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New members of the Editorial Board; TelSoc's first year; and Australia's hunger for networked data

Peter Gerrand
Managing Editor

- Summary: A welcome to this Journal's two new editors; congratulations to the Journal's publisher, TelSoc, on its first year of operation; and observations on the continuing hunger in Australia for networked data, of which Big Data (our major theme for this issue) will be an important future component.

New members of the Editorial Board

I am delighted to announce that Dr Marta Poblet and Dr Mark Gregory have agreed to join the multidisciplinary Editorial Board of this Journal; the other distinguished members are listed here. The most important role of members of of the Editorial Board is to help source timely, relevant and authoritative articles and themes for the Journal. The second important role lies in maintaining quality control of the Journal's contents through contributing to peer reviews, and in nominating other expert reviewers in their fields of expertise.

Dr Mark Gregory

Mark Gregory is a Senior Lecturer at RMIT University, where he has carried out research and teaching since 1992, after an earlier career as an Australian Army Officer. Mark has been a frequent contributor on telecommunications policy via columns in *The Conversation* (49 articles to date) and in *Technology Spectator* (over 50 articles to date), particularly on NBN policy, as well as having published more than 70 refereed papers on telecommunications engineering topics.

Mark has been active within Engineers Australia and he has been the lead organiser (General Chair) of the annual ATNAC conference in recent years. Mark was awarded an Australian Learning and Teaching Council Citation in 2009. And he has been a reviewer and author for this Journal.

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Dr Marta Poblet

Marta Poblet is an Associate Professor and Vice Chancellor's Senior Researcher at RMIT University. She is one of the co-founders of the Institute of Law and Technology at the Autonomous University of Barcelona and a past researcher at ICREA (Catalonia). She holds a Juris Doctorate and a Masters degree in International Legal Studies from Stanford University. Marta's research interests include law and conflict resolution, mobile technologies for development, and crowd sourced crisis mapping. She has published over 40 articles on these topics in international journals and books.

And yes, she is also a past author and reviewer for this Journal, and is the lead Guest Editor for our December issue, on the theme of telecommunications in disaster management.

TelSoc's first year

A rejuvenated TelSoc was established on 8 July 2013 to replace the Telecommunications Society of Australia (see the evolution of our 140-year history here), with the mission 'to promote knowledge, understanding and excellence in telecommunications and its applications including the digital economy'.

How has it fared so far? The following items from its Directors' Report 2013-14 illustrate the impressive range of activities organized by this grassroots society of enthusiastic volunteers:

- Over 25 local and national lecture events held in Melbourne, Sydney and Adelaide, where the great majority of our members are located. (*We are always looking for volunteers to help convene lectures in the other capital cities.*)
- The establishment of this new journal, the *Australian Journal for Telecommunications and the Digital Economy*, a peer reviewed, multidisciplinary journal with emphasis on contributions to communications policy, user experience, new technology and regulatory developments, and to the history of the industry. A total of 42 articles on important themes were published during TelSoc's first year. (*This October 2014 issue adds 13 more.*)
- The awarding of two Charles Todd Medals in 2013, to Michael Malone and Mike Quigley, the founding CEO's of iiNet and NBN Co respectively, for their outstanding contributions to telecommunications.

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- Holding the Charles Todd Oration in Sydney in October 2013, with Michael Malone as Orator; and the inaugural Henry Sutton Oration in Melbourne in May 2014, with veteran ABC science journalist Robin Williams as Orator.
- The establishment of a very fruitful collaboration with ITWire whereby TelSoc members receive free delivery of daily CommsWire daily newsletters and weekly summaries.

The Society's first Annual General Meeting takes place in Melbourne on 28 October, with five of the seven founding directors renominating, and three talented members of the industry putting themselves up for the new Board: Tristan Gutsche, Gary McLaren and Adam Redman.

To motivate attendance beyond the most stalwart of our supporters, Bob James and Gary McLaren will be providing what should be an entertaining as well as informative debate on 'The NBN Today - back on track, or could a new path emerge?'.

Our hunger for networked data

On 7 October the Australian Bureau of Statistics (ABS) announced that Australia had downloaded over one Exabyte (that's 10^{18} bytes) of data in the three months to June this year. It consisted of 996,160 terabytes via fixed broadband accesses, plus 38,734 terabytes via mobile devices. This result was remarkable for at least two reasons.

