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Longitudinal study of Linux networking in NZ industry and ITP education

Dileep Rajendran
Waikato Institute of Technology, New Zealand
dileep.rajendran@wintec.ac.nz

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Abstract

This paper focuses on the networking services that can be (and to some extent are being) taught using the Linux operating system. First it collates information from recent literature about server and desktop operating systems, allowing the reader to see the position of the Linux in the market.The second part uses a quantitative analysis of networking job advertisements in New Zealand (NZ), to investigate employer demand for Linux knowledge and skills in comparison to other technologies in this job category. Data was gathered for one year to see if trends could be observed and there is a comparison of the results from a previous study.Having identified the level of industry demand for Linux in the first two sections, the final part investigates the extent to which Linux networking services are taught in 89% of New Zealand ITPs. Additional data was gathered about the particular services and subject areas in which the services are taught.

Introduction

There are many aspects of the Linux operating system taught across a variety of courses and subject areas in New Zealand institutes of technology and polytechnics (ITPs). This paper particularly focuses on the networking services offered by Linux.

It is important to teach fundamental platform-independent knowledge and skills in computing. In relation to networking and data communications, platform-independent skills could include things such as IP-addressing, subnetting, routing, routing protocols and terminal emulation. It is also important that the tools used to teach computing such as the operating system and vendor-specific software are chosen to help with student employability, as this is one of the aims of New Zealand ITPs (ITPNZ, 2008). To this end, industry technology trends and employment demands are investigated to assist IT educators to include technology that reflects the dynamically changing workplace that students encounter.

This paper extends an earlier conference paper (Rajendran, 2007) by investigating employer demand for technologies in NZ networking jobs over the duration of one year. An analysis is done to observe changes over this time. There is also updated information from the literature on the operating systems market and additional data was collected for the final section from NZ institutes. This gives a more complete

perspective of the Linux networking services taught in different subject areas across the country, enabling more meaningful conclusions to be made. The results of the final section are of value when considering the Linux networking services to be included in teaching and in determining whether it is consistent with other institutes. It may also be of value to those considering a national ITP collaborative computing degree (Corich, 2006) in NZ.

This work was motivated by the author's experiences and observations of networking and operating systems papers in a NZ institute of technology. It was evident that, although a wide variety of useful and important services were taught, there was room for further aspects of Linux networking to be included.

Linux in the Market

Many agree that Linux is a major player in the global server operating systems market (Galli, 2007; Kumar, 2007; Morgan, 2006; Orr, 2003; Thibodeau, 2007; Wikipedia, 2008), along with Microsoft and Unix servers. It is known to be used for some very large systems; Magid (2007) gives the example of Linux servers being used to run the Google search engine.

Some of the discussion that follows relates to figures obtained by Burks (2006) from two of the top three market research companies in the IT Industry (Gartner Incorporated and the International Data Corporation (IDC), where Gartner is the dominant one). Thibodeau (2007) quoted figures from the Gartner Data Centre Division, projecting the 2007 server operating system market worldwide sales to be Windows (36%), Unix (30%) and Linux (16%). Other server operating systems (such as Open Virtual Memory System, Netware and mainframe operating systems) together share the remaining 18%. Gartner also project growth for Microsoft and Linux until 2012. Linux servers have shown double figure growth in this market for nearly four years up to 2005 (Galli, 2007; Morgan, 2006). Galli (2007) graphs IDC annual growth figures over this time, showing that 2003 Linux servers exceeded Microsoft by around 30%. This is consistent with the Linux server growth observed by the IDC in NZ and Australia during this time (Varghese, 2003).

2007 statistics indicate that Microsoft and Linux are growing and sources attribute this to the increasing use of x86 servers (Galli, 2007; Thibodeau, 2007). Thibodeau (2007) says the growth of Microsoft and Linux is at the expense of the market share of Unix servers. However Galli (2007) shows the overall market has been decreasing, as is that of Microsoft and Linux. Galli quotes IDC figures that show the growth of Linux has been declining more than Microsoft, but IDC acknowledge that "the number of servers shipped do not perfectly equal the number of operating systems in the market" and he indicates that figures do not take into account that people buy empty servers or recycle old Windows/ Unix servers and install Linux on them.

