IPv6 Deployment in Australia and China: A Tale of Two Countries

Sebastian Zander and Xuequn Wang

***Abstract*—To address the expected Internet Protocol version 4 (IPv4) address space exhaustion, IP version 6 (IPv6) was standardised in 1998. IPv6 provides a large address space unlikely to ever be exhausted. However, the transition from IPv4 to IPv6 has been very slow in many countries, even after Regional Internet Registrars (RIRs) ran out of unallocated IPv4 addresses in the last few years. This paper investigates the state of IPv6 deployment and future deployment plans in Australian and Chinese organisations based on a survey of organisations' IT staff. Compared to earlier results, we find that IPv6 deployment has advanced markedly, but it is still years away for a significant portion of organisations, especially in Australia. We also find interesting differences between both countries, for example IPv6's new features are viewed as more valuable in China. Finally, we provide insights into arguments why to deploy IPv6 and how to speed up the transition which have broad applicability beyond the two countries investigated.**

***Index Terms*—IPv6 deployment Australia and China**

I. Introduction

When the Internet Protocol version 4 (IPv4) was defined in the late 1970s, 32-bit addresses were seen as sufficient to cope with the future growth in terms of connected devices. However, with the rapid growth of the Internet in the 1980s it quickly became obvious that the Internet would run out of addresses relatively quickly. In the 1990s Classless Interdomain Routing (CIDR) and Network Address Translation (NAT) were introduced. CIDR allows a more fine-grained allocation of addresses than the original class-based system, and NAT allows hosts with private addresses, that can be reused in different networks, to communicate with the public Internet. CIDR and NAT successfully slowed the consumption of IPv4 addresses.

Meanwhile IP version 6 (IPv6) was developed with 128-bit addresses, making the address space so large that it is very unlikely to be ever exhausted. IPv6 was already standardised in 1998, but it was not deployed by most organisations for many years. The main reason for IPv6's slow start was its incompatibility with IPv4, which requires a full infrastructure upgrade and transition techniques that allow IPv4 and IPv6 coexistence, as well as IPv6's lack of attractive new features, other than the large address space, which makes the upgrade unattractive for first adopters. Since 2015 most of the RIRs, except AfriNIC, have run out of addresses [1]. Yet, IPv6 is still not widely deployed in many countries.

The transition from IPv4 to IPv6 has been the focus of a lot of research, mainly focussed on technical aspects of IPv6 or transition mechanisms. Over the last decade there also has been significant research into measuring the progress of the transition by various means, such as measuring the number of DNS requests for which AAAA records are returned or probing whether servers support IPv6 or not – Czyz et al. provide a good overview [2]. In comparison, relatively little work has been published on survey-based studies to track the transition's progress or investigate issues related to the transition. Most closely related to our paper is a study published by Dell [3] in 2012 that analysed the readiness for IPv6 in Australian organisations.

Many of the previous studies on IPv6 were published in 2012 or earlier, but until 2012 the use of IPv6 has remained marginal. IPv6 deployment has only started to accelerate since the second half of 2012 (see Nikkah and Guérin [4]). After an accelerated deployment for a few years, it is timely to conduct another study on the deployment of IPv6. Our goal is to obtain detailed results by focussing on a small number of countries, rather than doing a global survey with very low sample rates for any particular country. Most previous survey-based studies have focussed on a single country only.

Our study focusses on Australia and China for a number of reasons. First, both countries had low IPv6 deployment in early 2016, so the study will be very relevant to both countries. While brief macroscopic information of IPv6 deployment in Australia and China exists ([5], [6]), detailed data about the state of IPv6-deployment and future deployment plans is unavailable. Second, by investigating Australia we can compare our results against Dell [3] to measure how much the IPv6 deployment has accelerated in the last few years (and whether the progress matches observations from network measurement). Third, while Australia and China are similar with regards to low IPv6 deployment, they are very different economies. China is a large and still developing economy with a population much larger than the number of IPv4 addresses, whereas Australia is a small developed country with a much larger number of IPv4 addresses per capita than China. This has lead to different approaches for IPv6 adoption, i.e. while IPv6 was high on the agenda in China (and part of the 5 year plans), in Australia the reaction was more muted.

The aim of this study is to shed some light on the following questions with respect to organisations in Australia and China:

- How advanced is IPv6 deployment in organisations?
- How is IPv6 implemented, i.e. what technologies are used?
- What are the problems with IPv6 in production?
- How urgent is the transition for organisations that have not deployed IPv6 yet, how prepared are they and how quickly do they expect to transition?

Sebastian Zander is with the School of Engineering and IT, Murdoch University, Perth, Australia, e-mail: s.szander@murdoch.edu.au.

Xuequn (Alex) Wang is with the School of Engineering and IT, Murdoch University, Perth, Australia, e-mail: xuequnwang1600@gmail.com.

- What is the motivation and key arguments for IPv6 and what are main obstacles for IPv6 deployment?
- What can be done to further speed up the IPv6 transition?
- What are alternatives to IPv6 used by organisations?

Our results show that indeed IPv6 deployment has accelerated compared to Dell [3]. On the other hand, IPv6 deployment is still years away for a significant portion of organisations, especially in Australia. We also found that in general Chinese organisations are ahead of Australian organisation in the transition. Chinese organisations view IPv6's new features as more valuable compared to their Australian counterparts. Our study provides results for two particular countries, but it delivers broader insights into the progress of IPv6 deployment, from the viewpoint of two countries with different approaches to the IPv6 transition, that are applicable to other countries.

Section II discusses related work in the areas of measuring IPv6 deployment through network measurement or surveys. Section III describes the approach we used for data collection. Section IV presents the results from our study and Section V discusses the overall findings, limitations and future work. Section VI concludes the paper.

II. Related Work

This section first discusses the related literature, separated into network measurement studies and survey-based studies. Since our paper falls into the second group, we only provide a brief overview of more recent network measurement studies and then focus on previous IPv6 readiness surveys. Finally, we give a brief overview of the IPv6 adoption in Australia and China.

Our work differs from previous work in that our survey is more comprehensive than previous surveys, such as Dell [3], covering a wide range of questions about current deployment, future plan, motivation and obstacles and alternatives. Our study compares two countries and it is the first survey in these countries conducted after IPv6 deployment started to accelerate globally. Our paper provides timely results on the state of the IPv6 adoption in Australia and China.

A. Network measurement studies

Colitti et al. [7] measured the proportion of hosts that preferred IPv6 and the IPv6 technologies used for different countries based on a fraction of Google users in 2008–2009. They found that only 0.25% of hosts used IPv6. Shen et al. [8] studied the IPv6 deployment and the applications using IPv6 in China in 2009 based on NetFlow records. They found that at the time only a very small fraction of users used IPv6 (9%).

Kreibich et al. [9] analysed Netalyzr logs and reported that 4.8% of sessions used IPv6. However, they noted that this is an upper bound due to possible caching effects and "geek bias" (Netalyzr only tests hosts of users who choose to be tested). Smets et al. [10] estimated the IPv6 deployment for European Union (EU) states based on over 30 participating web sites in 2010. They found that the proportion of IPv6-capable hosts varied from under 1% (Cyprus) to over 12% (Sweden) with an average of 6%. Also in 2011, Nikkah et al. [11] compared the performance of IPv4 and IPv6 based on accessing a larger number of IPv6-capable web servers. They found that IPv6 and IPv4 performed comparably and routing differences were the main reason behind poorer IPv6 performance. Claffy [12] provided an overview of the progress of IPv6 deployment in 2011 and also identified areas that need further study.

Aben [13] measured the IPv6 deployment based on DNS AAAA records for popular servers, advertised IPv6 routing prefixes, and active web-based measurements. Aben found that in 2011/2012 around 6–7% of clients were IPv6 capable and 2–3% of clients preferred IPv6. Dhamdhere et al. [14] used BGP data and active measurements to analyse growth trends, structure, dynamics and performance of the evolving IPv6 Internet in 2012. Their results showed that the IPv6 network was maturing, albeit slowly. While provider in the core Internet had deployed IPv6, edge networks were lagging behind. Plonka and Barford [15] developed a method to match DNS rendezvous information to flows so that the performance of IPv4 and IPv6 protocols could be compared for a variety of Internet services. They demonstrated their method based on data collected on World IPv6 Day 2011 showing that (1) flow bit rate distributions varied significantly by time of day, number of active local clients and IP protocol version, and (2) these rate characteristics differ amongst services.

Zander et al. [16] measured the IPv6 capability of a wide range of clients using Google ads. They found that 6% of world-wide connections were from IPv6-capable clients, but only 1–2% of connections preferred IPv6 in dual-stack. Except for an up-tick around World IPv6 Day 2011 these proportions were relatively constant. Sarrar et al. [17] compared the IPv6 network traffic, with respect to volume, application mix and tunnelling used, around the World IPv6 Day 2011 at two places – an Internet exchange point (IXP) and a university campus. They showed that the volume of IPv6 traffic almost doubled at the IXP and increased by twenty times at the university, accompanied by a significant shift in the application and HTTP destination mix.

Czyz et al. [2] used twelve metrics on ten global-scale datasets to measure IPv6 adoption. They found that adoption, relative to IPv4, varied by two orders of magnitude depending on which metric was used and cautioned to use particular IPv6 adoption metrics in isolation. While adoption was far from uniform across regions[1], Czyz et al. concluded that there had been major progress in the adoption of IPv6 in the years 2012–2014 "indicating a maturing of the protocol into production mode". Han et al. [18] studied the IPv6 deployment in China. Based on traffic data collected on a backbone link of the China Science and Technology Network (CSTNET) they found that IPv6 traffic had grown fast from 2011 to 2013 (total peak traffic increased from 2 Gbps to 8 Gbps) with 80% of the IPv6 traffic being generated by P2P applications. Most of the IPv6 traffic was domestic (bound to China).

