Bringing together a Low-Cost Networking Learning Environment

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Abstract—There are many challenges typically encountered by a tertiary institution setting up applied, networking resources. Such labs are necessary to create industry-ready graduates. Smaller institutes face particular issues where they lose the benefit of economies scale. This is because networking resources usually scale particularly well as the number of users increases. In an earlier paper [1], the author discusses how the skills and equipment necessary to run a Cisco Network Academy can be used to build an effective Faculty-wide network for teaching and research use, at minimal cost. This paper builds on the first by considering a wider range of factors. The emphasis in this paper changes from a ‘Learning Network’ built on Cisco Network Academy experience, to a wider ‘Learning Environment’ that is far more than just a computer network.

This paper describes a range of elements of the Learning Environment. Each is described fully, then put into context of an overall, ‘living’ environment of many different aspects, build over the years 2000 to 2010. Initially some relatively statics elements of the environment are discussed. The first elements consider are the New Zealand educational environment, Whitireia’s adoption to that environment, and the physical classroom environment over the years of this study. Technical elements are then described – hardware and networking resources available. People skills are described next – the way the Learning Environment is used by academic staff, and the invaluable technicians employed over the years. There is consideration of a recent, and very exciting, addition to the Environment, then a look at the crystal ball of future directions, and mirror of lessons learned.

This paper will contain information useful to anyone managing an applied network lab, or a wider environment for teaching Information Technology (IT) courses.

Keywords: hardware, software, networking, low cost, small, research, teaching, VLAN, image, wireless, wifi, supercomputer, weta, learning environment, VLSM, Cisco, Linux.

I. TERTIARY EDUCATION ENVIRONMENT

The resources that can be offered to students are always going to be heavily influenced by the academic and political environment effective at the time. This section outlines the New Zealand education environment at the start of the 21st century, and notes how environmental changes have influenced activity since then.

Such an outline will add to the understanding of the technical developments over that time, which will be discussed in later sections.

A. New Zealand Educational Framework

The New Zealand educational environment was transformed in the 1990s. Legislation in 1989 created the New Zealand Qualifications Authority (NZQA) (http://www.nzqa.govt.nz/about-us/our-role). A key achievement of the NZQA was the creation of the New Zealand National Qualifications Framework (NQF). This structure assigns 'levels' to education at 'year 11' (about 15 years of age) up. Three years of a typical Bachelors degree are at levels 5, 6, and 7. Part of this process of 'equal treatment' of institutions was the provision for Polytechnics or Institutes of Technology (ITPs) to offer degree courses.

While originally based on models from the United Kingdom, the NQF was adapted to specific New Zealand needs over the first decade of use [1].

B. Types of Tertiary Providers

There are five different models used to provide tertiary education in New Zealand: Universities provide largely theoretical, research based, education; ITPs provide education at all undergraduate levels, with a more applied focus; Wānanga provide education implemented using strategies consistent with Māori – New Zealand's indigenous culture; Private training establishments (PTEs) are generally privately owned institutes that provide lower-level tertiary education; Colleges of education specialise in teacher training. Of these five models, Universities and ITPs provide the majority of level 6 and level 7 networking courses.

It should be noted that Universities have their own quality control systems, and have never been subject to direct Government control, or influence from NZQA. The other four types of provider operate under the quality control of NZQA, or one of various bodies with delegated authority from NZQA.
C. The Growth of Diversity

The changes of the 1990s included the Government divesting itself of a significant amount of the previous direct control over the non-University Tertiary sector. By the end of the decade each institute controlled most aspects of its operation. This control is tempered by a degree by the fact that a significant proportion of income (49% for Whitireia Community Polytechnic in 2009 [3]) comes from direct Government funding, and access to that funding is subject to political changes.

Perhaps the most important part of this autonomy was the ability of each ITP to determine the nature and content of the courses offered. ITPs offering IT courses worked together to form the National Advisory Committee on Computing Qualifications (NACCQ). Initially papers quality assured by the NACCQ, and offered by ITPs, centred on: use of applications; applications development; systems design; with some networking and operating systems papers [4].

D. The Whitireia Experience

During the first decade of the 21st century Whitireia adopted the Cisco Network Academy Program (CNAP) courses. Initially, these were part of two different diploma. By 2008 all Information Technology teaching had been transitioned into the Bachelor of Information Technology degree, and a bridging Certificate in Information Technology. Internal staffing and management changes within the Faculty of Business and Information Technology saw changes that benefitted students by offering a very cohesive programme, with more options than were previously available.