To a smaller extent than Microsoft Windows and Macintosh OS X, Linux is also used as a desktop operating system. Some consider it difficult to install and use (Magid, 2007). However, it has been growing in popularity on the desktop (Predd & Cass, 2005). In particular the Ubuntu Linux distribution is becoming very popular (Brooks, 2006; Castelluccio, 2006; Vaughan-Nichols, 2006) and is regarded as one of the more consumerfriendly versions of Linux (Magid, 2007). However, Mossberg (2007) feels even Ubuntu is still not user-friendly enough for the vast majority of computer users. Kumar (2007) found that there is a significant level of migration from Microsoft to Linux on both servers and desktops for organisations of all sizes in India, New Zealand, Singapore, Australia, the UK and the USA. There was also migration from Unix servers to Linux, though this is believed to be stabilising (Galli, 2007). Quantitative analysis of NZ networking job advertisements To estimate the demand for Linux in comparison with other technologies sought after by networking employers, job advertisements from two well known job advertising websites in NZ were analysed at three different times over one year: in November 2006, July 2007 and December 2007.

Advertisement Analysis Methodology

The Seek (seek.co.nz) and TradeMe (www.tradme.co.nz/trade-me-jobs/ index.htm) websites were used. For each website the 'search' needed to be defined to find jobs relating to networking. Jobs relevant to this research had a wide variety of titles, for example, network administrator/ engineer, systems administrator, IT specialist/consultant, security engineer, IP systems engineer. Systems analyst, database administrator and programmer/developer jobs were not included. Care was taken to avoid duplicate job advertisements, i.e. another advertisement for the same position.

For the Seek website, relevant jobs were found under the 'Information Technology and Telecommunications' classification. There were two subclasses: 'Networks & Systems' and 'Engineer:Network'. For the TradeMe website, relevant jobs were found under the 'Information Technology and Computing' classification. There was one subclass for TradeMe: 'Networks & Systems'. Both subclasses for Seek were combined to give another set of results called 'Seek Subclasses Combined' and as both websites had one common subclass (Network & Systems) this was also combined (Network & Systems Subclass Combined). So there are five sets of results for each iteration (refer Table 1).

In each advertisement, the technologies of interest were noted and grouped into three main categories:

- Must-Have: Skills/knowledge required for the successful applicant.
- Preferred: Skills/knowledge the successful applicant would ideally possess.
- Nice-to-Have: Skills/knowledge that would be advantageous for the successful applicant.

A simple weighted analysis was used where the elements were prioritised and given a numerical weighting (or judgment). The 'Must-Have' category is given a weighting of 3, 'Preferred' is given a weighting of 2 and 'Niceto-Have' a weighting of 1. Even though this paper is mainly interested in the results for the Linux,

Microsoft and Unix operating systems, other technologies appeared frequently in these job advertisements. These are included to give the reader a better sense of where Linux is placed. Technologies chosen for this research are: Linux (L), Unix (U), Microsoft (M), Cisco (CS), Citrix (CTX), Novell (N). Those relating to RF Engineer, VoIP etc were put into a category called 'other'. This category is not included as it is comparatively small and cannot be used to draw any conclusions.

Aside from the unweighted and weighted values of each technology, the percentage of total advertisements in which each technology is found, is also calculated by dividing the unweighted total for the technology by the total number of job advertisements for that subclass. These values are included as they lead to some interesting observations. The websites, classes, subclasses and technologies investigated and the methodology that is outlined above were kept consistent throughout the year in order to see if trends could be observed.

Advertisement Considerations

There was a reasonably clear distinction between Unix and Linux in the job advertisements. There is a possibility that Linux was not mentioned as a 'nice-to-have' when Unix was sought after and vice versa as the two operating systems have similarities (Kaplenk, 1997; Kumar, 2007; Orr, 2003; Wikipedia, 2008). This possibility is ignored in this analysis as it is not tangible. Although it does add to the usefulness of including Linux in teaching where there are transferable skills if one later decides to learn Unix. Linux has even been used to teach Unix system administration courses (Kaplenk, 1997).

