Project factsheet information

Project title	Surveying the State of IPv6 Deployment in Australia and China
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Country where project was implemented	Australia
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Partner organizations	None
Total budget approved	AUD 25,000
Project summary	The Internet Protocol (IP) is the core protocol of the Internet providing the required addressing for all connected devices. The IP version 4 (IPv4) address space is nearly exhausted yet the uptake of IP version 6 (IPv6), which has a much larger address space, is still low in Australia and China. The only alternative to IPv6 is large-scale Network Address Translation (NAT) which has a number of disadvantages. This project, focusing on Australia and China, set out to (a) accurately quantify current IPv6 deployment in organisations, (b) identify whether IPv6 deployment is likely to increase in the future and (c) identify what drives and hinders deployment of IPv6. The main goals were to provide a better picture of the current state, predict the speed of the future transition and help identifying how to more effectively manage the transition. The project started in March 2016 and finished by the end of 2016. The project developed an IPv6 deployment questionnaire and carried out a survey with participants in Australia and China. Participants were recruited trough two main channels in both countries. Market research companies were used to recruit participants from a diverse set of organisations. The survey was also advertised by APNIC to their members and on network operator mailing lists to recruit participants mainly from Telecommunications companies or Internet providers. Results show that deployment of IPv6 has significantly advanced in recent years, but deployment in Australia still lags deployment in China. Furthermore, despite the significant progress there is still a significant portion of organisations that have not deployed IPv6 yet and also have no plans to deploy it in the next one or two years. There is a marked difference between Australian and Chinese organisations with regards to the perceived benefits of IPv6. Chinese organisations have a much more positive view of the IPv6 features and benefits. Regardless of whether this is warranted or not, it demonstrates the effect of a more collectivistic society where the government has very actively promoted IPv6.

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Background and Justification

The central protocol in the Internet is the Internet Protocol (IP). Each device connected to the Internet must have a unique IP address and routers in the network use the IP destination address in packet headers to forward the packet to the receiver. IP version 4 (IPv4) has been used for many years, but has several shortfalls that were addressed in IP version 6 (IPv6), which was standardised in 1998 – most notably the address space of IPv4 is too small. IPv6 is incompatible with IPv4 which has made the transition difficult.

The IPv4 address space is nearly completely allocated now and only very small allocations can be obtained from the Regional Registrars (RIRs) [1]. Many organisations still have `reserves' of IPv4 addresses [2] but these will run out eventually, as the number of devices connected to the Internet will increase rapidly in coming years due to more and more types of devices becoming connected – called the Internet of Things (IoT). There are two main techniques to overcome the address shortage: migrating from IPv4 to IPv6 or continuing to use IPv4 with (large-scale) Network Address Translation (NAT).

Large-scale NAT allows many end-users to share one public IP address, but it has a number of disadvantages, for example it breaks some application protocols and makes IP-geolocation difficult. Also, once network providers have deployed large NATs, they have a convenient setup for differential treatment of network traffic (e.g. blocking some applications) which poses a risk to network neutrality. IPv6 has several advantages over IPv4 and does not suffer from any of the disadvantages of NAT.

After many years of little progress, IPv6 deployment has grown significantly in recent years in a number of developed countries, for example in the USA, Germany, Japan or Norway. The fraction of users that use IPv6 in the USA, Germany, Japan or Norway is well over 5% at the beginning of 2016 [3,4]. In contrast the fraction of users that use IPv6 in Australia or China is 5% or less at the beginning of 2016 [3,4]. IPv6 deployment in Australia and China is lagging behind and specifically for Australia this was also mentioned in [5].

We believe that not getting on board the IPv6 train will put countries like Australia and China at a competitive disadvantage in the near future. As Paul Wilson, director of APNIC, said in [5]: "Without IPv6, the Australian internet will be less efficient, it will be slower and less reliable, and more expensive -- and that would be bad for the country." This will become an even bigger issue as the mining boom of the century is now over and Australia needs other industries to fill the gap, such as manufacturing and services, many of which rely heavily on the Internet.

Not many details are known about the state of the IPv6-readiness in Australian or Chinese organisations in 2016. Existing published surveys, such as [6], [7] or [8], are either several years old, not very detailed, or were done on a global scale and do not have many participants from Australia or China. It is crucial to get an update at this point in time to be able to determine whether the uptake of IPv6 in Australia and China is really as low as [3,4] suggest or not, what the future deployment will be and what is holding back organisations to deploy IPv6. Information from this study can then be used to break down barriers or increase incentives for IPv6 deployment.

The transition from IPv4 to IPv6 is an active research topic at Murdoch University's School of Engineering and IT, since it is an important issue for the future of computer networks. Murdoch University has been a research-led University since its inception in 1973. The University believes in engaging with global challenges and in the translation of new knowledge into practice. The University's School of Engineering and IT is an innovative faculty and makes significant contributions to many areas of research. The research in computer science covers a range of topics including image recognition and processing, complex adaptive systems as well as computer networking.

Project Narrative

While macroscopic information of IPv6 deployment in Australia and China could be accessed [3,4], the state of IPv6-deployment and deployment plans of Australian and Chinese organisations in 2016 remained unclear. Existing published surveys, such as [6], [7] or [8], were either several years old, not very detailed, or were done on a global scale and do not have many participants from Australia or China.