II. INFORMATION TECHNOLOGY COURSES OFFERED AT WHITIREIA

Section I outlined developments in the New Zealand academic environment which allowed more flexibility for each institution. This section summarises the evolution of various Information Technology courses, and the place of Networking and Operating Systems papers within those courses.

Subsequent sections will look at the resources used to deliver these courses.

A. Humble Beginnings

In the late 1990s, networking had a low profile, and simple resources were required to support the papers being offered at the time. There were some old desktop PCs being used as servers, and housed in a Resource Development room, referred to in section III A. A single cable took this network to a classroom about ten meters away. In the classroom there was one switch, and long cables going from the switch to each computer. This was adequate to support the small level of networking and operating systems that was part of the curriculum at the time.

B. Computing as a Trade

During the 1990s, most teaching of computing development and maintenance was within the School of Computing. The most popular IT qualification would include about 50 papers, but only four to eight would be dealing with networking and operating systems. During the early 21st century, there was a move to increase papers in that area, and this included some adoption of Cisco Network Academy Program (CNAP) courses [5].

In 2000, Whitireia recognised that some of the IT teaching could be covered in the Trades School, and the process was put in place to create a Whitireia Cisco Network Academy, based at the new Trades campus being developed at the time, at Mohua Crescent [6].

While some CNAP courses were run in the existing lab at Wi Neera Drive, the Mohua Crescent classroom, MC105, was the 'real home' of the Academy at Whitireia. The CNAP Cisco Certified Network Associate (CCNA) course was used as part of a National Diploma [14], and also offered as a standalone paper, for those wanting the industry certification. This could either be a complement or alternative to an academic qualification, depending on the needs of the student [15]. Initially, the hardware components of the National Diploma were also delivered in MC105. It was identified that needs of these two topics were not complementary (hardware students required less cabling, and more bench surface). When another prefab became available, it was moved in to space next to MC105 at Mohua Crescent.

C. Move to Higher-Level Courses

Between 2005 and 2008 there were a number of political and academic changes that resulted in Whitireia redirecting all higher-level IT students into the Bachelor of Information Technology degree (BInfoTech). Students not ready for the degree could enrol in a Certificate in Information Technology (CIT).

III. PHYSICAL TEACHING ENVIRONMENT

After outlining the academic and political environment, this section describes the various buildings that have been used for teaching networking at Whitireia.

This section will consider how the equipment used to support those devices has evolved over the years.

A. The Wider Campus

Applied, industry focused and relevant, learning has always been a key objective at Whitireia. In the mid 1990s, lecturers realised that students needed some exposure to a typical computer network environment of the time. This was achieved using a minicomputer and set of terminals – surplus equipment donated by an industry partner.

At that time, the Whitireia campus largely comprised prefabricated buildings (prefabs), each 12 metres by 7 metres. At the end of most of these classrooms was an area about two metres long, and the width of the building, partitioned off for use as a resource development room. One of these rooms was the first home to an applied operating system lab mentioned above. By the year 2000, that resource had been replaced by a classroom which had benches installed, and contained PCs that had been replaced on the Whitireia production network. This was supported by...
one or two 'servers' (often also desktop PC class machines) in a separate resource development room.

B. First Network Lab

During the early stages of preparation of the Whitireia 'Trades Campus' [6], in 2002, a new prefab was moved to this site to house a course teaching applied PC support. That was the first home of the Whitireia Network Academy.

The author and trades technician designed a room layout that was totally different to any other classroom at the time. This room was designed to teach applied hardware and networking papers, and included extra cabling to enable the flexibility required to deliver Cisco Networking Academy Program (CNAP) courses. The layout chosen is shown in figure 1.

The first dedicated network lab included a specific structured cabling system. Each of the 20 workstations had four RJ45s. One went to a central patch panel in our server room (the resource development room off that network lab). That line was used for 'normal' connectivity – Internet and productivity applications. The other connections each went to one of two areas designated to house the routers and switches. Not only could the connections be used to connect Ethernet and console cables, but they could also be used to connect computers to each other for peer to peer or server-based networking classes. This flexibility continues to be a key asset, enabling students to reconfigure the environment to meet their needs.