Nikkah and Guérin [4] investigated the migration to IPv6 from the early 2000s until 2014 using several statistics, such as the fraction of top web sites that supported IPv6 and the traffic volume of IPv6. They examined the ecosystem of the

[1] Czyz et al. focus on global metrics and discuss differences between regions, but they do not include country-specific analysis.

transition, i.e. the stakeholders and what drove them to adopt IPv6 as well as the factors that affected their decisions. They also developed a utility model that explained the decision process of the different stakeholders. They showed that IPv6 deployment started to accelerate since the second half of 2012.

B. Survey-based studies

White et al. [19] were among the first researchers to carry out a survey on IPv6 deployment in US organisations. Participants were asked when their organisations' IPv4 addresses would run out and what the plans for adopting IPv6 were. Given the age of the survey and the fact that IPv6 deployment has dramatically increased in the US [2] we will not discuss the findings here. However, the results suggested that the majority of companies might not be planning to migrate to IPv6 by the year 2010, which turned out to be a correct prediction. There are a number of other survey-based studies conducted prior to 2010. Due to their age we cannot really compare them with our study and thus do not discuss them here.

Hovav et al. [20] investigated the adoption of IPv6 in South Korea. They proposed a model for adoption and used survey data collected in 2006 and 2007 to validate the model. In their second survey the number of adopting companies reached 31.6%, while 36.8% of companies were in the development stages and 5.3% were planning to implement IPv6 within the next 2–3 years. The remaining 26% of organisations had no intention to adopt IPv6 in the near future.

In 2012 Dell [3] published an analysis of the IPv6 readiness of Australian organisations. The study was based on a survey of 180 high-level IT managers in Australian organisations. Organisations from the Education, Manufacturing and Government Administration and Defence industry comprised 55% of responses. The survey found that while 90% of respondents were aware of IPv6 only 27% believed it to be urgent. There were no statistically significant differences between industries, except that participants from the Education industry viewed IPv6 as more urgent. Five facets of organisations preparedness were surveyed: training, high-level planning, assessment of current environment, policy frameworks and actual deployment. Only 10–20% of organisations had conducted significant training or high-level planning, and numbers for the other facets were even lower showing low readiness. The study did not provide any details about the actual state of IPv6 deployment.

Svedek et al. [21] reviewed the status of IPv6 in Croatia in 2011 showing that the percentage of networks that announced an IPv6 prefix for Croatia had grown from 1.82% in January 2009 to 8.45% in June 2011. Furthermore, based on a survey conducted by the Croatian Academic and Research Network (CARNet), 70% of CARNet member were interested in IPv6 deployment. Dobrijevic et al. [22] continued the analysis of the IPv6 deployment and transition plans in Croatia in 2012. They surveyed 12 Croatian ISPs that "constitute more than 99% of the relevant market in Croatia as per the gross income and the number of subscribers" and found that all but one were planning a transition to IPv6, but only 7 out of 12 had started the deployment.

Botterman [23] surveyed customers of all RIRs over several years (2010–2013). The last survey from 2013 had 1,515 respondents from 151 countries with most of the respondents being from ISPs (40% or higher), the IT industry (10%) or the education sector (10%). The results showed that two thirds of ISPs had IPv6 experience and there was a significant increase of IPv6 over the surveyed time period. The biggest issue was lack of user demand (55% of ISPs). Roughly 75% of organisations had an IPv6 address allocation in 2013 and nearly 80% had either an internal or Internet IPv6 presence. The study also showed a general increase in preparedness for IPv6 deployment, with more ISPs experiencing significant IPv6 usage by their customers and that carrier-grade NAT was generally seen as a solution to replace IPv6.

BT Connect [24] conducted a survey to determine the status of IPv6 deployment and attitudes about IPv6. The survey was completed by 140 participants from around the globe. However, most participants were from North America and only 24 of the participants (17%) were from Asia-Pacific. Less than 35–40% of participants expressed concerns that would force them to deploy IPv6 deployment soon (highest concern was in education sector), whereas around 40% of the respondents stated that IPv6 was already deployed or in the process of being deployed in their organisation (highest deployment was found in the education and not-for-profit sectors). The survey also asked what threshold (if any) of IPv6 deployment would impel organisations to deploy IPv6 – 40% of participants had no set threshold, but of the rest most considered 20–30% of the Internet IPv6-enabled as threshold.

Pickard et al. [25] surveyed 68 enterprise organisations located in the eastern North Carolina region in 2014 to measure their organisational IPv6 readiness across five facets of organisational IPv6 preparedness. Pickard's survey was an adapted version of Dell's survey [3] with an added question to capture the state of IPv6 readiness. Their results showed that the majority of organisations (59%) had no plans to deploy IPv6 and only about 10% had IPv6 already deployed or plans to deploy within 6 months (based on the study's numbers in 2016 deployment should reach almost 30%).

C. IPv6 adoption in Australia and China

The size of the allocated IPv4 address space relative to the population size helps explaining the differences in IPv6 adoption approaches between Australia and China. Australia has an allocation of about 47.6 million IPv4 addresses. With a population of roughly 22 million people that is about 2160 IPv4 addresses per 1000 citizens. China has a much larger allocation of 330.3 million IPv4 addresses, but given its population exceeds 1.3 billion people, this means there is only about 250 IPv4 addresses for 1000 citizens in China.

China has far more citizens than it has allocated IPv4 addresses, so the transition to IPv6 has been very important for China from the beginning. In August 2003, the State Council of China officially authorised the launch of the China Next Generation Internet (CNGI) project. The project was part of China's five year plan and its goal was to build nationwide commercialised IPv6-enabled backbones and access networks to provide commercial IPv6 access services for network users. Almost all major ISPs in China participated in this program. Under the CNGI project, IPv6 backbone networks were extended to over 22 major cities and more than 270 access networks were connected to the backbone [26]. The Chinese government also took a lead in planning and deploying IPv6 infrastructure in public-facing infrastructure (e-government).

The CNGI initiative basically mandated IPv6 to the industry. In 2014 it was reported that Chinese carriers claimed to have implemented full IPv6 deployment and the Ministry of Industry and Information Technology of China announced "it will continue to promote the Internet sector's adoption of IPv6 with an investment of over CNY20 billion" [27].

While in China the state-initiative has driven IPv6 deployment in most ISPs, in Australia the development has been more muted. The Australian government developed an initial strategy for implementing IPv6 in government agencies in 2007 (version 2 released in 2009) [28] and in 2013 it was determined that "the agencies were well advanced in their transition" and that "the majority of the work within agency systems is now completed"[2]. In Australia IPv6 trials were launched by several organisations early on and the national research network (AARNET) deployed IPv6 in 2006[3]. However, in 2016 there are still not many ISPs that have fully implemented IPv6 and offer it to all customers. It appears the larger number of available IPv4 addresses per capita has made the transition less urgent in Australia.

III. Data Collection

This section describes the recruitment of participants, the survey design, the data cleaning and the demographics of our survey participants.

A. Recruitment

We conducted surveys among organisations in Australia and China. In phase I (early 2016), survey companies were hired to conduct the data collection. Because this study examines the status of IP adoption within organisations, participants would only qualify for the survey if they passed a number of screening questions. In total we received 288 completes (Australia 138; China 150). In phase II (mid-2016), an invitation to the survey was sent to APNIC members, the AUSNOG mailing list and the CNNIC mailing list; 98 participants (Australia 60; China 38) completed the survey. Since in phase II we only advertised the survey to people that are knowledgeable about IPv6, no screening questions were asked.

We used two different ways to recruit participants with the aim to get a more diverse sample. Some previous studies only advertised their surveys via the RIRs, but then they were usually answered only by people from the telecommunications industry or large organisations. Using survey companies necessitates the use of robust screening question to filter out potential participants that lack the required knowledge.

The Chinese version of the survey was identical to the Australian version but was translated into Mandarin.

[2]http://www.finance.gov.au/archive/agimo-archive/ipv6/
[3]http://ipv6forum.com.au/timeline.php

B. Questionnaire

We developed a questionnaire to survey organisations readiness, which consisted of seven parts:

1) Screening questions (only used with survey companies)
2) Demographic questions
3) Introductory questions
4) Deployment status questions
5) Urgency and planning questions
6) Motivation for/against IPv6
7) Alternatives to IPv6

The screening questions were only used with the survey companies. The screening questions were designed such that participants would only qualify if they 1) work in the area of IT; 2) know what IPv6 is; and 3) understand the current state of the IPv6 deployment and the IPv6 strategy.

The demographic part asked questions about the industry type of organisations based on the categories from the 1993 Australian and New Zealand Standard Industrial Classification (ANZSIC), the size of the organisation, the number of customers, the number of IT staff and a number of questions about the participant such as age, gender, position inside the organisation and decision making competence.

The introductory part consisted of two questions. The first question asked whether an organisation has deployed IPv6 and the second question asked whether an organisation is planning to deploy IPv6. If the first question was answered "yes", then the participant was asked part 4 and part 5 questions. If the participant answered "no" to the deployment question but "yes" to the planning question, part 4 questions were skipped. Participants that answered both questions with "no" were not asked part 4 or part 5 questions. All participants were asked the questions in part 6 and part 7.

A number of questions in different parts were targeted to organisations in the telecommunications category and were only asked if a participant specified the industry type as "Information Media and Telecommunications". Part 5 of the survey contained the planning questions from Dell [3], so we can compare the results across the years. A number of questions for parts 4 and 5 were adopted from Botterman [23]. Since the survey was very comprehensive with over 50 questions in total (including the screening questions), we cannot describe it in detail here.

Two attention-checking questions were used in the middle and later parts of the survey to eliminate participants that did not pay attention to the questions and just randomly selected answers.