Microsoft has a wide variety of software products in these job advertisements. For the following results it was decided to combine these into one heading (Microsoft) as the breakdown of specific Microsoft technologies is not the focus of this research.

Advertisement Results

Table 1 displays the final weighted, unweighted and percentage of total advertisements calculated for all five subclasses and three iterations.

Table 1. Weighted, unweighted and percentage of total advertisements for all iterations

		L	U	M	CS	CTX	N
Iteration 1: November 2006							
Network & Systems (Seek)	unweighted	26	44	74	22	11	5
	% of total ads	16.1	27.3	46.0	13.7	6.8	3.1
	weighted	71	126	211	63	26	15
Engineer: Network (Seek)	unweighted	10	7	47	34	20	7
	% of total ads	11.1	7.8	52.2	37.8	22.2	7.8
	weighted	26	20	129	85	48	17
Network & Systems (TradeMe)	unweighted	16	27	69	24	9	6
	% of total ads	13.6	22.9	58.5	20.3	7.6	5.1
	weighted	45	78	198	70	25	18
Seek Subclasses Combined	unweighted	36	51	121	56	31	12
	% of total ads	14.3	20.3	48.2	22.3	12.4	4.8
	weighted	97	146	340	148	74	32
Network & Systems Subclass Combined	unweighted	42	71	143	46	20	11
	% of total ads	15.1	25.4	51.3	16.5	7.2	3.9
	weighted	116	204	409	133	51	33
Average Percentage for iteration 1:		14.0	20.8	51.2	22.1	11.2	4.9
Iteration 2: July 2007							
Network & Systems (Seek)	unweighted	43	65	137	38	36	5
	% of total ads	16.3	24.7	52.1	14.4	13.7	1.9
	weighted	113	182	393	99	85	15
Engineer: Network (Seek)	unweighted	18	21	74	28	32	3
	% of total ads	13.1	15.3	54.0	20.4	23.4	2.2
	weighted	42	56	204	68	72	8
Network & Systems (TradeMe)	unweighted	26	34	84	29	19	6
	% of total ads	15.8	20.6	50.9	17.6	11.5	3.6
	weighted	66	93	240	75	44	17
Seek Subclasses Combined	unweighted	61	86	211	66	68	8
	% of total ads	15.3	21.5	52.8	16.5	17.0	2.0
	weighted	155	238	597	167	157	23
Network & Systems Subclass Combined	unweighted	69	99	221	67	55	11
	% of total ads	16.1	23.1	51.6	15.7	12.9	2.6
	weighted	179	275	633	174	129	32
Average Percentage for iteration 2:		15.3	21.1	52.3	16.9	15.7	2.5
Iteration 3: December 2007							
Network & Systems (Seek)	unweighted	67	79	120	52	38	17
	% of total ads	27.7	32.6	49.6	21.5	15.7	7.0
	weighted	173	218	315	115	78	34
Engineer: Network (Seek)	unweighted	11	15	53	21	15	2
	% of total ads	10.8	14.7	52.0	20.6	14.7	2.0
	weighted	30	43	143	48	30	3

Network & Systems (TradeMe)	unweighted	30	36	70	24	21	1
	% of total ads	21.6	25.9	50.4	17.3	15.1	0.7
	weighted	81	102	186	58	46	3
Seek Subclasses Combined	unweighted	78	94	173	73	53	19
	% of total ads	22.7	27.3	50.3	21.2	15.4	5.5
	weighted	203	261	458	163	108	37
Network & Systems Subclass Combined	unweighted	97	115	190	76	59	18
	% of total ads	25.5	30.2	49.9	19.9	15.5	4.7
	weighted	254	320	501	173	124	37
Average Percentage for iteration 3:		21.7	26.2	50.4	20.1	15.3	4.0
Total Average Percentage:		17.0	22.7	51.3	19.7	14.1	3.8

Analysis of Advertisement Data

Weighted total results that were close together are considered an equal ranking because if the total number of jobs (sample size) were to be expanded by even a slight amount, they are too close together to estimate which one would have the higher ranking. Very few (8%) fall into this category.