In 2003 a dedicated hardware lab was also created. This had bigger benches for students to work on (1200mm square per workspace), but less networking connectivity.

C. Remote Campus

Starting from the mid-1990s, Whitireia operated two campuses at Paraparaumu, which is about 40 kilometres from Wi Neera Drive. In 2002 a network lab was established in an industrial area, in a campus commonly referred to as Manchester Street. This lab was used to offer the same papers as Mohuia Crescent, however, it was not custom designed, and provided significant physical challenges.

The Manchester Street site was used during the 2003 and 2004 academic years.

D. Moving to the Larger Campus

After being set up originally as a part of the Trades Faculty, the CNAP papers were migrated from being part of a Diploma to being, instead, part of the Bachelor in Information Technology (BInfoTech).

Growth in both the IT (particularly Networking) and Trades programmes created pressure on accommodation. The solution, implemented at the start of 2008, was to move the Networking classroom to the central campus (Wi Neera Drive). This freed up space for trades students, and brought the networking and hardware resources into the same building as the rest of the BInfoTech degree. Students no longer had to make the 10 minute trip between campuses to use CNAP resources.

There was already a classroom allocated to networking at Wi Neera Drive. The move was accomplished by simply moving the benches from one site to the other. Experience suggested a minor change to the room layout. The resulting layout is shown in Figure 2. In addition to changing the layout of the benches, the number of network outlets was changed. The Wi Neera Drive classroom has just three network connections per workspace. One is a 'standard' cable, hard-wired to a network interface card on each computer. In this lab, there are two outlets that students can re-configure. A feature in the new lab, which complements the extensive cabling, is an overhead data projector that also uses the room's structured cabling system to get the video signal to the projector. In the applied network classes, students are often at different stages of an exercise. In this environment, the projector can be patched to any computer in the room, to enable the lecturer to demonstrate a particular concept or issue.

E. Capstone Project Accommodation

Students studying the Whitireia Bachelor of Information Technology (BInfoTech) degree typically spend six months during their final year working on an Industry based "Capstone Project" [9]. The value of this paper is recognised by local businesses, and initially, Whitireia was awarded a business funding grant that funded the Project students to use rented office space about 500 from the Wi Neera Drive campus. In 2004, the Project students were moved to an unused classroom on the Trades Campus. This was seen as a temporary solution, and no permanent fixtures were put in place.

The following year, the Project classroom was moved to a building on the edge of the Wi Neera Drive campus. The following year it was moved again, to the same Wi Neera Drive building as the rest of the BInfoTech delivery.

While not directly related to the Networking classroom, the Projects have been supported in the same network environment. This will be referred to later in this paper.

IV. NETWORK HARDWARE FOR TEACHING

Previous sections have described the political, academic, and physical environment. This section describes the way
networking technologies, which were being taught at Whitireia, were also used to provision a Learning Environment for students and staff.

That will prepare for sections describing where these subject areas are heading.

A. Simple Servers

Initially, the Mohuia Crescent server room (shown in figure 1) contained one server and a Linux router for internal traffic.

The server was an old Dell model, 'donated' by Whitireia production network support services (ICTS). It provided basic file services, while an old desktop PC was used as a router. Both machines were running Linux. Internet connectivity was provided by an 256k bps ADSL connection, connected through a Cisco 1720 router. This provided by a slow, but very reliable, and, by New Zealand standards, very low cost, Internet connection. While the IT courses are no longer using this campus, the same Internet plan is still being used by Trade tutors in 2010.

When the Manchester Street lab was commissioned in 2002, the labs were linked using a second Cisco 1720, and a VPN connection between the two. At that stage two more previously de-commissioned servers were acquired, and a Novell Netware eDirectory environment was created, with one server at each campus.

Throughout this time a range of desktop computers were also used for various, non-critical, purposes.

The Manchester Street Lab was decommissioned in 2005, and resources consolidated to Mohuia Crescent. The Netware servers were replaced with Linux. Previously the Capstone Projects had been provisioned with a simple Microsoft network in their relatively isolated office accommodation. For the 2004 academic year the Project office was relocated to Mohuia Crescent, and was connected to the established Learning Environment there. This was the first use of a wireless bridge, as it was not practical to take a cable to the building housing the Project team.