By design our survey may be biased towards organisations that have IPv6 deployed, planning to deploy it or at least have it on their agenda. This is because in the survey conducted by the market research companies the screening questions would ensure participants knew about IPv6, and in the survey conducted via APNIC (and the mailing lists) it is more likely that respondents are from companies in the telecommunication category and/or are aware of IPv6. However, this is unavoidable as without screening questions the validity of the answers would be questionable for participants recruited by market research companies.

C. Data Cleaning

The similarities of responses for each country were then checked to detect potential data records from same organisations. Two responses may come from the same organisation if they 1) have the same domain name (voluntary question in the survey), 2) came from the same IP address (as logged by the survey web site), or 3) have quite similar answers regarding the demographics of the organisations and deployment of IPv6. After identifying similar data records, the authors then discussed and decided whether to treat them as duplicate records for one organisation. When duplicates were removed, the records removed were picked randomly. We also removed a few records where respondents stated that IPv6 was only used in a test environment but then in a later question stated that the volume of IPv6 traffic is equal or above the volume of IPv4 traffic. With contradictory answers, our trust in the records was low and we decided to remove them.

D. Respondents

The total number of participants in both countries recruited by both approaches was 292 (Australia 157; China 135). Around 75% of our participants were CIOs, top-level managers or mid-level managers (Australia 77%; China 75%), while 25% were low-level managers and IT administrators/technicians. The vast majority of them (Australia 93%; China 91%) said their decision making authority with regards to networking infrastructure was final or they have significant decision making influence. The senior level and decision making authority of the respondents means that they should have very good knowledge of the status of IPv6 in their organisations. Consistent with the senior positions, most of the respondents fall in the age bracket of 30–50 years.

Figure 1 shows the number of organisations by ANZSIC industry type. The majority of our organisations are from the media and telecommunications industry. This is expected because (1) APNIC members are biased towards this industry and (2) the screening question used for the market research companies required participants to know about IPv6, which also creates a bias towards this industry. Hovav et al. [20] experienced the same effect and noted that "studies examining the adoption of an IT-related infrastructure technology would be expected to have a large portion of sample from telecommunication industry".

Nevertheless, only one third of Australian organisations and slightly over 40% of Chinese organisations fall into this category. The rest comes from a variety of different industries, with the other larger categories being Manufacturing, Retail (Australia), Professional, Scientific and Technical Services, Education and Training and Healthcare (Australia). Our composition is different from Dell [3] which surveyed mainly Government, defence and education sectors (45%). The vast majority of surveyed organisations were for-profit organisations (Australia 90%; China 93%).

Of the "Media and Telecommunications" organisations (MTOs), the majority were Telcos or ISPs (Australia 71%; China 85%), while 17% (Australia) and 8% (China) classified themselves as "Other Provider or Reseller of IP Services (e.g. Research/Academic Network)", and the remaining organisations classified themselves as "Other". Most of the MTOs offer fixed-line and mobile services (Australia 57%; China 75%), while a significant number only offer fixed line services (Australia 35%; China 25%). The remaining providers offer only wireless services.

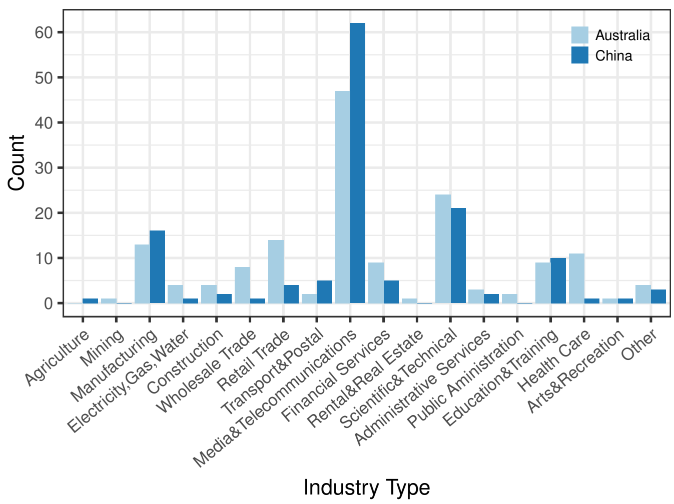

Figure 1. Number of respondents by industry type

Figure 2 shows the number of organisations depending on the organisation sizes. Our survey captures a significantly higher number of small companies in Australia, but more large companies in China. Most of the surveyed companies fall into the medium-size category which is consistent with Dell's study [3]. Our survey also captured a wide variety of organisations in terms of the number of customers, ranging from organisations with fewer than 1,000 customers to organisations with more than one million customers, and in terms of the number of IT staff, ranging from organisation with less than ten IT staff to organisations with more than 100 IT staff. Chinese organisations also had more customers and more IT staff on average, supporting the theory that participating organisations were larger in China on average.

IV. Results

We first discuss the IPv6 deployment status of the organisations surveyed. We then discuss the IPv6 technologies used and IPv6 production problems for those organisations that have already deployed IPv6. Next, we investigate the urgency and preparedness of organisations as well as the expected transition time of organisations that have not fully deployed IPv6 yet. Next, we discuss the motivation and obstacles for IPv6 including key arguments for IPv6. Finally, we analyse the alternatives to IPv6 used by the surveyed organisations and discuss suggestions on how to speed up the transition. Figure 3 summarises the structure.

We use χ^2-tests to test for difference in case of questions with categorical answers and we use t-tests to test for differences between means for questions where answers are on a Likert scale. We always assume a significance level of .05 (95% confidence).

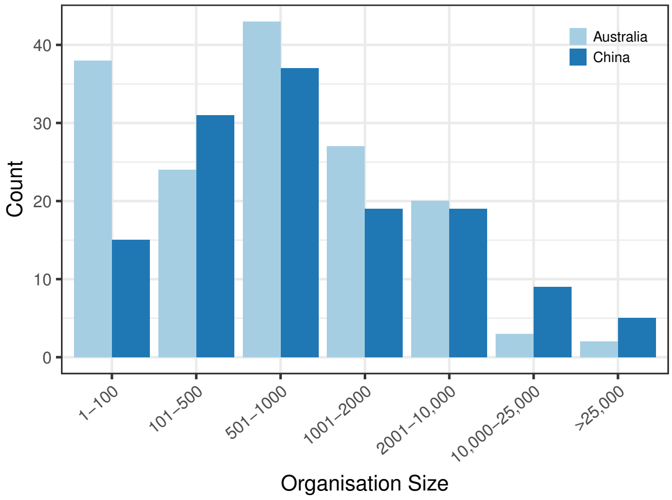

Figure 2. Number of respondents by organisation size

A. IPv6 deployment status

Figure 4 shows the breakdown of IPv6 deployment in Australian (AU) and Chinese (CN) organisations. The figure differentiates between MTOs, such as Telcos, ISPs, National Research and Education Networks (NRENs) and hosting providers, and Other organisations. Irrespective of country and organisation type only less than 25% of organisations have no IPv6 deployment at all. However, the percentage that has not deployed IPv6 at all or only in a test environment is still around 50% for Others and 35–50% for MTOs. MTOs appear to be further ahead with full/external IPv6 deployment in both countries, but in case of Australia the difference is marginal and even for China the difference is not statistically significant. China is significantly ahead of Australia for Others ($\chi^2 = 4.59,\ p = .032$), but even more so with regards to MTOs ($\chi^2 = 11.52,\ p < .001$) – over 50% of Chinese organisation have full IPv6 deployment whereas only 20% of Australian organisations have full IPv6 deployment.

Of the 20–25% of organisations that have no IPv6 deployment, roughly two thirds are not planning an IPv6 deployment (Australia 64%; China 67%). In China this is mainly (61% of organisations that have not deployed IPv6) because decision makers are aware of IPv6, but there is no plan to adapt it. However, in Australia in 18% of organisations that have not deployed IPv6 yet, the decision makers are not even aware of IPv6. Of the one third of organisations that are planning to deploy IPv6, in most of them decision makers are thinking about or planning the deployment, but no formal plans for IPv6 deployment have been developed. In Dell [3] only 25% of organisation reported that they were in some stage of deploying IPv6, so there has been a significant move towards IPv6 in the last five years.[4]

We compared deployment of small and large organisations (as defined by the number of employees). It appears as if large companies are ahead slightly, but the difference is not significant. We also compared deployment based on customer size. While in Australia organisations with smaller customer base are more inhomogeneous (more with no IPv6 at all, but also more with IPv6 fully deployed) and there is no statistically significant difference, for China there is significantly more IPv6 deployment when the customer base is smaller ($\chi^2 = 14.8,\ p = .005$). Finally, we compared deployment based on IT staff size. The results show that deployment is significantly more advanced in organisations with a larger number of IT staff in both countries (Australia $\chi^2 = 5.26,\ p = .02$; China $\chi^2 = 9.29,\ p = .002$).