When all three sets of results in Table 1 are combined, eleven of the fifteen results (73%) had the same ranking for the weighted and the unweighted results. It can thus be reasoned that if the weighted approach was not used, the resulting ranking would be reasonably accurate. However there were some anomalies (27%) where in many of these cases the unweighted results were so close together that they could be considered equal. However when the weightings were applied there was a reasonable difference between them. The weighted analysis appears to provide a more accurate ranking. Thus just the weighted results are used to determine the ranking of the technologies in Table 2. M(211) represents Microsoft with a weighted total of 211. The ranking is determined by the highest weighted number e.g.: M(340), CS(148)-U(146), L(97), CTX(74), N(32). This would place Microsoft in first place, Cisco and Unix in second, Linux in third, Citrix in fourth and Novell in fifth. There is no sixth place in this instance.

Table 2. Technologies ranked for each iteration and subclass with weighted totals

Place Value/Ranking	1	2	3	4	5	6
Iteration 1: 2006 November						
Network and Systems (Seek)	M(211)	U(126)	L(71)	CS(63)	CTX(26)	N(15)
Engineer: Network (Seek)	M(129)	CS(85)	CTX(48)	L(26)-U(20)	N(17)	
Network and Systems (TradeMe)	M(198)	U(78)-CS(70)	L(45)	CTX(25)-N(18)		
Seek Subclasses Combined	M(340)	CS(148)-U(146)	L(97)	CTX(74)	N(32)	
Network and Systems Subclass combined	M(409)	U(204)	CS(133)	L(116)	CTX(51)	N(33)
Iteration 2: 2007 July						
Network and Systems (Seek)	M(393)	U(182)	L(113)	CS(99)	CTX(85)	N(15)
Engineer: Network (Seek)	M(204)	CTX(72)-CS(68)	L(42)	U(56)	N(8)	
Network and Systems (TradeMe)	M(24)	U(93)	CS(75)	L(66)	CTX(44)	N(17)
Seek Subclasses Combined	M(597)	U(238)	CS(167)	CTX(157)	L(155)	N(23)
Network and Systems Subclass combined	M(633)	U(275)	L(179)-CS(174)	CTX(129)	N(32)	
Iteration 3: 2007 December						
Network and Systems (Seek)	M(315)	U(218)	L(173)	CS(115)	CTX(78)	N(34)
Engineer: Network (Seek)	M(143)	CS(48)	U(43)	L(30)-CTX(30)	N(3)	
Network and Systems (TradeMe)	M(186)	U(102)	L(81)	CS(58)	CTX(46)	N(3)
Seek Subclasses Combined	M(458)	U(261)	L(203)	CS(163)	CTX(108)	N(37)
Network and Systems Subclass combined	M(501)	U(320)	L(254)	CS(173)	CTX(124)	N(37)

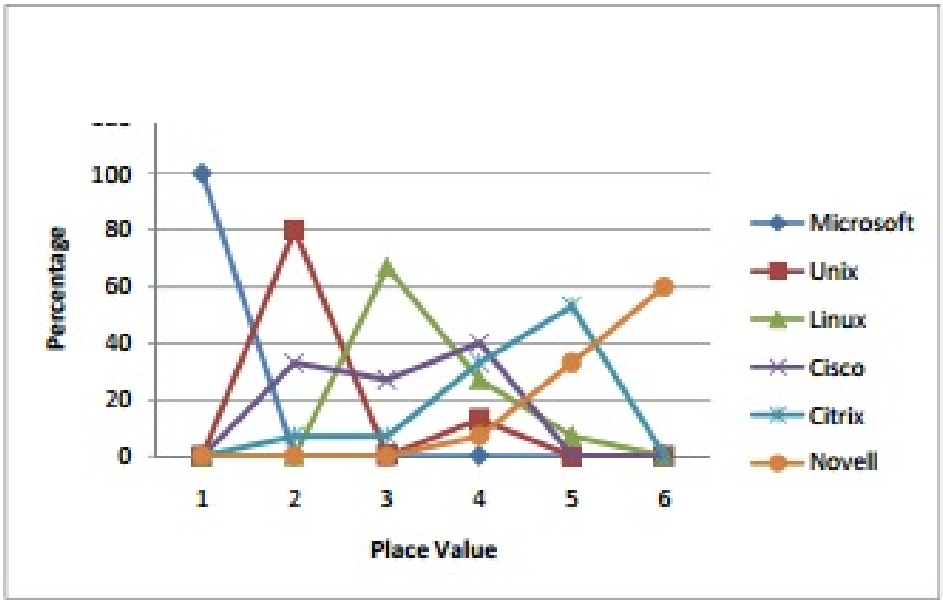
From Table 2, the number of times each technology was found in each place was

calculated and presented in Table 3 and graphed in Figure 1.