In 2006 two new servers were purchased for the Mohuia Crescent lab. This was the first purchase of new equipment for the learning environment. One server was used primarily for deploying software images to computers. It ran Microsoft Windows 2000, as this gave easiest compatibility with Symantec Ghost software, used at the time for deploying images to computers in the labs. The other server was used for file services.

B. Expansion Using Wireless

The Cisco Network Academy Program (CNAP) Fundamentals of Wireless LANs course was introduced to the Whitireia Network Academy during 2004. This led to an increase in knowledge of wireless networking. Both staff and students benefitted, and one result was the installation of the wireless bridge for the Project students in 2004.

During 2005 a project was established, and funded, to set up public wireless access in one building ("E Block") on the Wi Neera Drive campus. Funding for the wireless access project also paid for a high-speed (10M bps) connection to the Wellington Internet Exchange (WIX) [8]. The Project Classroom was also moved to the Wi Neera Drive campus for 2005. Students assisted with the installation of a trial wireless LAN, using CNAP equipment. Once it was confirmed that three sites: Trades Campus (800 metres from central campus); Project classroom; and E Block (figure 3), could be linked by a wireless network, equipment was purchased to put a long term link in place.

Extending the Learning Environment in this way not only enabled other students to enjoy the communications benefits, but gave Trades Campus students access to the much faster Internet connection now available using the E Block link to the WIX. It needs to be remembered that the Mohuia Crescent ADSL link was only 256k bps. The WIX connection was 10M bps. Consistent with most Internet connection in New Zealand, the high-speed connection has an international data cap. This case, the cap is just 5 gigabytes per month. More could be purchased, but the cost is outside the budget available. At the speed of this connection, the monthly cap could easily be used in a few hours. Fortunately, national traffic (ie – within New Zealand) is not metered. To make the best use of these conditions, static routes are used in the Learning Environment to route specified national traffic through the WIX.

The Project classroom required telephone access. Training from a CNAP IP Telephony instructors' course, plus further research, equipped staff with the knowledge to achieve this at minimal cost. An available analogue phone line at the Trades Campus was connected to an Asterisk IP PBX server, using an FXO analogue to digital interface. The recently implemented wireless Ethernet link could then connect that server to an IP phone in the Project classroom.

A solution was required for managing traffic between multiple LAN networks within the Learning Environment. The technician employed at the time, and lecturer, both had good Linux knowledge, and available budget did not cover the purchase of a suitable Cisco router, so Linux was an obvious choice for routing traffic.

Figure 3 Photo of Whitireia Porirua Campuses, including wireless line of site for three-way network. Google Maps
Staff and students using the Learning Network have always had access to the production network, and Whitireia productivity and administration systems. These systems provide secure, reliable, services. The Learning Network does not need to duplicate those services, so all sensitive information is kept on the production network.

C. Going Virtual

There was one significant hardware change in 2007. That was a move away from providing operating system classes using partition images stored on a local hard drive [9] to the increasingly popular use of virtualisation [10][11][12]. A second network card was added to each PC in the network lab. This allowed one network interface card (NIC) to remain attached to the lab switch for productivity applications, Internet use, etc, while the second NIC was available for students to connect to routers and switches for CNAP labs and research.

The second NIC works particularly well with multiple operating systems (OSs). A virtual NIC in a virtual OS can be bridged to the second physical NIC, and connected to another (physical or virtual) computer. Kroeker has written a summary of virtualisation development, with predictions of the future [16].

D. Server Evolution

It was mentioned in section III B above that staff use the production network for their general productivity applications. The term ‘Learning Environment’ is used to distinguish the services provided by the School of Information Technology staff to support the learning of their students. This separation has resulted in the situation where the School of IT does not need to provide all the services expected of a production network. Storage, email, printing, and numerous other services are provided by the production network, and do not need to be duplicated in the same way in the Learning Environment. For this reason, there has been little need for the purchase of new server hardware.

Up until the end of 2008, ‘servers’ consisted of a mixture of workgroup-scale servers, and ‘retired’ desktop machines. Of approximately eight servers in use in 2008, two were purchased new in 2006, and one in 2008. These ran a mixture of native server installations, and VMware Server installations. In 2009 an enterprise-scale server was purchased, and about the same time, the Faculty signed up for the “VMware ELMS Store”, which gives us access to most VMware products on academic terms, for research and teaching use. Most of the desktop machines that were previously acting as servers have been replaced by VMware Virtual Machines, with hosts running VMware ESX server. This has greatly simplified the management of the server environment. Guest servers, and workstations, can now be managed from software such as the VMware vCenter Server console.