The focus of this project, as defined in the grant proposal, is to shed some light on the IPv6 readiness and deployment of organisations in Australia and China, and gain insights into the motivations for deploying or not

deploying IPv6. The project goals are to quantify current IPv6 deployment in organisations accurately, to identify whether IPv6 deployment is likely to increase in the future and to determine what drives and hinders deployment of IPv6.

Further aims of the project are to identify how organisations that do not plan to deploy IPv6 soon intend to cope with the acute shortage of available IPv4 addresses, for example whether they plan to buy additional IPv4 addresses on the “second-hand” market or plan to deploy large-scale NAT. Another aspect that the project sets out to investigate is finding out whether there is a significant demand for IPv6 from some organisations and if yes, whether a slow IPv6 roll-out by ISPs has a negative impact on these organisations. Finally, the project aims to identify whether the pace of IPv6 deployment will increase in the future and what the time frame for planned IPv6 deployment is.

The focus of the study is private and government organisations from all types of industry sectors that use the Internet (not just the information technology sector). This broad focus provides a good basis to find the answers to the aforementioned questions. The study ignores home users, since they are very unlikely to be the driver for IPv6 demand.

The project’s focus is on Australia and China, because both countries have low IPv6 deployment at the beginning of 2016, so the study will be very relevant to both countries. 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 its number of IPv4 addresses, whereas Australia is a small developed country with a much larger number of IPv4 addresses per capita than China. We expected that these differences will lead to interesting differences in the survey results. Furthermore, since the Chinese and Australian economies are closely linked, with China being Australia's biggest export destination, the sentiment in China towards IPv6 may impact on the future IPv6 deployment in Australia.

In summary, this project was designed to deliver a much clearer picture of the current state of IPv6 deployment, the future trajectory for IPv6 and the main barriers to IPv6 deployment in Australia and China. Comparing the findings with historical survey data (e.g. from [6]) provides insights into how well past intentions have been translated into actual IPv6 deployment (which will potentially help to calibrate the future trajectory predicted). We also hope the research results may be useful for spawning new ideas on how to speed up IPv6 deployment through marketing, targeted actions or incentive programs by relevant bodies, such as local or state governments or the regional registrar (APNIC).

Participants for the survey were recruited in a number of ways. We used market research companies to recruit a random set of participants from all types of organisations to get a good snapshot across different industry sectors. With the help of APNIC we also recruited participants from the APNIC members. Finally, we advertised the survey via Australian and Chinese network operator forums.

The recruitment of Australian participants via market research companies proofed more difficult than anticipated. Our initial soft launch had very low response rates. The number of potential participants that worked in information technology was very low and so the vast majority of potential participants failed one of the very first screening questions. Of those participants that worked in information technology the proportion that had knowledge about IPv6 was relatively high. Employing a different market research company significantly increased the response rate and allowed us to recruit our target number of participants.

Our survey was developed in partnership with APNIC, and APNIC also helped us to recruit participants via advertising the survey to their members. We have published the key results as public web page to make them freely available for everybody, and also have submitted two articles to scientific journals. We will contribute the results of our study to the Internet Government Forum (IGF) IPv6 Best Practise Forum, which aims to develop an understanding of the motives for transitioning to IPv6 as well as the commercial incentives behind IPv6 deployment.

The beneficiaries of our project are the agencies interested in the status of IPv6 deployment, such as the government and RIRs, as well as the organisations in the two countries. While the results can be used by government and RIRs to assist with planning and improving the transition to IPv6, we think the results benefit all organisations in their future business decisions related to IPv6. We hope the results will also be translated into actions to further improve the transition to IPv6. Beneficiaries were involved in our project in two stages. Firstly,

they were involved as participants in the data collection. Any members of organisation in Australia and China with knowledge of their organisation's IPv6 deployment plan could participate in our survey. Secondly, our results have been made public on the web so that any interested parties can benefit from this study (http://www.it.murdoch.edu.au/nsrg/ipv6_deployment_survey/introduction.html).

Indicators

The following table lists our indicators to measure the success of our project.

Indicators	Baseline	Progress assessment	Course of action
Development of comprehensive questionnaire.	A number of questionnaires were used in previous studies [6], [7] or [8], but none contained all the questions required.	A comprehensive questionnaire has been developed and it has been approved by Murdoch University's Ethics committee.	No further actions.
Collect data from approx. 150 participants in each of the two countries.	There are no current survey results. Most previous surveys had fewer participants.	We have collected data from 198 participants (Australia) and 188 participants (China). Data was filtered to eliminate duplicates. After filtering we ended up with 173 participants (Australia) and 148 participants (China).	No further actions.
Answers to the questions raised based on the survey data.	There are no current survey results.	The survey data has been analysed, a web page with key results has been made public and two research papers have been submitted to scholarly journals.	No further actions.

Project implementation

Introduction

The aim of the project is to shed light on the current status of IPv6 deployment and future deployment plans in Australia and China in 2016. Our approach for the project is a survey-based study.

The first step of the project was a literature survey of previous IPv6 surveys. There are a large number of network measurement based studies into the uptake of IPv6, such as [9] and [10], but many focus on global metrics or countries other than Australia or China. Furthermore, these studies focus on measurable metrics and most do not deliver any insights into organisations' behaviour or motivations related to IPv6. Only a few survey-based studies exist and they are either several years old, not very detailed, or were done on a global scale and do not have many participants from Australia or China.