Firstly, the data downloaded by fixed-line broadband access accounted for 97% of all Internet downloads in those three months; mobile wireless accounted for less than 3%, even though this had grown by a respectable 20% pa. The contrasts between these results justifies NBN Co's ongoing policy in rolling out fixed line access technologies rather than relying on cellular wireless to meet the great majority of user demand.

And it also shows the canniness of Telstra's plan to roll out 2 million WiFi hotspots nationally over the next five years. Each hotspot will be fed by fixed line broadband – free to Telstra customers, but at a charge to non-Telstra customers – thus reducing congestion on Telstra's cellular networks, and delivering high speed data to customers via the cheaper-per-MB optical fibre networks that feed the hotspots.

Secondly the overall volume in April-June 2014 had increased by 51% compared to the same period one year before. Correcting for a national population growth of 1.7% over this period slims this increase down a tiny bit to a per capita increase of 48% in average downloaded data. We're still experiencing huge annual growth.

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The historical data on broadband usage since 2008 (i.e. since the Global Financial Crisis) shows clear exponential growth, year on year. A 48% annual increase compounds to a gigantic 50-fold increase over ten years. This suggests that those of us needing only a typical 12 Mbps for peak download usage now will require typically 600 Mbps for peak download usage in ten years' time, unless the pattern of data usage around the clock changes drastically.

The additional impact of 'Big Data'

Furthermore the much anticipated 'Internet of Things' is beginning to generate vast amounts of data which will impact on our national data networks in very challenging ways. The Square Kilometre Array radio telescope, the SIRCA Sense-T agricultural data trial in Tasmania, and emerging vehicle-to-vehicle communications are early examples. Big Data (the major theme of this edition of the Journal) is already here and growing fast. Connections to businesses and consumer premises will not be exempt.

Because of the likely impact of Big Data, the projections for data uploads and downloads during the decade of the NBN rollout will need to be lifted even higher.

How well are our networks delivering on the capability to handle our exponentially growing data streams?

The best news is that Australia's mobile network infrastructure is in good shape: the OECD's most recent comparative statistics show Australia as second only to Finland in the number of wireless broadband subscriptions at December 2013 (OECD 2014). One observes that the three major carriers (Telstra, Optus and Vodafone) are continuing to invest in new 4G infrastructure to maximize their cellular footprints. But as we have seen from the ABS figures (2014), the wireless networks only account for some 3% of the total downloaded data.

The news is not quite so good on fixed line capacity. Australia penetration per capita of fixed line broadband connections at December 2013 was only 26%, placing us at 21st in the OECD list, compared to New Zealand (15th) with 30% and the world leader Switzerland's impressive 45% penetration. (The Netherlands and Denmark were placed 2nd and 3rd with c. 40% each.) We can be tempted to blame our 'tyranny of distance' as a handicap, but Canada, similarly challenged geographically, had reached 33.5% by last December.

And against the continuing evidence of exponentially growing data usage, Australia is falling further behind other countries in average broadband download speeds (at 15.53 average Mbps, we are now 57th of 193 countries according to OOKLA on 13 October).

The need to keep accelerating the rollout of the NBN's high speed connections must remain a high national priority.

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The Bureau of Communications Research – Q & A with Dr Paul Paterson

Dr Paul Paterson was recently appointed as Chief Economist of the Commonwealth Department of Communications and Head of the new Australian Bureau of Communications Research. He brings more than 25 years' experience in advisory, regulatory, programme delivery, senior policy and research positions in the private and public sectors both in Australia and overseas to this role. He holds a PhD and Master of Economics from the Australian National University and a Bachelor of Agricultural Economics (First Class Honours), from the University of New England. He has a strong knowledge base in the telecommunications, media and postal sectors and, in particular, advising on issues such as fixed and mobile broadband network investment, access regulation, USO policy, media content rights and telecoms-media convergence.

Dr Paterson is currently finalising his role as a tribunal member of the NSW Government's Independent Pricing and Regulatory Tribunal (IPART). His past roles include a term as an independent advisor on the IT Start-ups Advisory Board and numerous research assignments, and, in his quieter moments, he has run his own consultancy practice.