V. NETWORKING FOR TEACHING

Section IV described various elements of hardware required for the Learning Environment. This section describes the development and growth of a stable network environment in which to use that hardware.

A. Logical Network Redesign

The establishment of networking and operating systems as a significant part of the Bachelor of Information Technology (BInfoTech) was a significant achievement. It was characterised by frequent changes to the physical and technical environment. The last significant move (up to the time of writing, and the planned future) was to consolidate all of the BInfoTech resources in one building. This removed the need for wireless links between sites, and prompted a network redesign, using a template from a CNAP lab. A section of the spreadsheet template is shown in figure 4. The design is based on variable length subnet mask (VLSM) best practice.

The nature of an applied IT degree programme requires exposing a network infrastructure to some risks. This is one of the reasons for the creation of a specialised learning environment for teaching IT courses. A key part of that environment is segmentation of the network into units as small as is practicable. That process will minimise any adverse effect of student research and experimentation, as such effects will usually only affect the network in which they occur.

The approach taken is to use VLANs and a hierarchical VLSM structure. Different networks are provided for each of a variety of zones, including classrooms, servers, staff computers, wireless, and other categories.

B. Public Wireless Access Trial

One BInfoTech paper covers Internet Security and Wireless Networking. When this paper was run in July 2008, funding was obtained to buy equipment to support a trial of public, free, wireless Internet in E Block. The students carried out site surveys of the building, and evaluated options for providing access. Equipment required was ordered, and the students set up the access points, running on a separate VLAN, and built a captive portal server to provide layer three security. In this way students achieved the necessary outcomes for their wireless networking paper, and Whitireia got a well-documented trial public wireless LAN at minimal cost.

The trial was a unqualified success. The minimal security measures put in place appear adequate to track
usage, and there has not been any undesirable activity detected or reported on either the trial network, or the operational version, which is described below.

C. Public Wireless Access Operational

Five students contributed to building the infrastructure for the public wireless network trial. Three of those students went on to be the first students to complete a networking-based capstone project. In keeping with the requirements of the Project, they had an 'external' (to the Faculty) client – in this case, a senior library staff member. The project required establishing public wireless access in Te Kete Wānanga, the Whitireia Library building. This project included collaboration between the Business Faculty and Whitireia ICT Services (ICTS). ICTS provided hardware in the form of access points and switches, and left it to the BInfoTech project students to install and configure then. Again, this was a successful project: students got 'A' passes for their project; ICTS were able to complete their own wireless service; and the Faculty was able to finish provision of a public wireless network. All this was accomplished with a very low budget.

D. Rapid Network Evolution

At the start of 2009, the Learning Environment encompassed: Network Lab; Server Room; Project Classroom; Staff offices; and Public wireless. This was a total of about 70 fixed machines and up to 25 wireless clients at one time. In February 2009, the production network was seriously impacted by the Conficker worm [13]. This, and a combination of other factors, was putting pressure on BInfoTech students. It was decided to move a classroom containing 30 computers from the production network to the Learning Environment. The Faculty staff who designed, implemented, and supported the Learning Environment had proven their network was reliable, and could scale, so were asked to take on the classroom. While this added about 40% to the number of fixed computers, the nature of use meant that the computers added (new machines, all running Vista) roughly doubled network traffic. Our Faculty students and staff using the network seemed very happy, as were staff from other areas of Whitireia who could not get their usual service from the production network while that network was impacted by the virus. There has not been any sign of Conficker in the Learning Environment.

Continued rapid growth in numbers of IT students, and the success of the February 2009 expansion, resulted in further expansion in July. An additional classroom, also containing 30 computers, was added to the Learning Network. At this stage the infrastructure was upgraded, for the first time in several years. An aging Linux PC had been doing very good service as a router. This was replaced with a Cisco 3560G gigabit layer-3 'core' switch. All access-layer switches were also replaced with gigabit switches (all desktops having had on-board gigabit network interface cards for some time). Areas often used for networking research also have a 2950 'fan-out' switch. One trunk port connects each fan-out switch to the core switch, and the fan-out switch can then be configured (by a staff member) to enable access to any VLAN required for research or teaching. The core switch connects only servers and other switches. The lecturer and network technician (a CNAP graduate) had no difficulty transferring their routing skills to the layer 3 switch, and the Microsoft-trained network administrator was learning the Cisco IOS command line quickly.