Approximately 28% (Australia) and 24% (China) of organisations have no IPv6 allocation yet. This is the same worldwide level reported by Botterman [23] in 2013, so it appears that Australia and China are lagging behind. Figure 5 shows the reasons for no allocation based on our survey. “Cost” and “convincing decision makers” are the least issues. “Not meeting requirements” is also a small issue in Australia, but a larger issue in China. The main reasons are a lack of business need and the unspecific “Not having it done yet”, especially

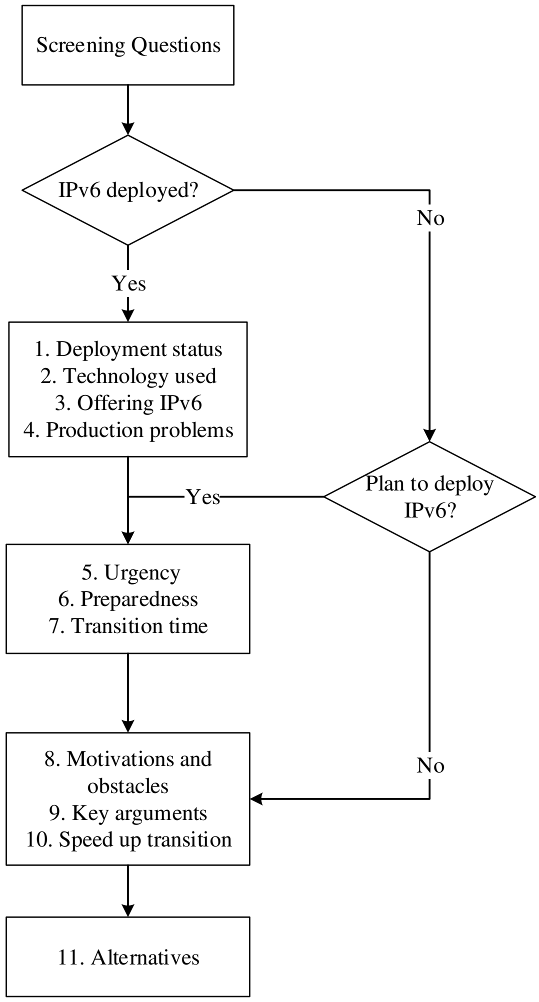

Figure 3. Structure of the result section and how it relates to the questionnaire parts

[4]Note that in Dell’s survey the fraction of MTOs, which are more advanced in the transition, was significantly lower, which may affect the comparison.

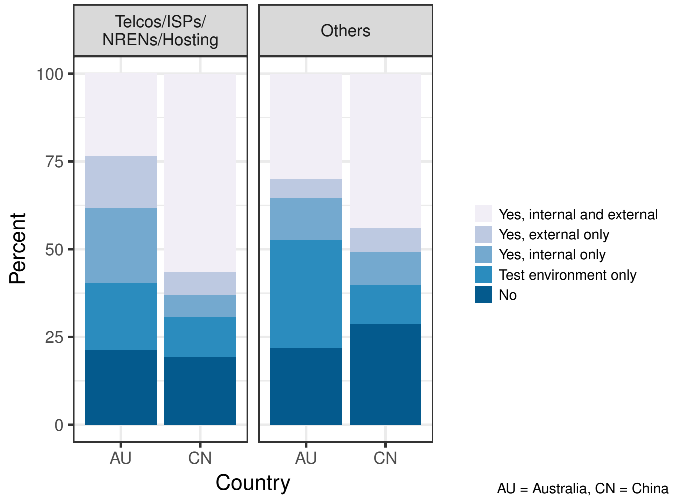

Figure 4. IPv6 deployment status in organisations

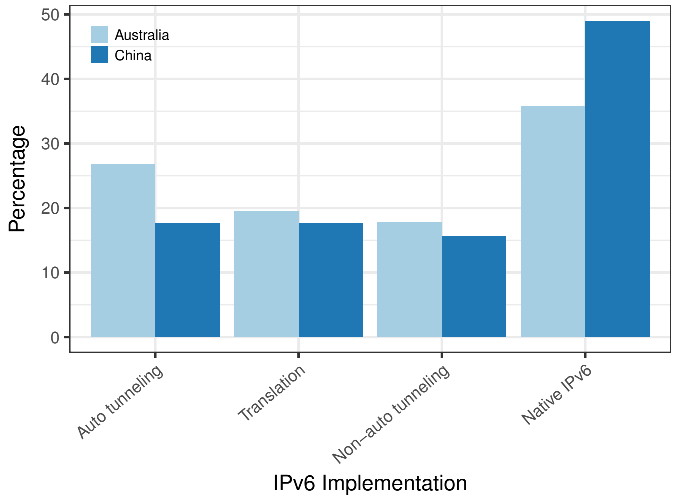

Figure 6. Nature of IPv6 implementation in organisations

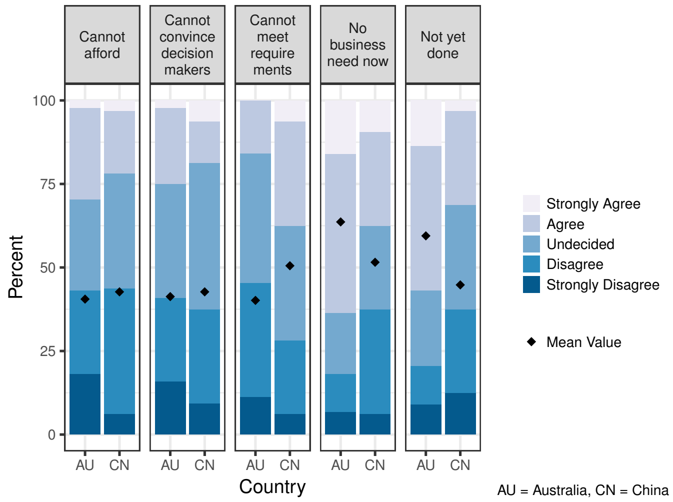

Figure 5. Reasons for not having an IPv6 allocation

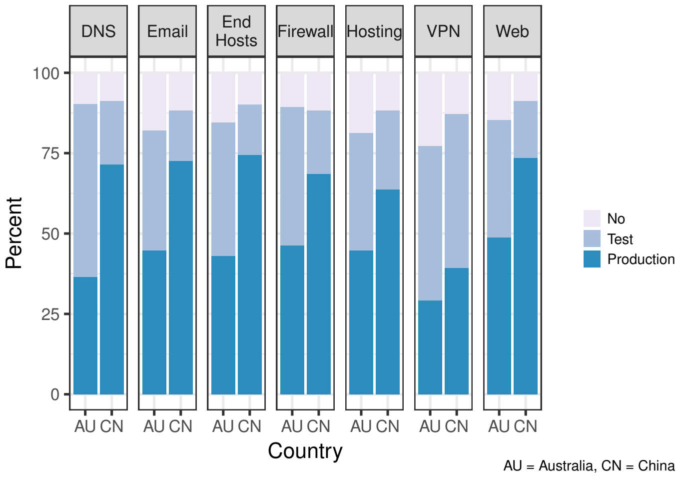

Figure 7. IPv6 support for services in organisations that have deployed IPv6

in Australia. The only significant difference between the two countries is the "Not yet done" category ($t = 2.23$, $p = .029$).

B. *IPv6 technologies used*

For organisations that have deployed IPv6 (including those that have IPv6 deployed only in test environments) we asked about their IPv6 setup. Most organisation have a dual stack setup (58% Australia and 65% in China) whereas most of the remaining organisations use separate infrastructure for IPv6 (35% Australia and 30% China). A small minority (around 5%) has an IPv6-only setup.

Figure 6 shows the nature of an organisations IPv6 implementation (in percent for each country). A variety of approaches are used, such as auto-tunneling (e.g. 6to4, 6rd, ISATAP), translation technologies (e.g. NAT64, DNS64, XLAT) and static tunnel configurations. However, native IPv6 is the most common approach with dual-stack clients and servers. When comparing the two countries, in China almost 50% of organisations use Native IPv6 and there are fewer organisations that use tunnelling or translation.

Figure 7 shows the IPv6 support for different services. There is not much difference between different services, with the exception of VPN which is less common to have IPv6 support. However, when comparing both countries it is very clear that Chinese organisation are ahead of Australian organisations with regards to IPv6 in production for all types of services.

An interesting question is whether the IPv6 traffic is significant in organisations that already have IPv6 in production (either internally, on the Internet, or both). Almost 95% of organisations from China reported that the amount of IPv6 traffic is either on par or larger than the amount of IPv4 traffic. However, in Australia this is only the case for 75% of organisations, with more than 20% reporting insignificant IPv6 traffic.

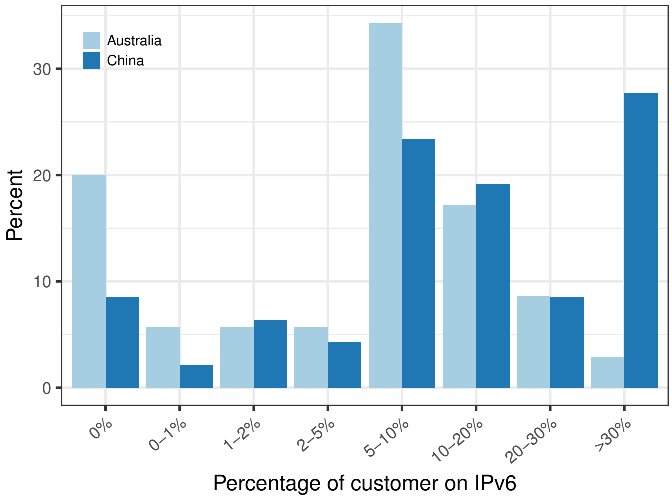

Figure 8. Percentage of customers that use IPv6 for telecommunications organisations that offer IPv6

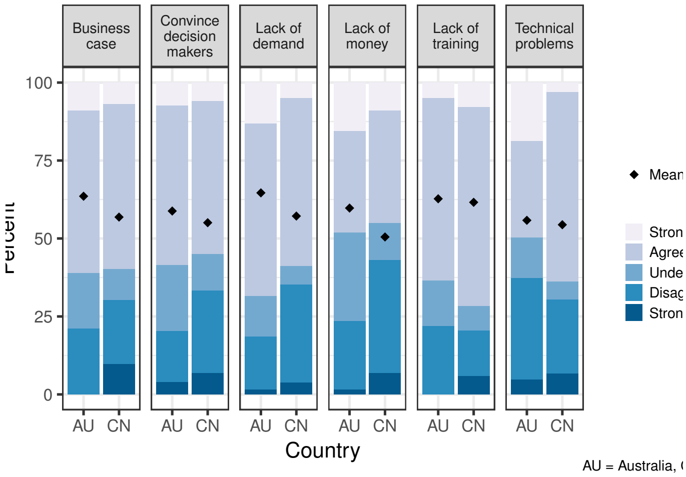

Figure 9. Problems with IPv6 in production

C. *Offering IPv6 to customers*

For organisations of the MTO category we asked whether they offered IPv6 to their customers. In Australia 34% of MTOs offer IPv6 to all customers, 40% only offer it to business customers and 25% do not offer it to any customers. In China 48% of MTO's offer IPv6 to all customers, 35% offer it to business customers and only 15% do not offer it at all. In Australia around 65% of MTO's promote IPv6 to customers, whereas in China around 80% promote IPv6 to customers.