Previous IPv6 Surveys

Dell [6] studied the IPv6 readiness of companies in Australia based on a survey conducted in 2011. The paper analysed the awareness and urgency of IPv6 along five facets: training, planning, and assessment of current environment, policy and actual deployment. While the study has a comprehensive analysis of the awareness and urgency of IPv6, it does not provide much insight into the motivation/reason for deploying or not deploying IPv6 or the main obstacles for IPv6 deployment.

An RIR community survey carried out by Botterman [7] focussed on network operators was conducted in the years 2010—2013. It was a global survey and the number of participants from Australia and China was small.

BT Connect [8] carried out an industry survey in 2014. The sample from Asia was very low with less than 25 responses from the whole Asian region.

Pickard [11] studied the IPv6 readiness of enterprise organisations located in the eastern region of North Carolina using questions very similar to Dell [6]. A low response rate and narrow geographical focus means the results cannot be generalised, the authors even make the point that "the findings cannot be generalized to the larger population of all U.S. companies".

Svedek [12] studied the IPv6 readiness and transition plans of Croatian organisations connected to CARNet (Croatian NREN). Only a single question was asked and the results only show whether organisations were interested in IPv6 or not. In a follow-up study Dobrijevic [13] studied the IPv6 readiness and transition plans of 12 Croatian ISPs and 14 public administration bodies in more detail.

We based some of our survey questions on the questions of Dell [6] as well as on the questions used by Botterman [7] and BT Connect [8].

Project Implementation

Based on the literature and our project's goals we developed a structured questionnaire. A key issue was to design screening questions that allowed filtering out potential participants recruited by market research companies that did not know anything about the IPv6 deployment in their organisation. Note that this is a problem none of the previous surveys faced as they were targeted directly at knowledgeable people (biasing the sample though towards telecommunication companies, ISPs etc.).

We sent a first version of the questionnaire to APNIC for feedback and subsequently improved the questionnaire. We also developed a consent form for the survey.

With the initial version of the questionnaire and the consent form we applied for Ethics approval. It is standard procedure that all studies with human subjects carried out by Australian Universities must undergo an Ethics approval process. The Ethics committee of Murdoch University approved our study after some additional clarifications were provided and the questionnaire was improved further.

Our Ethics committee initially did not approve the recruitment of survey participants via APNIC without a support letter from APNIC. After we received a support letter from APNIC, we filed an amendment to the Ethics approval, which was later approved.

We then implement the English version of the survey using Qualtrics [14], one of the largest and most popular Internet survey platforms. We tested the survey and made several improvements in the implementation (again with the help of APNIC). We then translated the survey to Mandarin for use in China.

We started a soft launch of the survey in Australia with the company CriticalMix [15] in June 2016. During the soft launch we further tweaked the screening questions. The soft launch in Australia already showed low response rates, but we proceeded to a full launch in Australia. In parallel we started a soft launch and then a full launch with CriticalMix in China.

In China we had no issues collecting the 150 responses we targeted for in a relatively short time, but in Australia we collected only 35 responses in 3 weeks. The main problem was that a very large fraction of potential participants did not work in the IT area and thus failed one of the earliest screening questions. We finally stopped the survey when it was apparent that we would not get anywhere near to 100 participants.

We then used a second market research company, emPANEL Online [16], to recruit more participants in Australia. emPANEL's cost per participant was higher, but the response rate was also higher and we were able to attract enough participants to reach almost 140 responses in Australia from both market research companies combined. Both surveys with market research companies finished in the middle of August 2016.

Since APNIC carried out their member survey in July 2016, we could only start recruiting participants via APNIC in early to mid August 2016. APNIC sent out our announcement to their Australian and Chinese members and also forwarded it to CCNIC. The announcement was also sent to the AUSNOG mailing list. This recruitment proceeded very well and we closed the survey at the end of August 2016.

For each country the similarities between responses was checked to detect potential data records from the 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 with regards to the demographics of the organisations and deployment of IPv6. After identifying similar data records, the research team discussed and decided whether to treat them as duplicate records for one organisation. When duplicates were removed, the records removed were picked randomly.

Table 1 shows the number of participants recruited in each country (separating the two recruitment methods) after the data cleaning.

Table 1: Number of participants after data cleaning

Recruitment Method	Australian Participants	Chinese Participants
Market Research Company	114	111
APNIC members, AUSNOG, CCNIC	59	37
Total	173	148

The final step of the project was the analysis of the data. We performed two different types of analysis. First, results for different questions were plotted as bar charts and hypothesis tests were conducted to compare responses between the two countries. Second, we used regression modelling to examine how various organizational factors influence Internet standards adoption.

The following table lists the main project activities and their status.