Table 3. Summary of place values for each technology

Technology	Number of times out of 15 in 1st place	Number of times out of 15 in 2nd place	Number of times out of 15 in 3rd place	Number of times out of 15 in 4th place	Number of times out of 15 in 5th place	Number of times out of 15 in 6th place
Microsoft	15 (100%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)
Unix	0 (0%)	12 (80%)	1 (7%)	2 (13%)	0 (0%)	0 (0%)
Linux	0 (0%)	0 (0%)	10 (67%)	4 (27%)	1 (7%)	0 (0%)
Cisco	0 (0%)	5 (33%)	4 (27%)	6 (40%)	0 (0%)	0 (0%)
Citrix	0 (0%)	1 (7%)	1 (7%)	5 (33%)	8 (53%)	0 (0%)
Novell	0 (0%)	0 (0%)	0 (0%)	1 (7%)	5 (33%)	9 (60%)

Figure 1. Graph of place values in Table 3



A cursory glance at Table 3/figure 1 would suggest the following ranking: Microsoft (100%), Unix (80%), Linux (67%), Cisco (40%), Citrix (53%), Novell: (60%). This is based on the highest percentage in each place. However this would not be very accurate, for example in the case of Cisco that has significant and somewhat similar figures in several places (2, 3, and 4). So it would not be accurate to give Cisco fourth place based on the fact that this is where it has the highest value. Several of the technologies have some presence in several places. Calculating the mean place gives a more meaningful result. Taking the Unix figures as an example; 80% of the time it was in second place, 7% in third place, 13% in fourth place and it was never found in first, fifth or sixth place. Therefore the overall place for Unix can be calculated as: (0×1) + (0.8×2) + (0.07×3) + (0.13×4) + (0×5) + (0×6) = 2.33. This can be rounded to second place for Unix. This calculation is done for the all technologies and the final ranking is: Microsoft (1.00), Unix 2.33, Cisco (3.07) - Linux (3.44), Citrix (4.32), Novell (5.53). It can be noted that Cisco and Linux tie at third place and there is no sixth place.

Table 4. Ranking comparison

Place	Previous Study (Rajendran, 2007)	This Study
1	Microsoft	Microsoft
2	Unix and Cisco	Unix
3	Linux	Cisco and Linux
4	Citrix	Citrix
5	Novell	Novell
6	None	None

The overall ranking discovered in this paper is similar to, but slightly different from, that obtained in the earlier conference paper (refer Table 4), showing that the demand for Cisco is closer to that of Linux rather than Unix. However both support the view as indicated in the literature that the demand for Linux is significant (third place) under that of Microsoft and Unix. The results in this paper are considered to be more accurate as it takes the figures over the course of the one year as opposed to on one day.

