]. The unit involved students in selecting a case study from a sector of business and industry. They are expected to produce a set of requirements for the case study relating to a particular computer networking theme. From this they are expected to develop solutions that may involve elements of practical work. However the type and nature of the topics chosen by students varied widely and the tutor often found it difficult to find time in the sessions to support the wide range of technical issues presented to them. The standard of outcomes was variable and some students avoided practical work. The unit leader had been intending to concentrate on just two or three topic areas that incorporated practical laboratory work in their solutions. The partnership with Westermo gave the opportunity to introduce a case study based upon a real life-like scenario faced by a typical customer. To offer choice to the students and to ensure that the practical session could be manageable two other themes were introduced: network management and monitoring using OpenNMS [9] and Software Defined Networks [10]. Separate case studies were developed for these themes. Students were given the choice of which theme they wished to pursue. Eight students from two separate sessions chose to engage in the Westermo case study and with two sets of equipment available this number would be easily manageable.

Westermo run their own certification programme for their customers. They have a standard laboratory configuration using their own range of Lynx and Wolverine layer 2 and 3 switches. They were able to donate two complete laboratory configurations to the University. Westermo have developed teaching and learning materials for their certification programme consisting of a study guide relating to the theory and a practical exercise guide relating to the practical configuration of their systems.

2.2 Case Study Implementation

The case study that Westermo offered to the networking students was based upon a fictitious company that managed a number of road tunnels. This offered a situation similar to some of Westermo's typical customers [11]. From the scenario students were expected to develop a more formal set of requirements upon which to base their work. They could act in the role of a consultant negotiating the requirements with the customer in the form of the tutor and a representative from Westermo's technical support team who was closely involved with the project. This person was also able to visit the students to deliver an initial guest lecture on the subject of Industrial Networking and also to field targeted questions from students. The outcomes of the unit involved students in developing a set of solutions for the requirements of the case study supported by theoretical research and practical work on the Westermo equipment. The scenario required a resilient local area network at each tunnel to which could be connected IP enabled CCTV equipment, emergency

phones, legacy ventilation fans, messaging systems, number plate recognition systems and other sensors. Three players were involved: the company responsible for managing the tunnel, the Highways Agency and the Police. The network at each tunnel had to be connected via a secure link to the head office and also parts of the network should be connected to the other players. For example the Police must only have connectivity to certain parts of the tunnel systems, such as number plate recognition and CCTV, whereas the Highway Agency might have access to other systems. Students were expected to deliver a report on the solutions to the requirements and eventually to present the results of their work in a seminar presentation. The findings had to be supported by practical laboratory work using the Westermo networking devices. Whilst students were encouraged to work in small teams to share some resources their final report on the case study would have to be based on their individual analysis of both requirements and solutions.

A strategy with two outcomes was recommend to students. This strategy involved students in reading the study guide to assimilate the theoretical concepts and then working their way through the practical exercises provided by Westermo. One outcome would result in evidence gathering to support solutions to the case study. The other outcome gave students the opportunity to take the examination for Westermo certification.

During the guest lecture delivered by a member of the Westermo technical team the concept of Industrial Networking was introduced and its importance in building connected and managed systems emphasised in relation to current and future networking trends. In order to assist their understanding of the context of Industrial Networking students might consider this as a part of the Internet of Things (IoT).

3.0 Outcomes of the Case Study

3.1 Development of Solutions

Students were expected to correctly identify the most suitable solutions for the requirements of the scenario. For example a resilient network should be constructed at each tunnel using either a single or dual homed ring network using the Westermo proprietary Fast Re-configuration of Network Topology (FRNT) protocol. The connection between a tunnel and the head office would require a Virtual Private Network (VPN). Resilience of this link would require a dual homed connection, perhaps utilising Virtual Redundant Router Protocol (VRRP). Restricted access and segmentation of various parts of the tunnel network might require Virtual Local Area Networks (VLANs), with each agency and the tunnel company only having access to their own VLAN. A routing protocol, such as Open Shortest Path First (OSPF), might be required to allow correct routing on the local area network and a firewall could be used to improve security at each site [12]. The Westermo certification training mainly comprised these technologies. Students were expected to follow the training and laboratory materials available from Westermo and to take screenshots of practical work to support their discussion of each part of their solution, although it wasn’t necessarily expected that students

should implement a working solution to the problem as a whole. This would allow students to follow each part of the Westermo certification program and at the same time to extract information relevant to the case study to provide a complete solution.