He recently answered some questions from The Australian Journal of Telecommunications and the Digital Economy (ajTDE) about the Bureau, its work and his view of the future.

ajTDE: What is the purpose of the Bureau of Communications Research (BCR) and how has it been set up?

PP: The Bureau of Communications Research was established within the Commonwealth Department of Communications on 1 September 2014 as a progressive advocate for fact-based research and policy in the online world. The launch of the Bureau will help to inform both policy development and public debate and is a key strategic step for the Department in valuing a stronger knowledge base, and an exciting addition to the communication sector. As the Head of the Bureau, and Chief Economist within the Department, I am supported by 20 highly effective staff with a wealth of skills and experience in working across the telecommunications, media, post and IT-based applications sectors.

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Specifically, the Bureau:

- has been established to publish authoritative, easy-to-digest research and analysis to inform policy development
- will support the Department's role as the advisor on communications policy
- has established work stream priorities in economics, market analysis, data and statistics, and economics communication, and
- will build its reputation for providing robust, independent, expert economic and technological research.

ajTDE: What attracted you to this role, and what experience do you bring to the BCR?

PP*:* Along with a PhD in Economics and extensive experience in senior policy and research management positions in both the public and private sectors, I have a strong knowledge base in the telecommunications, media, post and IT-based applications sectors. My past experience also includes advising on issues such as fixed and mobile broadband, network investment, access regulation, USO policy, media content rights and telecoms-media convergence.

This role offers a unique opportunity to share that knowledge and experience and join a Department which is dedicated to the advancement of an innovative and competitive communication sector through fact-based policy advice to the government.

ajTDE: What plans do you have for the BCR over the coming year?

PP*:* This initial establishment phase involves me, as Head of the Bureau, engaging with stakeholders across government, industry and the research community to understand their issues and priorities and opportunities for partnering. While staff are already working on a number of important internal projects with the policy areas across the Department, I am developing the overarching framework and rationale for our research program and agenda to guide the forward work program of the Bureau.

I expect that the work of the Bureau will be a mix of shorter-term projects that are built around a program of longer term research initiatives. Projects will be relevant to the issues and priorities identified, and will be undertaken in consultation with the Department's policy areas, the Minister and wider stakeholders. The Bureau will be publishing some material externally, while other work will feed into initiatives already underway within the Department.

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ajTDE: What are your preliminary ideas on the key issues the BCR might address in its first 12 months and longer term?

PP: The communications, digital technology, media and post sector is central to our overall economic competitiveness and productivity. The sector is future-focused and intrinsic to the performance of other sectors across the economy from agriculture to financial services.

Within the sector we are familiar with the digital revolution but we need to do more work to set out how this is shaping our economy, undertake research to ensure that this is as productive and economically efficient as possible and identify the barriers to future growth and competition. I am expecting that the Bureau's research program in its first year will be working across the following layers of investigation:

- Understanding the fundamental role of ICT in economy-wide productivity growth—that warrants the same intense level of attention/priority as financial and labour market reform
- Cataloguing the likely sources of inefficiency in ICT markets—recognising that these are likely to be different to those traditionally addressed due to ICT convergence and the deep interconnectedness of the ICT sector with all economic (and social) activity
- Identifying the top-priorities for reform in telecoms, media, post, computing and applications markets—to enable these markets to operate as efficiently as possible
- Establishing and pursuing the BCR's research, market analysis and database program—for the immediate and longer term.

Along the way the activities we are planning include leading indicators, comparative policy studies, market design issues and snapshots into new data and research that will put the Bureau on the map, so-to-speak.

ajTDE: As Chief Economist and Head of the Bureau, what do you see will be the main challenges to delivering in this area?

PP: I am conscious that as a 'digital born' research team, we are well placed to see such things as the growth of big data and the Internet of Things in a larger field which is always seeking to be at the forefront of innovation. A key challenge for the Bureau, as a small team, is to balance the competing priorities, focus on adding value and, above all, be relevant and influential. The Bureau is developing strategies to overcome these challenges so we can thereby support the Department's policy leadership role, build stronger stakeholder relationships and stimulate informed discussion on policy and regulatory issues. It's a very exciting time.