VI. ADD A SUPERCOMPUTER ...

The establishment of the Learning Environment has been described to the current point (August 2010). There is no obvious need to make significant changes to the day to day running of the Environment in the foreseeable future.

There are other services that could be offered, which are described here.

This paper will then describe the way in which technical staff have been employed to support this environment.

A. IBM Blade Servers

Wellington, New Zealand, is currently credited as home to five of the most powerful supercomputers in the world. (http://www.top500.org/list/2010/06/300). In June 2005, Weta Digital of Wellington, had a supercomputer in the top 100 (http://www.top500.org/list/2005/06/100). This resource has frequently been referenced in the technical, academic, and mainstream media [17][18].

The 'top500' references above show that Weta changed from an IBM BladeCenter HS20 platform to a Hewlett-Packard Cluster Platform 3000BL. Late in 2009, the last IBM equipment was donated to Whitireia [19].

This donation includes four data cabinets, populated with over 300 Xeon EM64T 3.6 GHz blade servers, each with 8 gigs of RAM. There is also a significant quantity of older blades. At the time of writing, plans are being formulated for the long-term use of this resource.

Existing resources allow for three chassis to be used for experimental work. This includes School of IT staff learning how to manage the blades in a cluster. Whitireia has a design school, which will be using the blades for rendering of images – a key requirement of Weta Digital as a local employer.

It is envisaged that the School of IT will be able to enhance the student experience through the use of blades for a range of purposes. The immediately obvious use is to create a VMWare vSphere cluster. The Learning Environment already relies on VMWare technology. It is used to provide services to students and staff, as well as being in use directly by students, as part of their learning. Initial experiments suggest it might be a very simple process to cluster a number of blades so they appear as one host for any virtual machines that need to be run as guests.

There will be other uses for the blades. One has already been used by a Capstone Project team to provide a virtual reality simulation server.

B. High Speed Communications

Later in 2010, it is envisaged that the Learning Environment will be enhanced by a connection to the...
Government sponsored Kiwi Advanced Research and Education Network (KAREN – http://www.karen.net.nz/about/). Whitireia will have a one gigabit connection to this network, which operates a 10 gigabit backbone over all of New Zealand, with slower connections to Australia and the United States. Whitireia operates a campus in Auckland, about 900 kms from Porirua. Courses offered on this campus include the BInfoTech, but Auckland students and staff have not yet been able to share all the benefits of the Whitireia IT Learning Environment because they do not have a network connection. KAREN will enable the two networks to be linked. Resources can be shared, and all students and staff will benefit from the enhanced environment.

Connection to KAREN is also a key requirement to make full use of the blade servers. They are a resource much bigger than any demand from within Whitireia, however, connection to KAREN will enable them to be used by other academic and research organisations around New Zealand and worldwide. Those organisations could then contribute to the cost of running the blades as a supercomputer grid.

VII. Technician Support

Staffing an academic working lab is another challenge[20]. There are a variety of factors to consider, and ways to address the issue. This brief section outlines some of the factors.

A. Avoid Over-Commitment

It is important to acknowledge at the outset that the author believes, from personal experience and observation, that there is an imbalance in the support expectations of networking and operating system lecturers (infrastructure), when compared to application development lecturers. Both would like to always have equipment working to an agreed standard before class or lab work. The infrastructure lecturer will generally know how to fix many hardware and network problems. It is in the nature of most teachers to want the best for their students from each session. The lecturer needs to draw a line, and remember that knowing how to fix a problem does not necessarily mean you should spend time fixing it.

B. A Computer is a Computer ...

There can also be pressure to use the same support services for an IT learning environment as is used by other disciplines. The most common rationale this author has heard is that there can be pure duplication – two people doing the same work, making the same mistakes, at the same time. Ten years of experience suggests this is not the case.

An example is the building of desktop images. Standard productivity applications tend to be used by all PC users, and can be installed by a mid-level support engineer. Application development images, however, can have far more complex interdependencies. The person building the image needs some knowledge of how do basic tests of each application, to ensure that each works when installed, and keeps working as other software is added.