Some students who had chosen the OpenNMS case study decided that they would instead utilise the Westermo tunnel case study as part of their investigation. OpenNMS is a network management and monitoring system that uses the Simple Network Management Protocol (SNMP) to receive traps from agents running on a managed network device. So it made sense that the tunnel network should be monitored so that events such as system or network failures can be notified and logged on a Network Management Station. The students using the OpenNMS case study were able to develop their own requirements for monitoring the tunnel networks and they were able to piggy back on the practical work being carried out by those working on the Westermo equipment for the tunnel case study. Since one of the requirements for the original case study involved network resiliency those monitoring the network could develop the requirements of a Service Level Agreement (SLA) [13]. The metrics relevant to the SLA could be monitored using OpenNMS. Students were also able to browse the Management Information Base on the switches with support from Westermo.

3.2 Assessment of the Case Study

Students submitted a report and then presented their solutions in the form of a seminar. In the report they were expected to develop a formal set of requirements based on the case study and analyse the issues. Then they would discuss solutions to the requirements supported by their finding from research and practical work involving laboratory experiments using the Westermo equipment. During the seminar students would summarise their solutions and discuss them with other members of their seminar group. This allowed an exchange of ideas and reinforced their learning.

Since there were additional marks in the assessment of the report for development of the case study and requirements based upon further analysis and research one small group decided to develop their own case study similar to the tunnel network, but based on a typical scenario presented on the Westermo web site. This related to electricity power generation plants rather than tunnels. This scenario also required network resilience. One student investigated solutions for the network, whilst the other investigated monitoring solutions involving OpenNMS and other systems.

Students were also offered the opportunity to discuss employment opportunities in the area of Industrial Networking with Westermo. The best presentation from among the interested students was chosen by Westermo and the student responsible for this was asked to present their solution in front of Westermo management and technical staff.

3.3 Feedback Questionnaire

Students who worked on the case study were asked to complete a feedback questionnaire on their work for the Westermo case study. The questions presented were as follows:

Q1. Did you work with the Westermo equipment?
Q2. Did you work on providing a network solution for the Westermo case study (or a development of it)?
Q3. Did you work on providing an OpenNMS monitoring solution for the Westermo case study (or development of it)?

For the following questions please answer the following on a scale of 1 to 4, where:
1 = I strongly disagree
2 = I disagree
3 = I agree
4 = I strongly agree

Q4. The guest lecture that Westermo delivered introduced me to industrial networking for the first time
Q5. The guest lecture that Westermo delivered enhanced my understanding of industrial networking

If you answered yes to Q1 then please answer the following questions:
Q6. Working with Westermo has helped me to gain a better appreciation of industrial networking.
Q7. Following work on this unit I have a better appreciation of the meaning of the Internet of Things.
Q8. Westermo have supported us well with our work on the case study.
Q9. I enjoyed the challenge of working on the Westermo equipment.
Q10. I am equipped to consider Westermo technology for an IoT related project.
Q11. Gaining Westermo certification would enable me to consider a career in Industrial Networking or IoT

20 students responded to the survey. 13 of those either used the Westermo equipment or monitored a Westermo topology using OpenNMS. However they all attended the Westermo guest lecture on Industrial Networking. Most of the students said that were introduced to the concept of industrial networking for the first time by the Westermo lecture and all but one felt that it had enhanced their understanding of this topic. So whilst this is a positive outcome it indicates that further work should be done on introducing this topic at an earlier stage, bearing in mind that these were final year students.