We also asked what percentage of customers was using IPv6. Figure 8 shows the percentage of MTOs that offer IPv6 to all customers or business customers based on what percentage of customers are using IPv6. The percentage of customers that use IPv6 is clearly higher for Chinese organisations. For over one quarter of MTOs it has already surpassed 30%.

D. *IPv6 production problems*

Figure 9 shows the responses to the question what the problems are with IPv6 in production. "Lack of investment money" is viewed as the smallest problem (China significantly lower than Australia $t = 2.34$, $p = .020$), with the biggest problem being the "Lack of training of staff". Consistent with the higher deployment of IPv6 in China, the "Business case", "Convincing decision makers" and "Lack of demand" appear to be smaller problems in China compared to Australia, yet only for demand the difference is statistically significant ($t = 2.14$, $p = .034$). Technical problems are seen as more of an issue in China, possibly because Chinese organisations are further ahead in IPv6 deployment and have had more opportunities to experience technical problems.

E. *Urgency to transition*

Of the organisations that have not deployed IPv6 yet (but are planning to deploy it) and those that have not fully deployed IPv6 yet (not deployed in internal networks *and* Internet facing services), 51% of Australian organisations and Chinese organisations view a transition to IPv6 as only moderately urgent or not urgent. About 39% of Australian organisations think the transition is fairly urgent to very urgent and 10% view it as extremely urgent. In China 46% think the transition is fairly urgent to very urgent and 3% view it as extremely urgent. In comparison, in Dell [3] only 27% of organisations thought the transition was urgent, 21% were not sure, and approximately half (52%) asserted it was not urgent.

Figure 10 looks into the factors determining the urgency to transition to IPv6. The most important factors across both countries are the "Depletion of the IPv4 space" and "Customer demand"; "Regulatory compliance" and "Lack of IPv6 hardware and software" are the least important factors (note that our sample does not include many government organisations). There is a huge difference for the factors "Competitive advantage" ($t = -12.37$, $p < .001$), "Industry pressure" ($t = -14.19$, $p < .001$) and "IPv6 features" ($t = -13.22$, $p < .001$) – these are seen as important for the urgency of the transition in China, but viewed as rather unimportant in Australia. Furthermore, differences for "Internet presence" ($t = -4.95$, $p < .001$), "Internet of Things" ($t = -4.41$, $p < .001$), "Regulatory Compliance" ($t = -8.06$, $p < .001$) and "Lack of IPv6 hardware and software" ($t = -4.51$, $p < .001$) are also significant.

F. *Preparedness to transition*

We now look at the preparedness of organisations that have not deployed IPv6 yet but are planning to deploy it and those that have not fully deployed IPv6 yet (those that have not deployed IPv6 in internal networks and Internet facing services). The questions we discuss here are very similar to the questions from Dell [3].

Figure 11 shows the status of planning for IPv6 in various areas. The category in which most organisations have made progress is (somewhat unsurprisingly) "IPv6 allocation obtained", which is usually the first step. Differences between Australia and China are relatively small in most categories and not significant.

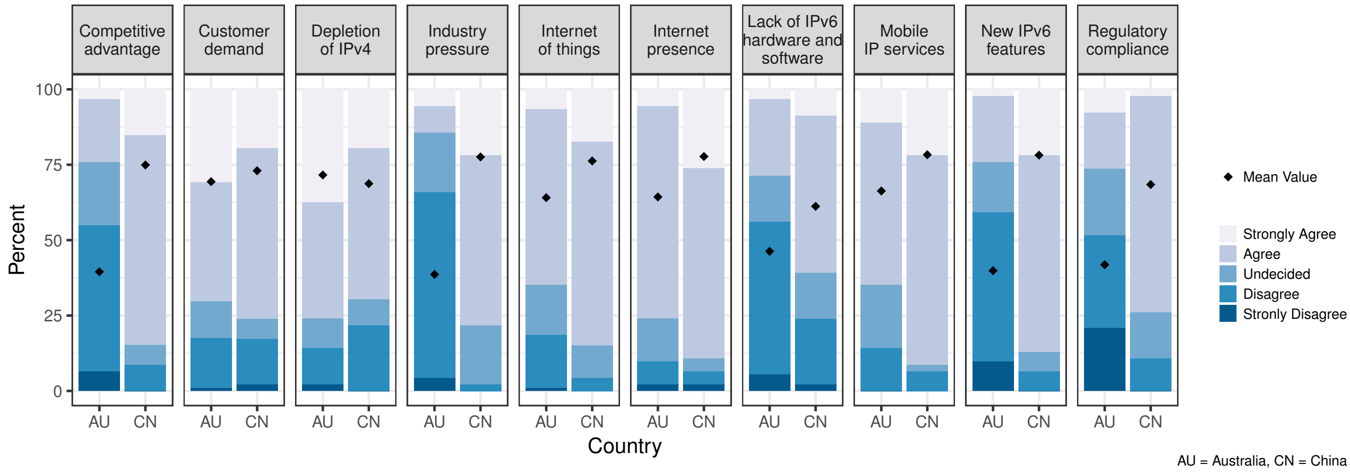

Figure 10. Factors determining the urgency of the transition to IPv6

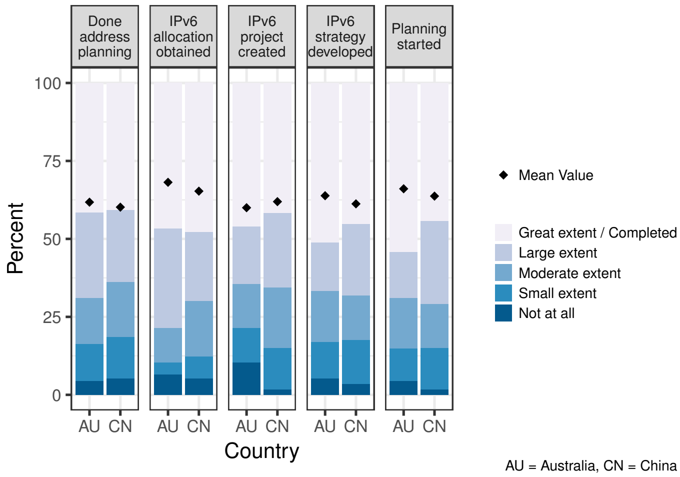

Figure 11. State of planning for IPv6 in organisations

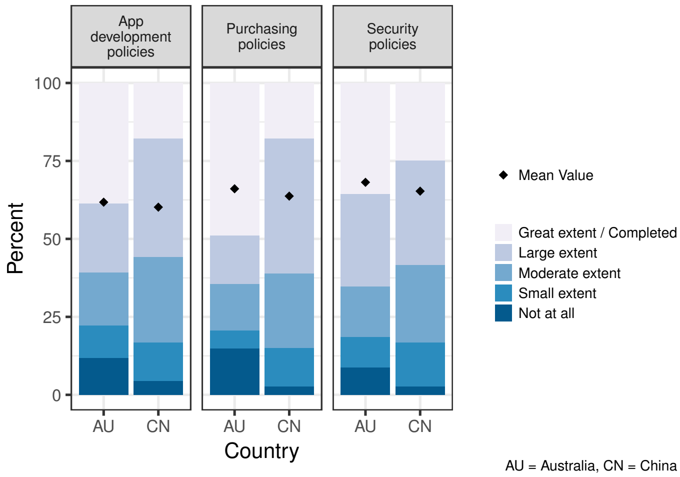

Figure 12. State of IPv6 policy development in organisations

Dell reported that more than 50% of Australian organisation had not planned for IPv6 at all. This has drastically changed with only about 5% of organisations having done no planning at all in Australia and a negligible number in China.

Figure 12 shows the status of IPv6 policy development. There are more Australian companies that have completed policy development to a great extend, but if we look at the percentage of organisations that have completed policies to a large or great extend, both countries are similar (as indicated by the mean response). In comparison Dell reported that 55% or more of organisations had not developed any policies with regards to IPv6 [3]. The only significant difference between both countries is "Purchasing policies" ($t = 2.16,\ p = .032$).

Figure 13 shows the state of assessment of IPv6 in the organisation. There is a significant difference between China and Australia in all the categories ("App portfolio" $t = -3.52,\ p < .001$; "IT assets" $t = -3.72,\ p < .001$; "Training" $t = -3.55,\ p < .001$). China is ahead in all categories, most noticeable in the "Training" category. In Dell [3] 45–65% of organisation reported to have done no assessment at all. This has reduced to 15–20% in Australia, but is still a lot more than in China where it is around 5% for "App portfolio" and almost negligible for the two other categories. When compared to the two previous figures, assessment is clearly less advanced than planning or policy development.

Figure 14 shows the state of IPv6 training provided. There is not much difference between the different training areas (as in Dell). China is consistently ahead in all categories, most noticeably in IPv6 security ("Configuring IPv6" $t = -3.56,\ p < .001$; "Developing IPv6 applications" $t = -2.57,\ p = .011$; "IPv6 security" $t = -3.88,\ p < .001$; "IPv6 technology" $t = -2.44,\ p = .015$). In Dell [3] 55–65% of Australian organisations reported no training in the different categories. This has reduced to 15–25%. When compared to the other preparedness areas, training is the least advanced.