Many support requirements are different. IT students tend to do their own level one support (usually successfully). They will then often log help requests on line for anything more significant. When there is a need for support, it tends to be time-critical, such as a previously undiscovered software incompatibility. A variable need to specialised assistance is not each to schedule against competing ‘productivity application’ demands for support time.

The Whitireia Learning Environment does not significantly duplicate services provided by ICT Services (ICTS). None of the following services are guaranteed: file storage; email; printing; student results processing etc; wireless network; accounting; web services; remote access. Each of these services, if provided at all in the Learning Environment, is provided on a ‘best effort’ basis. It should be noted, however, that many of those services have been provided, on a very low budget, to the satisfaction of Whitireia students, for up to ten years.

Provision of an academic learning environment is best provided by academic staff. This is the same for Trades, Nursing, Education, Arts, and Information Technology.

C. Support Staff Over the Years

As one would expect, the increasing complexity of the environment has been accompanied by the engagement of increasingly skilled staff to support the networks. Two of the five technicians employed between 2000 and 2010 have moved on to work with ICTS. Each time there was talk of a ‘shared technician’ but this changed to a role with little time for the Learning Environment over a period of about a year. Interestingly, two IT hardware tutors are also now employed by ICTS. It should be noted that of the five technicians referred to above, two are still employed in the Learning Environment, so only one has left Whitireia!

Of the five technicians, all but one had first contact with Whitireia as students. Two staff members were employed in the Learning Environment from circumstances that made it difficult for them to find employment in industry. In these and other examples, the flexibility, exiting research opportunities, and relaxed environment have encouraged staff to stay in an academic environment when they could have got a higher remuneration elsewhere.

Currently technical and network administration support are provided by two staff on a part time, largely ‘ad-hoc’ basis in the Learning Environment. One of the strengths of the current networking team is that members generally work part-time (keeping down operating budget), but make themselves available in times of crises or heavy work loads (generally in student study breaks, at the beginning of each teaching semester). With future developments such as work with the blade servers and providing laptop support, it is anticipated that the hours of the support team will need to increase.

VIII. Future Directions

This paper has documented the path taken at Whitireia Community Polytechnic to build an effective, scalable, teaching and research network for Information Technology programmes.
All that remains is to consider the way forward, and summarise lessons learned from the past ten years.

A. Current Research - Future Implementation

Continued success running the Learning Network has improved confidence in our abilities. Firstly within Faculty management, and following from that, broader Whitireia management. There is now continuing stream of exciting projects becoming possible.

Particularly relevant to this paper is a feasibility study considering students’ use of laptop computers, rather than desktops, in classrooms. This study builds on our experience in a number of areas. The current public wireless network gives us a range of reports and anecdotal evidence, informing our analysis of the needs of an extended wireless network. Our success supporting both desktop and laptop users since July 2008 gives an indication of the support needs when 30 senior students are depending on a laptop-enabled environment. Knowledge of VMware, built up during 2009, enables us to consider how virtualisation can be used in the new environment.

A current research proposal is considering the use of a mesh of low-cost access points (APs). The author wants to determine if a mesh can provide better performance than discrete APs when there is a high density of users in one classroom.

Other areas of research will be considered beyond that. There will be opportunities to look at network and Internet traffic patterns as users move from desktops to laptops. Commissioning of the blade servers could lead to another project considering new opportunities offering students a virtual ‘personal’ machine each. This is one of many options using grid computing, working with other academic partners.

B. Lessons Learned

There is an often-quoted metaphor of IT support being built out of three parts. There is quality, reliability, and low cost. The metaphor suggests that a increase in any of these three factors requires a decrease in at least one of the others. The Whitireia Learning Network constantly manages this juggling act. Some of the ways this is done, and the implications observed, are listed here:

1) Beware of personal burnout

There are always enthusiastic students, who want to help. Sometimes it is necessary to tell these students to focus on passing their papers, then come and see if they can do something for us! Staff, too, can see the benefits of growing the Learning Network, or adding new functionality, that our students and colleagues would use. Sometimes we spend too many extra hours working on the network, and suffer some fatigue.