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Data Storage Energy Efficiency in the Zettabyte Era

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Summary: Data storage has become an increasingly significant issue with the widespread availability of cheap storage technology and the development of global data centres for cloud storage. This paper reports on a study of energy consumption for data storage in data centres. Unlike previous estimates, which have been extrapolations of broad energy usage within the data centre, we take a bottom-up approach. Firstly, we describe the technologies that can be used for data storage. Then we build up a model of energy consumption in data centres based on tiers of data storage.

Based on published forecasts of data storage growth and assumptions about improving energy efficiency in technology and data centres, we then estimate the energy consumption for data storage in data centres in 2020. We show that energy consumption will rise substantially if a "business as usual" approach is adopted. We further show that the growth in energy consumption can be mitigated somewhat by adopting a more aggressive policy of data archiving on long-term, low-energy, "cold" storage; or more ideally purging data of little or no future value. This, however, would require a change in the popular assumption that data will be available readily online and forever.

Introduction

The popularity of cloud computing, the development of 'big data' analysis and the Internet of Things have led to an explosion in the generation and storage of data. In 2010, the world entered an era in which the amount of data stored in the digital universe, global data stored on all devices, exceeded 1 zettabyte (that is, $1x10^{21}$ bytes) (IDC 2011a). Subsequent analysis by IDC (2014a) has estimated that the amount of data stored surpassed 4.4 zettabytes (ZB) in 2013. For the future, estimates vary but all predictions are for rapid and exponential

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growth in storage. IDC foresees the digital universe increasing by ten times between 2013 and 2020, with a predicted 44 ZB of data stored by 2020.

Another paper in this issue (Zwolenski 2014) describes what is driving this remarkable growth in data storage. Our concern here is with the technologies used to provide data storage and their likely evolution that could limit the amount of energy required for storage. We expect that, even with an optimal mix of technologies, total use-phase energy for storage will continue its inexorable rise given the ever-increasing demand. Better data handling can go some way to mitigating the increase in demand, which is the subject of a third paper (Lambrechts 2014) in this issue.

The rise of large, modern data centres has been generally beneficial for energy efficiency. For enterprises, relatively small and inefficient data centres can be replaced by very large, shared data centres. In the consumer market, the growth in end-user personal storage is slowing and one can envisage that most end-user storage in the future will be in the cloud (Gartner 2012). It is estimated (Seagate 2014a), for example, that in 2010 62% of data storage products were destined for end-user devices, while the prediction for 2020 is that 61% of data storage will, by contrast, be delivered via cloud applications.

Very large data centres can concentrate the effort to drive greater energy efficiency. Such efforts will, however, be limited by the technologies available for storage. This paper is concerned with the storage technologies, their use-phase energy consumption, and their likely evolution. We first outline the available storage technologies and describe their energy use. We then consider the future mix of technologies that could be used to provide a more energy-efficient future for data storage. We show, however, that even with a judicious mix of technologies for online and offline (or cold high latency) storage, total energy use will continue to rise rapidly if the demand for storage continues as predicted. We conclude with some remarks about sustainability of storage solutions into the future.

Storage Technology

One reason that storage has become ubiquitous is that it is readily available and cheap. In the period from 1956 to 2005, the storage density of a hard disk drive increased by 50 million times (Walter 2005), a year-on-year increase of 43.6%. In 1956, an IBM 5 MB hard disk drive cost US$ 50,000 and weighed over 1000 Kg (Komorowski 2014) – see Figure 1.

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Figure 1: A 5MB IBM hard disk drive is loaded onto an aeroplane in 1956

Source: https://twitter.com/HistoricalPics/status/419449414533783552/photo/1, retrieved 28 July 2014

Today, a 3 TB hard disk drive costs about US$ 100, or about US$ 0.03 per GB. A graph of hard disk drive cost, plotted on a logarithmic scale in Figure 2, shows the "precipitous drop in prices that has occurred over the last 35 years of innovation and increasing storage demand" (Komorowski 2014).

Figure 2: A History of HDD Data Storage Costs
(reproduced with permission - Komorowski 2014)

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In this section, we describe the most common data storage technologies and outline their energy requirements.