Project activities	Input	Outputs	Timeline	Status
Questionnaire developed	Research team with help from APNIC	Survey questionnaire	15/03/2016 – 15/04/2016	Completed
Ethics approval obtained	Research team with feedback of Murdoch University Ethics committee	Ethics approval letter	22/03/2016 – 11/05/2016	Completed
English version of survey implemented online with Qualtrics and tested	Research team	Online survey (English)	12/05/2016 – 31/05/2016	Completed
Survey translated to Chinese	Research team	Online survey (Chinese)	1/06/2016 – 15/06/2016	Completed
Soft launch of survey in Australia	Research team with market research company contracted	Improved online survey	16/06/2016 – 22/06/2016	Completed
Participants recruited via survey company	Market research company contracted	Survey data	23/6/2016 – 15/08/2016	Completed
Participants recruited via APNIC mailing list and operator mailing lists	Research team with support from APNIC	Survey data	9/8/2016 – 31/8/2016	Completed
Data analysis carried out and two research papers written	Research team	Research paper containing results	1/9/2016 – 31/12/2016	Completed
Result web site implemented	Research team plus casual hired	Public web site	15/12/2016 – 31/1/2017	Completed
Results presented at conference	Research team	Presentation	After project end	After project end

Communication and dissemination

We have written two scientific papers and submitted them for publication to high quality scientific journals. We also published key results on a public web page part of Murdoch University's web page (http://www.it.murdoch.edu.au/nsrg/ipv6_deployment_survey/introduction.html). A technical report with the main results is also available on that web page. Once our submitted papers are accepted, we aim to publish the papers in open access form if possible. This is subject to the project funding covering the additional open access publication cost. If open access publication is not feasible and the publisher(s) allows it we will make author copies available via the web page.

We will present the results at one conference after the official end of the project.

The project's results will be announced on our school's web page, as Murdoch University press release (subject to approval) and via relevant Internet forums including but not limited to the IGF's BFP IPv6 forum, AUSNOG mailing list, CCNIC mailing list. We will ask APNIC to announce the results on their blog and possible to their Australian and Chinese members via their mailing list.

The effectiveness will be measured by the usual means, for example citations for the research paper(s) (e.g. Google Scholar) and access or download numbers for the paper(s) and the result web site. We will also keep track of the number of interested parties that contact us based on blog and mailing list announcements.

Project Management and Sustainability

The project experienced a slow start due to the fact that the APNIC grant agreement is different from most other research grant agreements that we encounter at Murdoch University. The grant agreement includes the IDRC terms and conditions, which makes the agreement very hard to read and understand. Our administration and legal staff took much longer than usual to process the grant agreement and several meetings were necessary to clarify legal details. We would like to acknowledge the assistance of Janine Blake, Carla de Gois and Magdalena Castelli who spent a significant amount of time prior to getting the contract signed.

Apart from the delay in signing the grant there have been no administrative issues or delays. To our knowledge the project has not required any special processes or procedures. Murdoch University is obviously familiar with handling research grants.

Our Ethics committee is not used to applications from the networking space and we took extra care to explain the project very well in the application. Getting Ethics approval was a relatively smooth process and we would like to thank Erich von Dietze, manager Research Ethics and Integrity, and the Ethics committee members who helped us to improve the questionnaire.

We would also like to thank APNIC's George Michaelson who helped us improve and advertise the questionnaire and APNIC's Siena Perry who took care of advertising the survey to APNIC members.

Finally, we would like to acknowledge the outstanding support from APNIC's Sylvia Cadena during the whole project but in particular during the grant agreement signing process.

Besides the project administration outlined above, the project dealt with staffing, procurement and sustainability, as follows:

- **Staffing:** One casual staff member was funded by the grant money. The casual staff member, a final year undergraduate student, implemented the web site documenting the main results of the study. The work experience was very useful for the student, who wants to continue working in the web development space.
- **Procurement:** Initially we had planned to purchase a Qualtrics license to carry out the survey, but then the opportunity arose to use an existing Qualtrics license. So we decided to use the money planned for the license to recruit more participants instead. The cost for the market research company turned out to be higher than anticipated due to a lower than anticipated response rate. However, we still met our target of approximately 150 participants in each country with the available funding.
- **Sustainability:** Our survey is a snapshot in time in the year 2016, and the project does not aim for sustainability beyond the point where we have the answers to the IPv6 deployment questions we are

interested in. Potentially, we will repeat the survey in the future, but that depends on available funding and continued support from APNIC or others. We hope that the project will leave a legacy in terms of the insights it provides and the potential impact it makes on improving the uptake of IPv6 in Australia and China.

Project Outcomes and Impact

Key Results

This section summarises the key results. More results can be found on the web page (http://www.it.murdoch.edu.au/nsrg/ipv6_deployment_survey/introduction.html).

Deployment Status

Figure 1 shows the breakdown of IPv6 deployment in Australian (AU) and Chinese (CN) organisations. The figure differentiates between Media and Telecommunication Organisations (MTOs), such as Telcos, ISPs, National Research and Education Networks (NRENs) and hosting providers, and other organisations (Others). 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, but even more so with regards to MTOs – over 50% of Chinese MTOs 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.

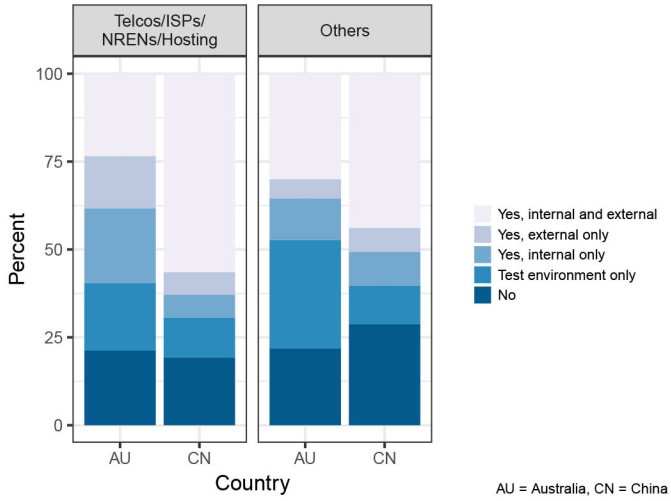

Figure 1: IPv6 deployment status in organisations

Production Problems

Figure 2 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 has a significantly lower mean response than Australia), 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. 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.