2) Communicate

Poor communication is blamed for the failure of many IT projects. Maintaining a network on a very limited budget does not leave space for waste of any resources through different participants not knowing what each other are doing. There are many areas where communication is essential. Two are detailed here.

a) Manage User Expectations

As mentioned earlier, the Learning Network does not offer ‘normal’ productivity and administration services. Likewise, no promise is made regarding security of data on the network. We have a production network that offers all of these attributes. There is also an expectation, usually met, that staff and students communicate with network support people if they find an issue. Occasionally, we have a ‘crisis’ of one sort or another. In those situations, staff and students alike rally round to help! This strategy works when dealing with IT lecturers and students. More investment will be required to support a network that is used by a wider range of people.

b) Document Everything

The nature of the support infrastructure means that development and use of the network is cyclical. Students are able to contribute where the outcomes from a particular paper correspond to a feature that is required on the network. They may, or may not, fully implement that feature during the course of their paper. If work completed is well documented (often a required outcome of a paper), other staff, or next year’s course, might be able to complete it.

Technical staff also come and go over time. Again, good documentation is vital to keep momentum in this situation.

Within the Whitireia Learning Environment, we use Google Docs to record most of our non-sensitive technical documentation. While there are security and philosophical issues with this solution, is it very easy to implement, and doesn’t depend on having our own document management system to facilitate document retrieval.

3) Consider ‘Volunteers’ Carefully

We have found that student (and non-technical) staff volunteers are a high risk. They often require time to be trained, and then find they don’t have the time they would like to devote to your project. Sometimes you train them to a reasonable level, and they then find a ‘real’ job, and no longer have time to work on the Faculty network (and we wish them well – student success is our top priority).

4) Watch Your Budgets

Ensure classroom equipment is distinguished from infrastructure equipment. We have frequently used classroom equipment to evaluate potential network expansion, but if something is going to be left in place past the end a semester, the question must be asked “Which capital budget will the replacement come from?” Being consistent on this strategy means management respect and expect this distinction. On the other hand, it is important too, that academic staff are not too ‘precious’ about this. Classroom equipment that has been replaced, or is not likely to be used in class again (perhaps because of a change in the content of a paper) should be offered for infrastructure use.

5) Maintain the Teaching and Research Role

Ensure that your teaching network is not being used for core, production, purposes. When sourcing equipment for your teaching network, ensure suppliers know this. Cisco Network Academy Program participants should discuss with their Area Academic Manager whether Academy priced equipment can be purchased for your teaching network. Use links within the IT community to approach other suppliers,
and schemes such as the Microsoft MSDN-AA program, and VMware ELMS storefront, to see if software and hardware through various suppliers is available at a lower price.

6) Use Low-End Equipment With Care ...

There is a reason why some ‘enterprise’ solutions cost many times as much as small office or home office (SOHO) equipment. The Learning Environment uses some Linksys switches and wireless access points (APs). This is unlikely to be considered for devices that require any degree of complication in their configuration. While Linksys is referred to here, similar comments apply to equipment produced by other SOHO-targeted brands.

An example of the subtitle differences can be seen when configuring multiple networking devices. Cisco equipment can often be configured with graphical (GUI) tools, however, any configuration is also shown, and can be modified, by referring to the command line interface (CLI). Linksys equipment generally requires configuration through a web interface. The interface for a managed switch contains over 100 screens! This makes it complicated to track the overall status of the device.

We have compromised in the provision of gigabit access layer switches. These are over-provisioned (48 port Linksys switch per 30 seat room), so all ports are on the same VLAN, and there is minimal configuration. In this example, management requirements are kept to a minimum, which seems to work.

The Linksys APs are going to be replaced when finances allow for this. Currently each AP needs to be configured individually. We will evaluate options from Cisco, HP, and D-Link that offer a wireless LAN controller of some sort, so all APs can be managed from one interface.

7) … but remain open to purchase of second hand equipment

Much of our Cisco equipment has been purchased from a New Zealand auction site. At the time of writing, we had found all equipment purchased this way performed very well.

C. Conclusion

The Whitireia Community Polytechnic is a very small institute in world terms. We believe we have created an excellent, world-class, environment for learning applied application development and networking. We have done this by taking advantage of the skills of staff and students, and any other resources available to us.

This paper has described how we did this. If you are a staff member in any similar institute, you are encouraged to learn from our experience, add your own flair and enterprise. Build your own teaching network, and contribute to the Literature with a description of how you have created an environment of excellence for your students.

IX. REFERENCES