Hard Disk Drives

Hard Disk Drives (HDDs) have been the mainstay of data storage for more than 50 years. A HDD includes spinning disk platters that are magnetically written to and read from via heads moving across the platter surfaces. HDDs have three key components requiring power – the spindle motor, the read/write head control and the device electronics (central processor, cache memory, input-output (IO) interface). Of these, the spindle motor consumes the largest amount of energy especially when spinning up from a stopped state. HDDs have a range of possible power states that include parking the head activity, stopping or slowing down the spindle motor, and ultimately shutting down the device electronics (no IO possible). Where a spindle motor has been turned off, it can take up to 10 seconds or more for the hard disk drive to resume normal operations.

HDD spindle speeds are typically 4,800, 5,400 or 7,200 revolutions per minute (RPM). To reduce rotational latency (time for the right information to spin around underneath the head), high performance enterprise hard disks often spin at 10,000 and sometimes 15,000 RPM. HDDs with lower spindle speeds and smaller platter sizes require less power to be drawn by the spindle motor. Reducing the HDD physical size from 3.5-inch (8.89 cm) format to 2.5-inch (6.35 cm) format can provide a 45% to 50% reduction in power usage for equivalent spindle speeds and performance, but cannot offer the same energy use per storage (in W/TB) and per physical equipment rack storage density.

Both Seagate and Western Digital have recently commercialised 6 TB 3.5-inch HDDs. Costing US$ 600 to US$ 800, they are currently 3 to 4 times more expensive per TB to purchase than 3 TB HDDs. Nonetheless, 6 TB HDDs do offer twice the data density and approximately half the W/TB of 3 TB units. The price of 6 TB drives will no doubt decline as manufacturing scale and demand increase.

The latest Western Digital (HGST 2013) 6 TB 3.5-inch HDD is the first commercial HDD that is hermetically sealed with helium, rather than air (Electronista 2013). The use of helium (being lighter than air) reduces internal turbulence caused by the spinning platters and, as a result, saves power and lowers the operating temperature. When configured with a SAS 6 Gb/s interface, it typically consumes 8.8 W (1.467 W/TB) when active at 7,200 RPM and 5.7 W (0.95 W/TB) when idle. As at June 2014, Amazon.com pricing is about AU$ 750 – or AU$ 125/TB.

Seagate's equivalent Enterprise 6 TB HDD (with a SAS 12 Gb/s interface) has a specified power consumption of typically 11.9 W (1.98 W/TB) when active at 7,200 RPM and 8 W

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(1.33 W/TB) at idle (Seagate 2014b). As at June 2014, Amazon.com pricing is about AU$ 725 – or AU$ 121/TB.

In August 2014 Seagate (Seagate 2014d) announced the commercialisation of the world's first 8 TB 3.5-inch HDD for high capacity enterprise and cloud storage applications. At the time of this article's publication, Seagate was yet to publish pricing and technical specifications, but it is assumed that the W/TB has continued to improve. By 2020, the data storage capacity of a 3.5-inch HDD is foreshadowed to be at least 20 TB (Merian 2013) for similar energy consumption as today's HDDs.

Solid State Drives

Solid State Drives (SSDs) have no moving parts and therefore generate no sound or vibration. They are comprised of an embedded processor (caching, encryption, data maintenance), non-volatile memory (e.g. flash memory), and IO interface.

SSDs are typically used in three different deployment configurations – as server installed cache, storage installed cache, and finally as an all-SSD storage array (i.e. no HDDs). Today, SSDs are commonly used for improving the analytics performance on big data sets where the processing of the data is constrained by IO throughput. The cost-optimal deployment configuration for using SSD to improve IO throughput will ultimately depend on the nature of the data analysis. Data that is being repeatedly read can be optimised with server-installed or storage-installed cache. For data sets that are sequentially (rather than recursively) being read, then all-SSD storage may be preferable.

SSD active state power consumption is typically 2 to 3 watts. Idle state (i.e. no IO) power is typically about 1 watt. With a low power consumption and no moving parts there is little heat generated by SSDs. Seagate 1200 SSD (Seagate 2014c) supporting 800 GB and SAS 12 Gb/s interface in a 2.5-inch form factor consumes 4.05 W (5.06 W/TB) when active and 3.0 W (3.75 W/TB) when idle. As at June 2014, Amazon.com pricing is AU$ 2,735 (or AU$ 3,418/TB – 27 times more expensive per TB than current generation 6 TB HDDs).