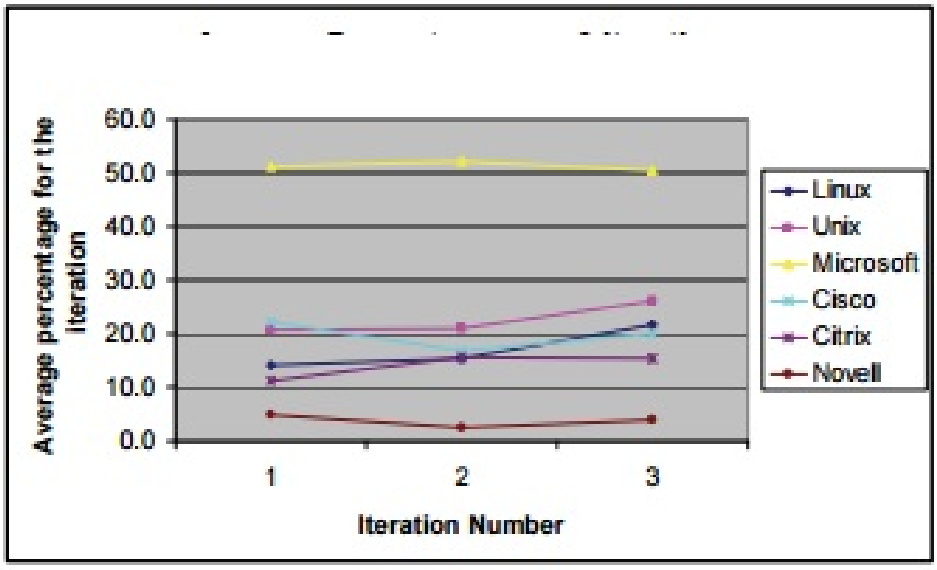
Trends Observed During the Year

Microsoft is always (100%) on the top (first place) of ranking and Novell is always (100%) on the bottom (fifth or sixth place) of the ranking. Figure 2 graphs the average percentage of total advertisements in which each technology is found, over the three iterations. This reveals what employers are looking for:

- Linux skills/knowledge is found to have consistently increased (by 8%) over the year.
- Unix skills/knowledge is found to have consistently increased (by 6%) over the year.
- Citrix skills/knowledge is found to have slightly increased (by 4%) over the year.
- Microsoft, Novell or Cisco skills/knowledge seemed fairly consistent (within 3% of the highest and lowest figures for all) throughout the year and none was noted to decrease in demand.

Thus we can conclude that Linux had the greatest increase in demand (in terms of average percentage) by NZ networking employers over the year followed by Unix. This conclusion is relevant to this research and indicative of the growth mentioned in the literature. However future trends cannot be predicted.

Figure 2. Average percentage over three iterations



Linux Networking Taught in NZ ITPS

To gain perspective on the Linux networking services taught in ITPs around NZ, an email survey was sent during 2007 and early 2008 to the eighteen institutes on the ITPNZ website (ITPNZ, 2008). Sixteen (89%) institutes responded. This is a significant number of the institutes, giving some meaningful conclusions. There are nineteen institutes on the website but one of them does not have a computing-related department/ course, so it has not been included.

Survey Methodology and Results

The survey listed networking services (Table 5) and asked whether or not the service was taught using Linux. If Linux was used, the respondent included the subject area(s) in which it was taught. The subject areas suggested in the survey were: networking, operating systems, web development, system administration, electronic commerce, software development, multimedia and programming. If the service was taught in an entirely different subject, then the respondent could make a note of this as well.

Respondents were also able to note down any other Linux networking service they teach that was not on the list and were asked which services they considered to be most important overall. The level of complexity to which each service is taught was not surveyed. However if the respondent indicated that the service was only briefly mentioned then it was not included in the results. Table 5 displays these collated results.

Table 5. Percentages of surveyed institutes that teach particular network services using Linux across different subject areas

Service	% in any subject	% in a Networking subject	% in an Operating systems subject	% in a Systems Admin subject	% in a Web Development subject	% in an Internetworking subject	% in a Databases subject	% in a Software Development subject	% in a Programming subject
Telnet or SSH	**81.3**	43.8	56.3	31.3	12.5	6.3	6.3	12.5	6.3
Samba Share	**75**	43.8	43.8	25	0	0	0	0	0
DNS	**62.5**	50	6.25	18.8	6.3	6.3	0	0	0
DHCP	**62.5**	56.3	18.8	18.8	6.3	6.3	0	0	0
Routing	**43.8**	37.5	12.5	18.8	6.3	0	0	0	0
CUPS	**43.8**	12.5	25	18.8	0	0	0	0	0
iptables firewall	**43.8**	31.3	18.8	18.8	12.5	0	0	0	0
Linux firewall application	**43.8**	31.3	12.5	12.5	12.5	0	0	0	
VPN	**31.3**	25	6.3	6.3	0	0	0	0	0
LDAP	**25**	25	6.3	6.3	0	0	0	0	0
IMAP	**18.8**	18.8	6.3	6.3	0	0	0	0	0
Nmap	**12.5**	12.5	0	0	0	0	0	0	0

Survey Analysis

The results show that seven (44%) of the respondents teach more than half of the twelve networking services surveyed using Linux. In other words more than half of the respondents (56%) teach less than or equal to half of the services using Linux, this is quite a significant number. 38% teach a quarter or less of the services and a two (12.5%) do not teach any of the services.