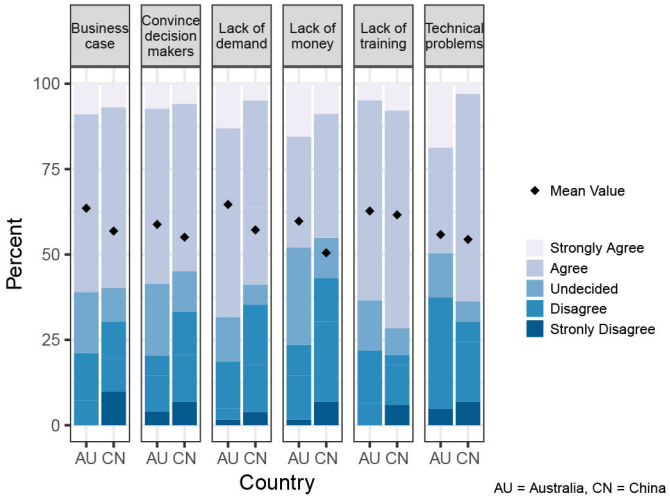

Figure 2: Problems with IPv6 in production

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.

Figure 3 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”, “Industry pressure” and “IPv6 features” – 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”, “Internet of Things”, “Regulatory Compliance” and “Lack of IPv6 hardware and software” are also significant.

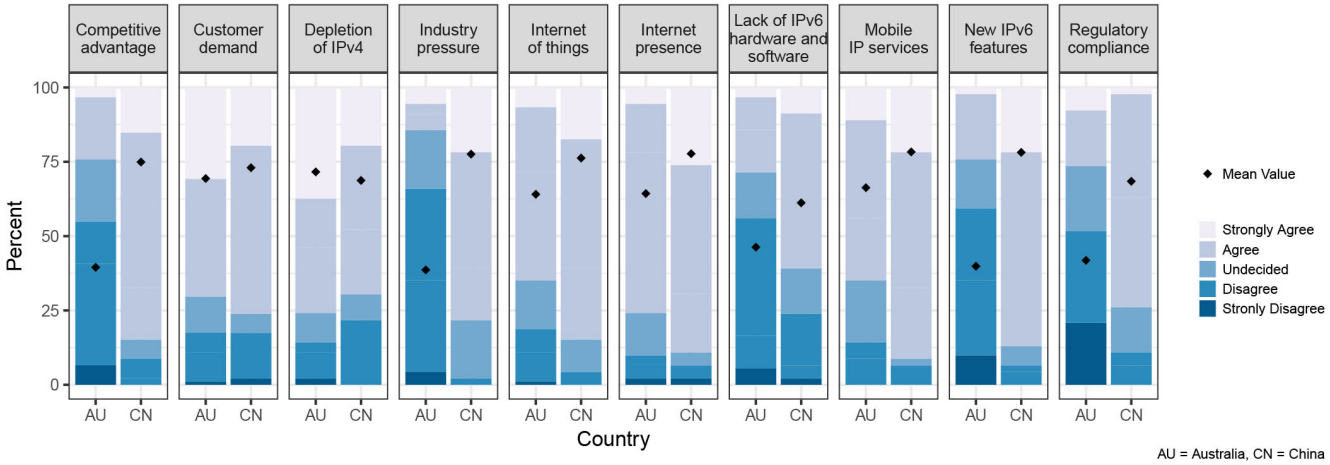

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Figure 3: Factors determining the urgency of the transition to IPv6

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 in Dell [6].

Figure 4 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.

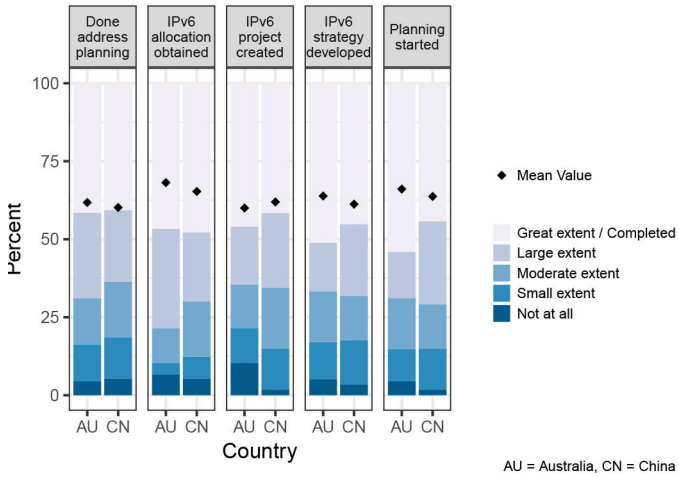

Figure 4: State of planning for IPv6 in organisations

Figure 5 shows the state of assessment of IPv6 in the organisation. There is a significant difference between China and Australia in all the categories. China is ahead in all categories, most noticeable in the “Training” category. When compared to Figure 4, assessment is clearly less advanced than planning or policy development.