All but one of those that worked with the Westermo equipment believed that it had given them a better appreciation of Industrial Networking, although only about half of these students felt that this had given them a better appreciation of the meaning of the Internet of Things. This may be because the IoT is a more recent concept and more work should be done on introducing the general concepts at an earlier stage, although Westermo themselves prefer to separate the concept of industrial networking from the IoT generally.

All but one student felt that Westermo had supported them well in their case study and all but one had enjoyed the challenge of working with the Westermo systems. Sometimes business and industry might be reluctant to spare valuable resources engaging with students directly, so it is positive to see that so many students made use of and appreciated the opportunities made available to them for support from Westermo.

Whilst over 60% of students from the group who had worked with the equipment believed that they were equipped to consider Westermo technology for an IoT project, almost 40% disagreed with this. The outcomes of this question may perhaps be ambiguous since one could argue that the students might either be considering their level of interest in a project of this type, or on the other hand their perceived level of technical ability in this area. Although almost 70% of the same group felt that if they gained Westermo certification it would help them to consider a career in Industrial Networking or IoT. Clearly this has made many think of the opportunities available to them, although a few may not want to pursue a career in this field.

The questionnaire was designed to gauge students perceptions of Industrial Networking. Nevertheless it would be interesting to see if the modifications to the unit that have included this subject have improved student perceptions of the unit itself. This information will be available once students have completed the standard university unit questionnaire. Students were also able to provide feedback concerning the Westermo training material and these were passed onto Westermo so that incremental improvements can be made.

3.4 Professional Certification

Students who had worked on the Westermo networking equipment were offered the opportunity to take a Westermo certification examination to enhance their CV. The first group of students took the examination shortly after completion of the case study unit. From the experiences learned from allowing students to study the Westermo course materials for the undergraduate unit it should now be possible to offer the Westermo certification as a stand-alone training programme for other students or for companies that want to train their staff. This perhaps could be run as a short course in a similar way to other professional certification programmes for which the University also has experience of delivering. This will allow opportunities for graduates to work in this sector and enable companies to benefit from a pool of suitably qualified professionals.

4.0 Conclusions and Recommendations

Prior to establishing the partnership with Westermo the University engaged in the teaching of computer networks based on fairly standard concepts. We might consider that most routers and switches were housed in environmentally friendly conditions and designed to address the needs of the average business. For example they might be serving the needs of a datacentre. The relationship with Westermo has enabled us to think out of the air conditioned box. Many industrial switches

exist in harsh environments and as the demands of improved connectivity increase more equipment of this nature will be required. For example railway systems have developed considerably since the days of hand operated semaphore signals. Today both track and locomotive are connected to a computer network [14]. There are many infrastructure and industrial projects where connectivity will be upgraded to meet the demands of interconnection. As there will be an increasing demand for new systems there will be an increasing demand for suitably equipped graduates to meet the challenges of the new technology. The partnership is good for the employability skills of our graduates and it will equip the University to pursue new areas to keep up to date with these challenges. Most of the students feel that this has been a positive and enlightening experience and have appreciated the link with a real business. This work has improved the employability of our graduates by adding Industrial Networking to their skillset which will offer them opportunities in this sector.

Westermo will benefit from developing a pool of suitably experienced graduates. They may either employ them directly or offer the graduate expertise to their clients so that a general upskilling is possible within the Industrial Networking sector. Having trialled the Westermo certification programme on undergraduate students the University could offer this to Westermo clients and also to other students within the University. Westermo clients would benefit from having a suitably equipped training partner to upskill their existing employees.

Industrial Networking was introduced into the programme within an existing unit. However it will be necessary for the course team to investigate ways in which the subject of Industrial Networking can be further embedded within the programme. It could also investigate the viability of incorporating this in an apprenticeship programme in co-operation with Westermo and their clients.

There is no doubt that the IoT generally will be an important part of any computing programme from this moment onwards. This work could also form the basis of a wider awareness of the IoT within the curriculum where Industrial Networking will be an important facet of this subject.

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