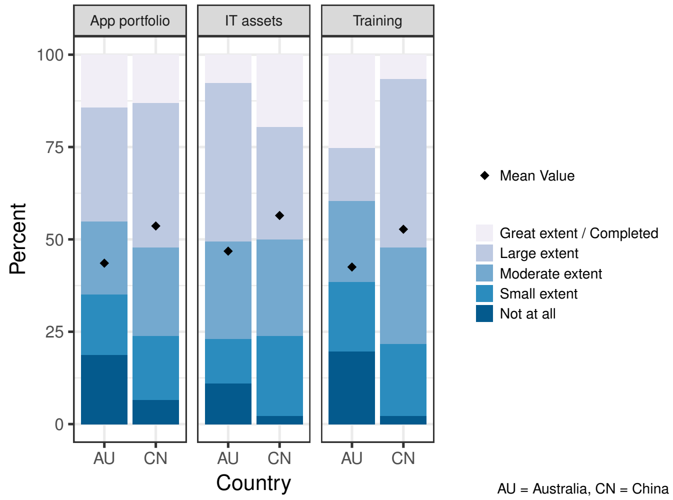

Figure 13. State of assessment of IPv6 in organisations

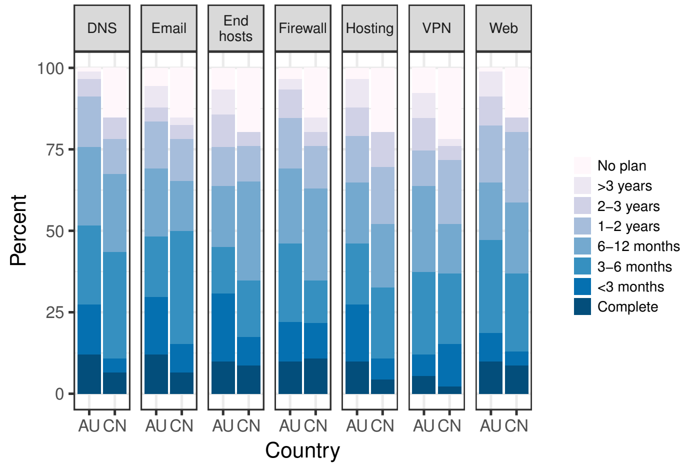

Figure 15. Expected transition times for different services

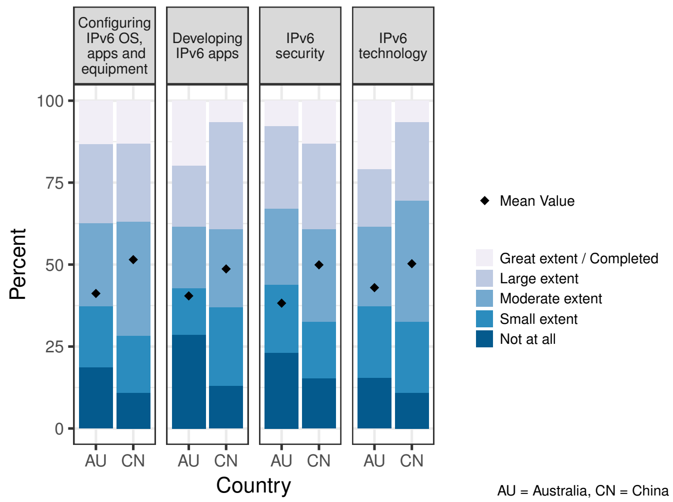

Figure 14. State of IPv6 training in organisations

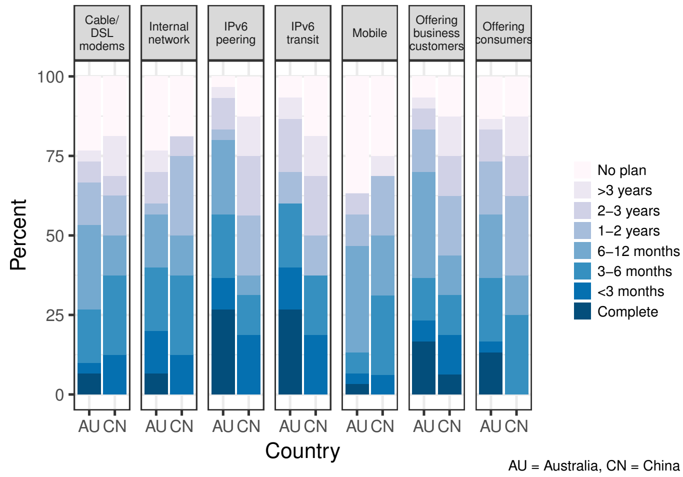

Figure 16. Expected transition times for network services offered by Telcos, ISPs or research networks

G. Expected transition time

For those organisations that have not deployed IPv6 yet but are planning to deploy it and those that have not fully deployed IPv6 yet (not deployed in internal networks and Internet facing services), we now investigate the required transition time as estimated by the respondents.

Figure 15 shows the expected transition times for different services. Depending on the service 50–75% of organisations plan to transition in the next 6–12 months. However, 25% or more of organisations (depending on the service) will need another 1–2 years, while approximately 20% of organisations will need more than two years. Overall the transition plans of Australian companies are more aggressive, but for a number of services the difference is very small.

We also asked MTOs how long the transition will take for their offered services. Figure 16 shows the expected transition times. While for some services there is not much difference between Australia and China, for others there is a noticeable difference with Australian organisations planning for a shorter time frame until deployment.

We also asked organisations that have not deployed IPv6 yet, how long they think they can continue with IPv4. From the results, shown in Figure 17, it is clear that many organisations plan continuing with IPv4 for a number of years. Approximately 30–40% of organisations can continue with IPv4 for up to two years, and approximately 60% can continue with IPv4 for 4 years or longer. Chinese organisations see the need for a faster transition with approximately 25% that can only last for another year without IPv6 compared to less than 10% of Australian organisations that can only continue for another year with IPv4.

H. Motivation and obstacles

From the literature we know that a number of the new features IPv6 provides were seen as not very attractive. To confirm whether this is still the case, we asked all participants

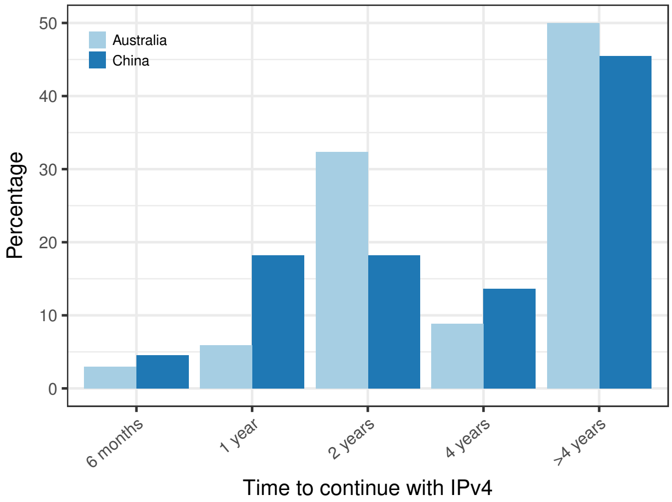

Figure 17. Time organisations can continue with IPv4

about the value of the new features. Figure 18 shows the results. The most valuable feature is clearly the "Large address space" (similar response in both countries). A number of other features are seen as average value or less by at least 50% of Australian organisations ("Security" and "SLAAC" are even viewed as problematic by some). However, all of these other features are viewed significantly more positively by Chinese organisations with only 30% or less ranking them as average value or less ("Flow labels" $t = -5.47$, $p < .001$; "Header extensions" $t = -5.91$, $p < .001$; "Mobility" $t = -5.66$, $p < .001$; "QoS" $t = -4.01$, $p < .001$; "Efficient routing" $t = -4.15$, $p < .001$; "Security" $t = -5.45$, $p < .001$; "SLAAC" $t = -4.26$, $p < .001$).

We also asked *all* participants, including those from organisations that have already deployed IPv6, what the main obstacles for IPv6 deployment are. Figure 19 shows the results. "Lack of security products", "Lack of vendor support" and "Institutional Barriers" are seen as the smallest obstacles, while "Conversion of existing applications", "Cost", "Network Management" and "Training of Staff" are seen as the largest obstacles, especially in Australia. When comparing both countries, there are significant differences in the categories "Cost" ($t = 2.07$, $p = .040$), "Inability to show business case" ($t = 2.86$, $p = .005$), "Institutional barriers" ($t = 2.20$, $p = .028$), "Lack of demand" ($t = 3.04$, $p = .003$), and "Only benefit is larger address space" ($t = 4.54$, $p < .001$). All of these are seen as smaller obstacles in China (consistent with higher demand in China and Figure 18 showing that various IPv6 features are perceived more positively in China).

Finally, we aimed to find out if organisation have a threshold in terms of the IPv6-enabled proportion of the Internet that would motivate them to deploy IPv6 with some urgency. Around 40% of organisations in both countries have no set threshold. For the remaining organisations, in China most consider a threshold between 10% and 20% whereas in Australia most consider a threshold of 20–30% (consistent with [23]). About 6–8% of organisations in both countries consider a threshold of over 50% (our maximum threshold in the survey).

I. Key arguments for IPv6

We asked participants what key arguments convinced budget decision makers to appreciate the business case for IPv6 adoption. While the answers were diverse the most common arguments used in both countries were:

- IPv4 depletion: The depleted IPv4 address space was one of the main arguments used in several organisations. In a number of cases this argument was used in conjunction with the rapidly increasing number of connected devices due to the Internet of Things (IoT).
- Security: The increased security that IPv6 offers was another popular argument. Specifically mentioned are that IPv6 has IPSec integrated, security issues with tunnelling approaches can be avoided, host scanning is harder in IPv6 and IPv6 would help in reducing Distributed Denial of Service (DDoS) attacks.
- Future-proof: The ability to be ahead of the game and be ready when IPv6 is needed or demanded by customers was another popular argument. As one of the participants put it: "A smooth transition requires understanding the challenges and a timely start, knowledge and expertise in this field."
- Regulatory compliance: This was mentioned by several employees of Australian and Chinese government agencies or organisations close to the government.
- Reduced cost: The argument was either reduced cost of getting IPv6 addresses rather than buying more IPv4 addresses (organisations with an IPv4 allocation can get an equivalent IPv6 allocation at no extra cost [29]), or reduced cost because of the better security IPv6 offers. A few Australian participants also used the argument of eliminating NAT and hence saving costs.
- Keeping up with the competition: This argument was mainly used in MTOs – either in the form of keeping up with the competition that already offers IPv6 services or the view that "experience gained in implementing it internally can be contracted out to customers for their implementations".