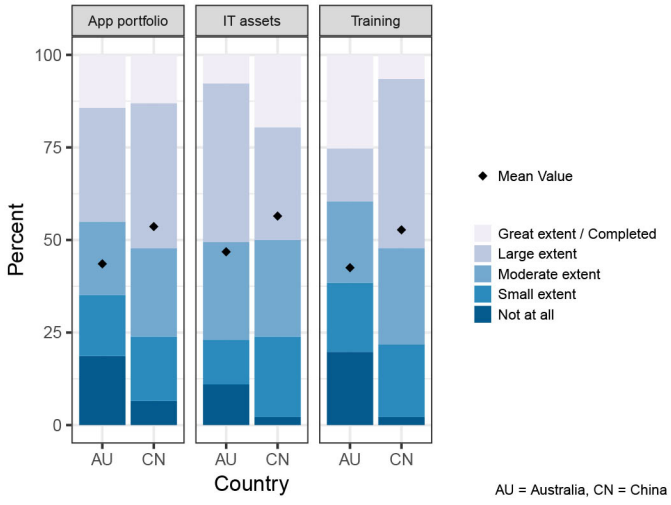

Figure 5: State of assessment of IPv6 in organisations

Figure 6 shows the state of IPv6 training provided. There is not much difference between the different training areas (as in Dell [6]). China is consistently ahead in all categories, most noticeably in IPv6 security. When compared to the other preparedness areas, training is the least advanced.

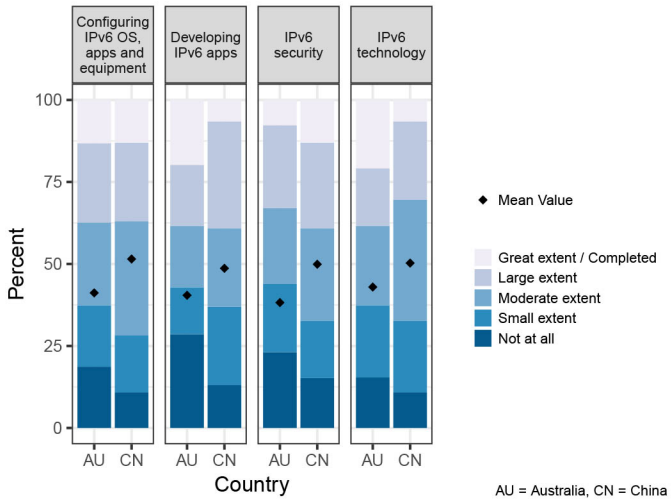

Figure 6: State of IPv6 training in organisations

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 investigated the required transition time as estimated by the respondents.

Figure 7 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.

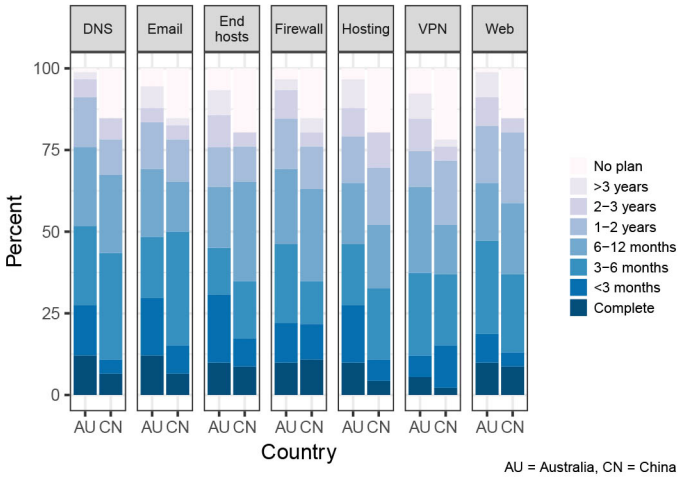

Figure 7: Expected transition times for different services

Motivation and Obstacles

From previous studies we know that a number of the new features IPv6 provides are viewed as not very attractive. To confirm whether this is still the case, we asked all participants about the value of the new features. Figure 8 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 or worse value 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 or worse value.