All the services surveyed were taught to some extent. We can observe that the Telnet/SSH (81%) and Samba Share (75%) services are the most commonly taught. DNS (63%) and DHCP (63%) services are also widely taught. It was discovered that the IMAP and Nmap services were taught to a very small extent and they were the least taught of all the services.

Services were taught in a variety of subject areas across the country. Many were taught in several subject areas. Most of the Linux services are taught in networking (44%) with many also being taught in operating system (24%) and system administration (21%) subjects. They were taught the least in programming, software development and database subjects and were not taught in multimedia and e-commerce by any of the respondents. There were no additional subject areas mentioned by any of the respondents.

Linux networking services other than those surveyed were said to be taught such as; FTP, VoIP, SNMP, email protocols etc. However the only two services that had a significant number of respondents were Network/Port address Translation (NAT/PAT) (25%) and the SQUID proxy server (25%). These figures can be compared to the 'percentage in any subject' column in Table 5 and we can see that they are beneath the higher scoring services mentioned above. Two institutes (12.5%) also indicated that they used Linux for teaching virtualisation. The services that respondents considered most important are DHCP (38%) and DNS (33%).

As a significant number of institutes in NZ responded to the survey, the results are a good indication of what is being taught across the country and may be useful to all institutes. For those that teach minimal or no Linux networking services and would like to include more, the results indicate which services are commonly taught and the subject areas in which they are taught. Those institutes that teach a number of the

services can see if they are teaching common services in common subject areas.

Conclusions

The literature continues to indicate that Microsoft and Unix are leaders in the global server operating systems market and Linux is considered the third major player with observed and forecasted growth. The weighted analysis of the website job advertisements is similar yet gives a number of differences from the earlier conference paper. Firstly a slightly different ranking was found between the unweighted and weighted rankings in a few (27%) cases which were not previously apparent. The weighted ranking was found to be more accurate. The final ranking is also slightly different: Microsoft, Unix, Cisco-Linux, Citrix and Novell. This is considered to be more accurate as data has been gathered and analysed over the period of one year as opposed to one day. However it further supports the view, as indicated in the literature and the earlier conference paper, that the demand for Linux is significant (third place) under that of Microsoft and Unix and is increasing.

Technology trends were also observed in the job advertisements over the year. The average percentage of total advertisements in which each technology is found, showed that employers looking for Linux skills/ knowledge increased the most during the year (8%) compared to the other technologies, followed by Unix. All technologies were seen to either increase in demand or stay consistent.

The first two sections highlight that Linux has a significant presence in the global server operating system market and in NZ networking jobs. It would thus be useful for ITPs to include Linux networking services in their teaching alongside Microsoft and Unix technologies.

The last part of the paper showed that Linux networking services are taught to varying degrees in NZ ITPs. A significant number of the institutes (89%) responded to the survey over the year giving a good indication of which Linux services are being taught across the country. It was found that more than half of the respondents (56%) teach 50% or less of the services surveyed using Linux and there were some (12.5%) that did not teach any. Telnet/SSH and Samba Share are confirmed to be the most commonly taught of the services surveyed, and overall, services were found to be mostly taught in the networking subject area.

The results and analysis relating to the Linux services provide direction for those who may wish to include more Linux networking services in their teaching and also enables a comparison with what is currently taught.

Acronym List

CUPS Common Unix Printing Services

DNS Domain Name Server

DHCP Dynamic Host Configuration Protocol

FTP File Transfer Protocol

IMAP Internet Message Access Protocol

ITPNZ Institutes of Technology and Polytechnics of New Zealand

LAN Local Area Network,

LDAP Lightweight Directory Access Protocol

SNMP Simple Network Management Protocol

SSH Secure Shell

VoIP Voice over Internet Protocol

VPN Virtual Private Network

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