Another argument was "customer demand". This was more common for Chinese organisations and more often phrased as actual demand. For Australian organisations it was also mentioned, but more often in the context of meeting future demand. One participant pointed out important growth in developing markets "which may go IPv6 only due to the 'west' absorbing a larger percentage of address space when compared to population".

Several Chinese participants used the new features of IPv6 as argument (e.g. "simplify header, increase the speed of packet forwarding and output; better security for authentication and privacy; support more types of services" or "IPv4 is limited in its service quality, transfer speed, security, mobile support"). This argument was less popular in Australian organisations, which is in line with the results in Figure 18.

Several participants explained that they used the opportunity of a "necessary hardware refresh due to infrastructure lifecycle management" to convince decision makers that enabling new capabilities would be beneficial. One Chinese participant

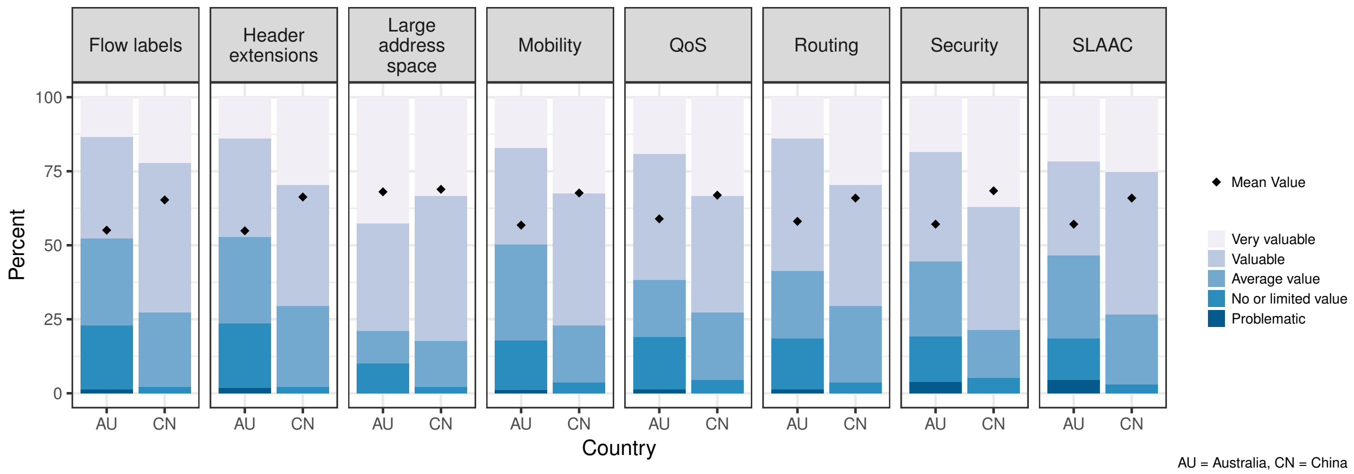

Figure 18. Perceived value of IPv6 features

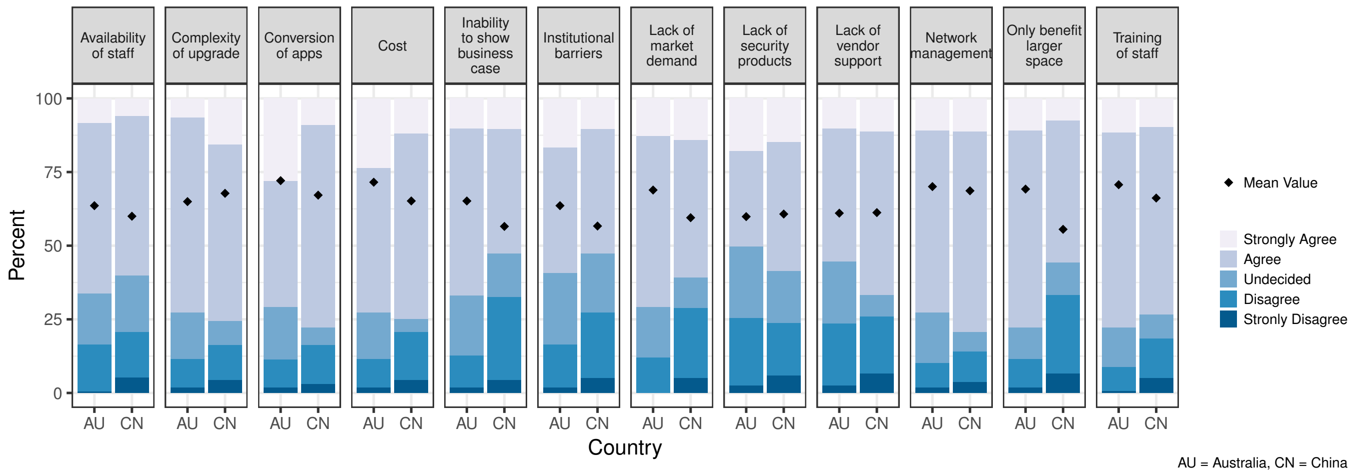

Figure 19. Obstacles for IPv6 deployment

mentioned that one argument was the possibility that IPv6 "was not subject to as much inspection in countries with high censorship, but that has not proven to be the case".

In organisations that have transitioned to IPv6, according to several participants it helped greatly when decision makers had a "technical background" or when non-technical decision makers were not involved in the decision.

J. How to speed up IPv6 transition

We asked which services could be offered by registrars or government agencies to help speed up the transition. Figure 20 shows the results. Most respondents agreed or strongly agreed to all categories, with the highest level of agreement for "Stimulating ISPs to support IPv6". The four leftmost categories in Figure 20 show significant stronger agreement from Chinese organisations ("Financial support" $t = -4.34$, $p < .001$; "Policy advise" $t = -3.66$, $p < .001$; "Stimulating ISPs $t = -2.66$, $p = .008$; "Technical assistance" $t = -5.33$, $p < .001$).

An open ended question gave participants the option to name other services that could be offered by registrars or government agencies to help with or speed up the adoption of IPv6.

Most of the answers contained the points already in Figure 20. For example, financial support or economic incentives in the form of "subsidised equipment modernisation", "financial rewards" or a "government allowance" were mentioned. Free/subsidised IPv6 training and IPv6 education programs were also mentioned. This could be in the form of an "IPv6 training roadshow" as suggested by one participant. Another participant suggested to provide more courses that cover IPv6 in universities to train more technical people.

Some participants complained about the lack of government support, for example "none of [the] government agencies provide help". Other participants asked for more "support and help from server vendor". It was also mentioned that it would help if "big company on user device/software side, e.g. Apple Inc, or other third party [started] pushing IPv6".

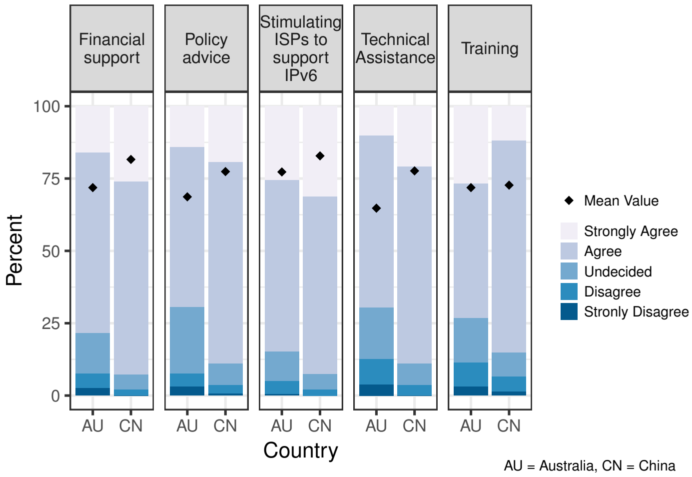

Figure 20. Services RIRs or governments could offer to speed up transition

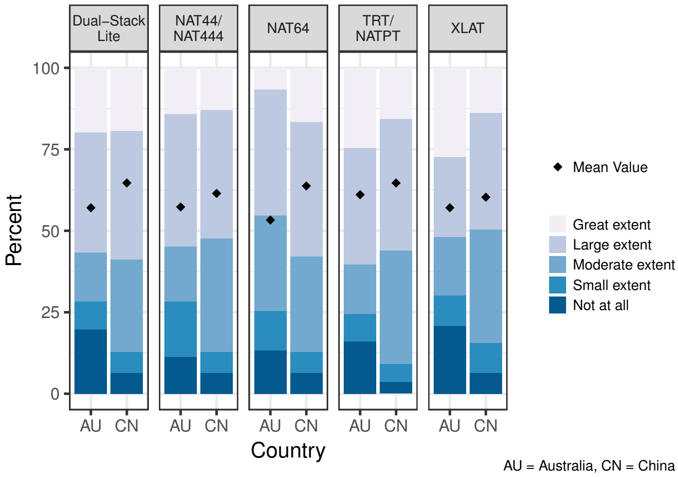

Figure 21. NAT techniques organisations use or plan to use

Several Australian participants asked for more pressure on ISPs. For example, one participant asked for "ISP management" as "our ISP refuses to issue us IPv6 despite multiple requests over several years". Another asked for IPv6 to be "mandated, particularly for ISPs". As one participant put it "If the very large players in the market can continue to consume their (already allocated) IPv4 address space without some type of mandate from IANA and others, SMEs[5] won't see any benefit or need to worry about IPv6 support". An Australian participant suggested "requiring [the] 'gang of four' to open up IPv6 peering" (the gang of four are Australia's four largest ISPs).