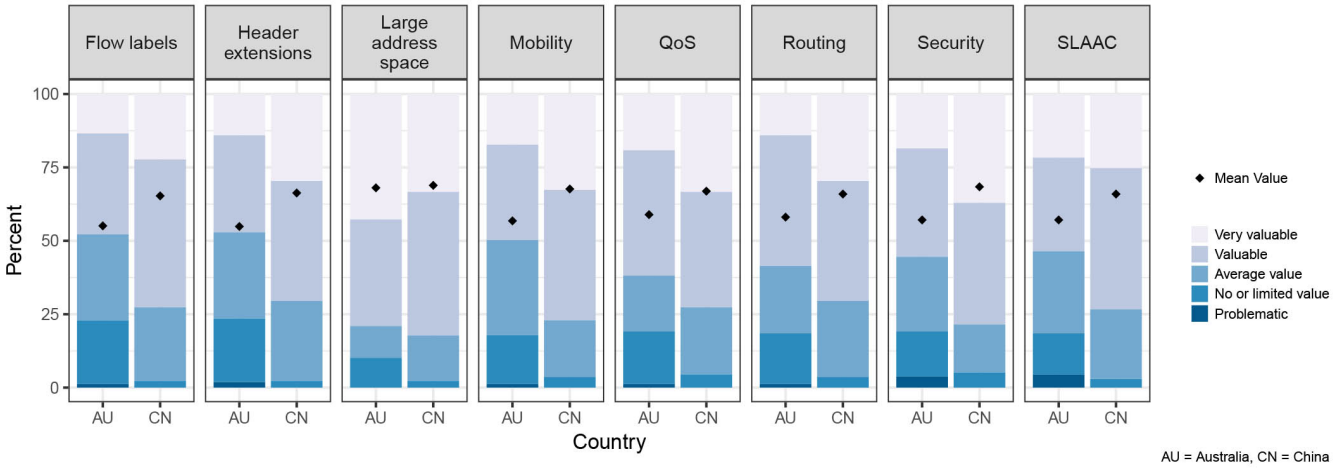

Figure 8: Perceived value of IPv6 features

We also asked all participants, including those from organisations that have already deployed IPv6, what the main obstacles for IPv6 deployment are. Figure 9 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”, “Inability to show business case”, “Institutional barriers”, “Lack of demand” and “Only benefit is larger address space”. All of these are seen as smaller obstacles in China (consistent with higher demand in China and Figure 8 showing that various IPv6 features are perceived more positively in China).

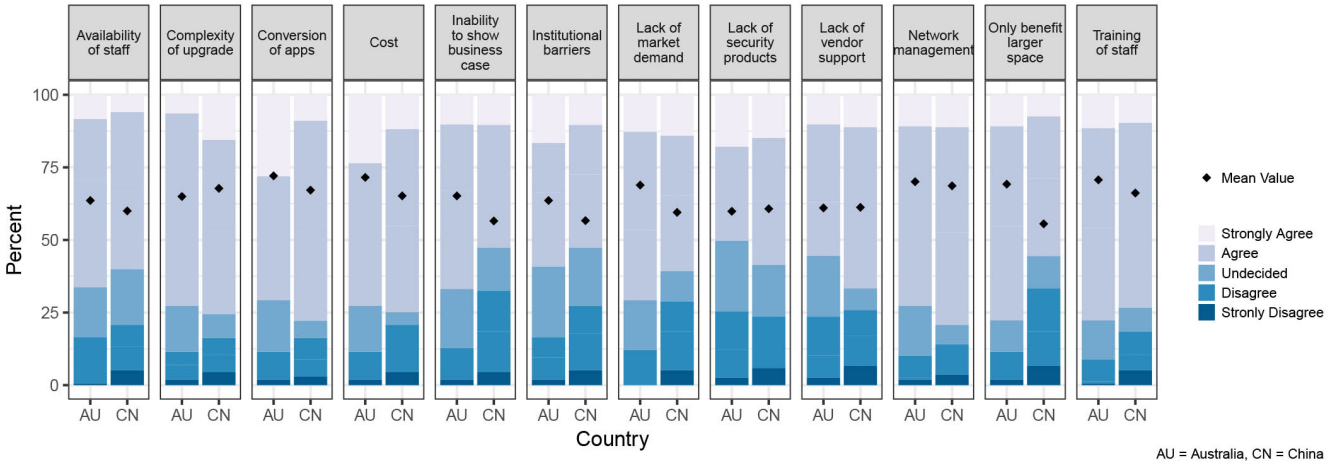

Figure 9: Obstacles for IPv6 deployment

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 10 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 10 show significant stronger agreement from Chinese organisations.

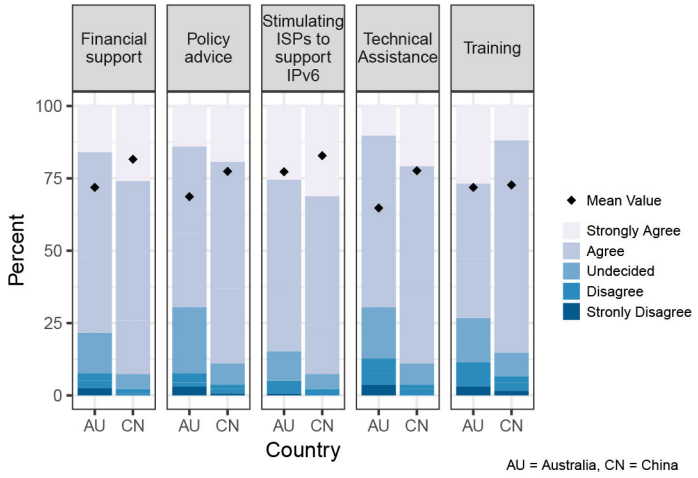

Figure 10: Services RIRs or governments could offer to speed up transition

Outcomes

For the participants of the study, we hope the project has encouraged them to reflect on their organisation's experiences with IPv6. This should help to provide a greater understanding of the IPv6 deployment, which will benefit not only future business decisions related to IPv6, but hopefully will also be translated into actions to further improve the transition to IPv6.

For other organisations, the main outcome is that there now is current data publicly available about the IPv6 deployment state and future plans of Australian and Chinese organisations. The results of the study are useful for decision makers in organisations who have not fully deployed IPv6 yet, as it allows them to make more informed decisions about their future IPv6 deployment.