While putting more pressure on ISPs was also mentioned by Chinese participants, it was far more prominent for Australian participants. This is somewhat expected as many Australian ISPs still do not offer IPv6, whereas the situation is better in China. On the other hand a few participants from MTOs commented that there was no demand for IPv6. So it appears we are still somewhat stuck in the chicken and egg problem.

To move forward some participants from Australia and China commented that governments should mandate and used IPv6 for themselves, and not just for a few public-facing systems but for *all* internal systems and networks, to "put pressure on all vendors to provide IPv4/IPv6 equivalent products/services".

One participant asked for better guidelines: "We need a list of best practice guidelines for deploying IPv6. Share the experience that is not contained in RFCs[6] for a whole range of policy decisions."

Another participant argued that the fact that "IPv6 is never owned by an individual – it's rent only" hinders the rapid deployment. If IPv6 space were owned and a condition to keep it was to advertise and have it active within 12 months, then a lot more organisations would deploy IPv6 and demand it from their ISPs.

[5]Small and medium-sized enterprises
[6]IETF Request for Comments

Some Australian participants suggested there was still a lack in public awareness that needs to be addressed. Other participants suggested to "shame CEOs and CTOs as they were ultimately what's holding it back" (which could be in the form of a "status report and ranking of current versus planned versus missing IPv6 deployments").

K. Alternatives to IPv6

We also asked several questions that aimed to find out about the alternatives to IPv6: 1) obtaining more IPv4 addresses and 2) using NAT. Based on our survey 47% of Australian and 40% of Chinese organisations have purchased, directly or indirectly, IPv4 addresses from an IPv4 address broker or another company. Furthermore, 27% and 26% of Australian and Chinese organisations plan to buy IPv4 addresses in the near future and an additional 24% and 33% of Australian and Chinese organisations have no immediate plans to buy but are considering to possibly buy IPv4 addresses at some time in the future. This indicates that there is more demand for IPv4 addresses and we would expect to see further buying and selling of IPv4 addresses.

Of the Australian organisations 36% have NAT deployed, while 17% are trialling it and another 14% are planning to use it. Of the Chinese organisations only 30% have NAT deployed, but 25% are trialling it and another 25% are planning to it. The vast majority of organisations, 90% in Australia and 96% in China, that have NAT deployed, are trialling or planning for it, plan to use it along side IPv6. Figure 21 shows the NAT technologies considered by the organisations. No particular technology stands out and the differences between the two countries are small except for NAT64 where there is a significant difference ($t = -2.80,\ p = .006$).

Figure 22 shows for which types of customers MTOs plan to use NAT for. There are no significant differences between the countries or the categories, except that in Australia there appear to be significantly fewer organisations that are planning to use NAT for mobile customers ($t = -2.40,\ p = .021$).

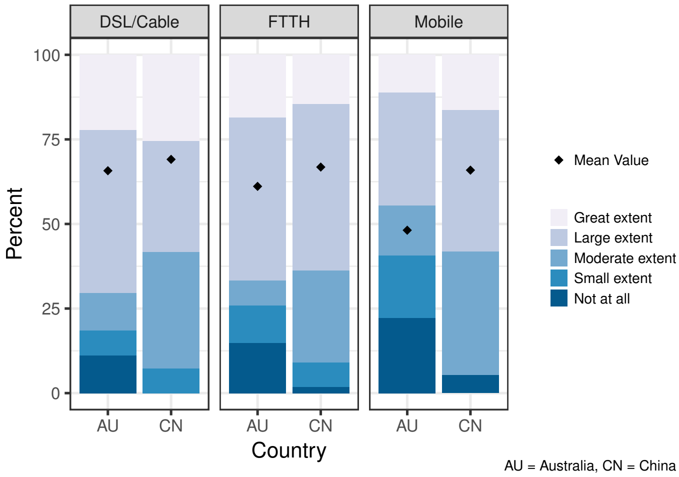

Figure 22. Types of customers for which telecommunication service providers plan to use NAT

V. Discussion, Limitations, Future Work

A. Discussion

Our results show that IPv6 deployment has advanced significantly in Australia since 2012 (around 25% of organisations have full deployment). Planning for IPv6 is now taking place in 80–90% of organisations and most organisations have made significant progress in planning, policy development, assessment and training. Planning and policy development are the most advanced areas whereas training is the least advanced. The lack of training also appears to be the biggest production problem in both countries. While there is not a lot of difference in planning or policy development between the two countries, China is ahead in all assessment and training categories.

Media and telecommunication organisations are ahead of companies from other sectors with regards to IPv6 deployment, which is expected since IPv6 is an infrastructure technology. Two thirds of MTO's still do not offer IPv6 to consumers. For those that do offer IPv6, in Australia usually not more than 20% of customers use IPv6, whereas in China for over 25% of ISPs more than 30% of customers already use IPv6.

When looking at IPv6 deployment versus organisation size, customer base size or IT staff size, the highest correlation is with IT staff size, i.e. there is less deployment with smaller IT staff size. To increase the speed of the transition it would therefore make sense to implement measures that help companies with smaller IT departments, that possibly do not have enough resources to implement the transition, such as training opportunities or subsidies, for example tax write-offs.

Huge differences between China and Australia become obvious when looking at the factors that determine the urgency of the transition to IPv6. "Competitive advantage", "Industry pressure", "New IPv6 features" and "Regulatory Compliance" are viewed as very important by Chinese organisations but as rather unimportant by Australian organisations. However, organisations from both countries agree that "Customer Demand" and "Depletion of IPv4" are very important factors. Looking at the expected transition times of organisations that have not fully deployed IPv6 yet, it appears though as if Australian organisations plan to move quicker. This may be because Australian organisations lag behind Chinese organisations in IPv6 deployment, or possibly Australian companies have a more optimistic view on the time scale it takes to deploy IPv6.

Organisations in both countries see the larger address space as most valuable feature of IPv6. However, Chinese organisation also view many of the other IPv6 features as valuable whereas Australian organisations see less value in most other features. The main obstacles for IPv6 deployment are the conversion of applications, the cost of the transition, network management and training. The least obstacles are lack of security products and vendor support. In China making a business case for IPv6 and institutional barriers are also seen as lesser obstacles, but these are viewed as more problematic by Australian organisations. Lack of market demand is also seen as a much more significant obstacle in Australia.

Convincing decision makers that the transition to IPv6 is needed does not appears to be a great hurdle for many organisations. Upgrade costs and lack of training are viewed as greater hurdles. Organisations in both countries would appreciate more help from government or RIRs to help speed up the transition. Financial and policy support, stimulating ISPs to support IPv6, technical assistance and training are all viewed as very helpful.

Many organisations indicate that despite deploying IPv6 or planning to deploy it, they still require more IPv4 addresses and consider buying those from brokers. We expect to continue to see an IPv4 market, possibly even with increased activity, for a number of years. While many organisations already use NAT or plan to use it, the vast majority of organisations plan to use it alongside with IPv6.

Overall, our study shows that China is ahead in IPv6 deployment compared to Australia. We suspect this is due to the Chinese government making the IPv6 transition part of their 5 year plans since 2003. This has effectively mandated IPv6 deployment for most larger ISPs. An interesting difference between Australian and Chinese organisations is how valuable they view IPv6's new features. Chinese organisations see more value in various features other than the large address space. This more positive view could have been shaped by the Chinese government promoting a positive picture of IPv6 which has been well permeated through society due to the collectivism nature of the Chinese society.

B. Limitations and future work

Our study required participants that were aware of IPv6 and knew the status of IPv6 in their organisations. This means our study is possibly biased towards organisations that are ahead in IPv6 deployment, such as Telcos and ISPs, as employees in these organisations have a higher level of IPv6 knowledge. However, given the questions we wanted to ask this bias is impossible to avoid. Hovav et al. [20] experienced the same effect and noted that "studies examining the adoption of an IT-related infrastructure technology would be expected to have a large portion of sample from telecommunication industry".

We investigated what fraction of survey respondents worked in IT, but were rejected from doing the survey because they did not know what IPv6 is or they did not know the IPv6 deployment status and plans of their organisations (for the surveys conducted by survey companies). The fraction of rejected respondents was 60% and 75% for Australia and China respectively. Considering that 1) many IT employees do not work in the networking area and thus may not know about IPv6, and 2) many low-level employees may not know the details of an organisation's IPv6 deployment or future plans, these fractions appear reasonable (note that 75% of our respondents were at least mid-level managers). Although bias is likely, the fractions do not indicate a large magnitude.

Another limitation is that our study only covers two countries to get a decent sample size per country with manageable cost and effort. Future work could extend the survey to more countries in the Asia-Pacific region or the world, but it is unlikely that a single survey could ever cover many countries in great detail.

VI. Conclusions

The IPv4 address space is now almost completely exhausted, yet the transition from IPv4 to IPv6 is still slow in many countries, such as Australia and China. This paper investigates the state of IPv6 deployment and future deployment plans in Australian and Chinese organisations based on a survey of organisations' IT staff. To our knowledge it is the only detailed study that has been carried out in either of the two countries recently. Our work also differs from others in that we study two countries in detail – existing work either focussed on a single country or conducted a global survey with very little country or regional specific details.

Compared to the data from previous studies, we find that IPv6 deployment has advanced markedly, but it is still years away for a significant portion of organisations, especially in Australia. Compared to Australia, China is clearly ahead in IPv6 deployment. We also point out some interesting differences between both countries, for example that IPv6's new features are viewed as more valuable in China. Finally, we provide insights into arguments on how to convince decision makers to deploy IPv6 and ways to speed up the transition. We believe these are not just relevant for the two countries studied, but have broader applicability and are relevant for many other countries as well.

Acknowledgements

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