For governments and RIRs, the study provides a snapshot of where the IPv6 transition is, what the main obstacles are and what possible actions could be done to further speed up the transition.

For the research community our project provides some new insights into the adoption of Internet standards and more specifically what drives the adoptions of standards. For the research team, the project has strengthened the research experience and capabilities.

Impact

We hope that the long term impact of the project is a higher and potential quicker adoption of IPv6 especially in Australia. Ideally the significant increase in IPv6 deployment we observed will lead more organisations to rethink their position and speed up their deployment plans. Similarly, the indication from our study that there is some demand for IPv6 may lead Telecommunication companies and ISPs to speed up their deployment for customers. On the other hand, governments/RIRs may implement some of the suggested measures to help speed up IPv6 deployment. Finally, we hope that the results from our project will drive new research into how to improve the adoption of new Internet standards in general.

Overall Assessment

The project has met its objective. A survey of IPv6 deployment was conducted in Australia and China based on approximately 150 participants in each country. The most important findings are that deployment of IPv6 has significantly advanced in recent years, but deployment in Australia still lags deployment in China, and that despite the significant progress there is still a significant portion of organisations that are not deploying IPv6 yet and also have no plans to deploy it in the next one or two years. In addition, our study revealed a number of interesting findings, such as organisations' IPv6 transition plans, the perceived value of IPv6, deployment

problems encountered and what could be done to further speed up the transition. The findings have been made public or will be made public as described in previous sections.

The results of our project are useful from two main perspectives. First, our project can help organisations understand what resources organisations need to facilitate the implementation of IPv6. Second, our project can help organisations understand the value of IPv6. Especially, our results can help IT staff to make a stronger argument and better convince decision makers to implement IPv6.

Two important aspects that were particular important to the success of the project were the recruitment strategy and the survey design. The combination of different recruitment types, via survey companies and APNIC as well as operator forums, was instrumental to reach the target sample size. While any survey-based study can benefit from even more samples, we think our achieved sample size represents a good value for money. Our survey had rigorous screening questions (for participants recruited by market research companies) and attention checking questions to prevent irrelevant responses. Our survey was well designed with a clear flow and conditional parts that were only activated depending on answers given to previous questions. This resulted in participants being able to complete the survey within an acceptable timeframe of about 20 minutes.

We also learned a few lessons. It turned out to be more difficult than expected to conduct a highly technical survey via market research companies. The initial response rate was very low and we had to use two different market research companies in Australia. The second complication was the difficulty to perform electronic surveys via market research companies for organisations. Market research companies focus on individuals and it is not possible to obtain per-organisation responses. We implemented several mechanisms to identify whether different respondents belonged to the same organisation, such as tracking respondents IP addresses, recording organisations' domains (if provided by respondent) and recording various organisational metrics that can be used as a 'fingerprint'. However, we are fully aware that all of these still do not provide a perfect solution. It is hard to see though how our approach could be significantly improved with surveys that provide anonymity for the participants, as there is a lack of incentives for market research companies to implement any approaches for anonymous surveys. With the benefit of hindsight we also identified further ways of how the survey could be streamlined in the future.

This project has helped to increase research capacity at Murdoch University in the IT/networking area, which is important as Murdoch University aims to significantly increase the research profile of its IT discipline. We think that obtaining this grant will also help the involved researchers to attract more funding in future. Furthermore, the collaboration with APNIC was very helpful not only for recruiting participants, but also because of the technical input and the outreach gained.

Recommendations and Use of Findings

As future users of the findings of this project we see the following groups: policy makers, decision makers in companies, the public, and other researchers. We are hopeful that our findings may influence policy makers to do more to increase the uptake of IPv6. Our findings will also enable decision makers in companies or other organisations to make more informed decisions about IPv6 deployment. Our findings are also relevant for a wider public audience that seeks information about the deployment status of IPv6 in Australia and China. Finally, we hope that our findings will drive more research into how to approve Internet standards adoption more generally.

While our findings are primarily relevant for an audience in Australia and China, we think that they are also potentially relevant for organisations, policy makers and researchers in other countries, especially for those that seek to benchmark the IPv6 deployment in their countries against others. Lastly, we believe that some of our findings are not just limited to the two countries surveyed, but have broader applicability and are relevant for many other countries as well.

Our project can help other practitioners/researchers to better understand important aspects of IPv6 deployment which they can use for their future assessment and research. Other practitioners can also learn from our survey design and implementation and use similar surveys in other countries. Overall, our approach in this project followed current best practices for survey studies and there are no recommendations we could make to other practitioners that are not already known from previous literature.

The support of ISIF Asia and APNIC during the project was excellent. Nevertheless, here are a few suggestions for improvements with regards to the process.

Reducing the complexity of the grant agreement would help streamline the process of signing the agreement. The main grant agreement included another set of clauses, which made the agreement very hard to understand even for our legal department. This caused the actual project start to be significantly delayed.

Currently, there is one report template for final reports and interim reports, but for the latter it is impossible to fill out the last few sections. In the future it would be good to either have a separate template for final reports and interim reports or have a single template accompanied by instructions that explain which sections can be ignored in interim reports. Also, the report template seems more appropriate for the more general ISIF grants than the APNIC Internet operations research grants. It could be beneficial to have a slightly modified template more specific to the nature of the APNIC Internet operations research grants.

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