Despite the high cost per TB of SSD, it can offer energy reductions and overall cost savings when the delivery of frequently accessed files is a primary deployment requirement. See the EMC example shown in Figure 3.

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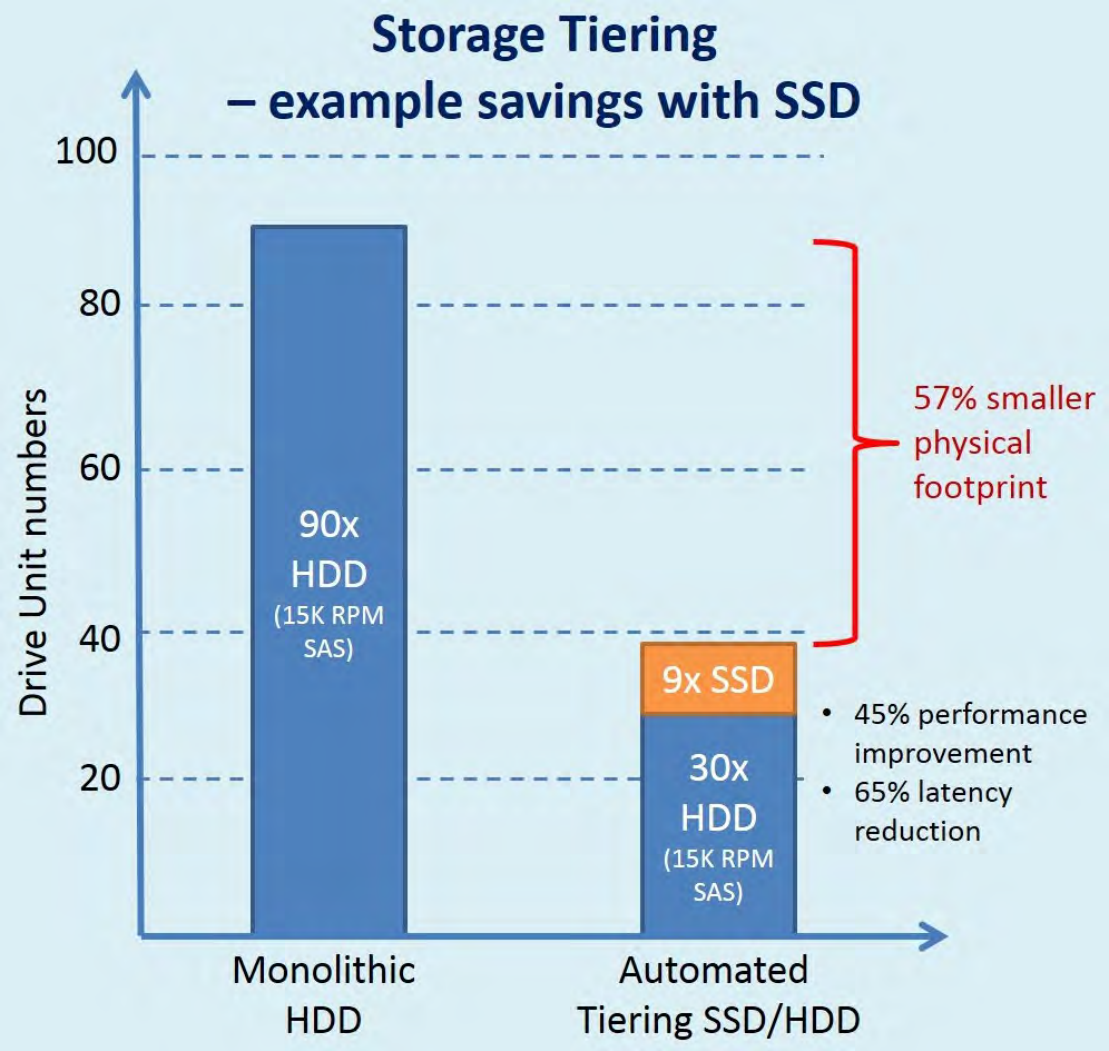

Figure 3: Example of SSD versus High-Performance HDD Performance Savings
(EMC 2012 – Figure 2)

Solid State Hybrid Drives

Solid State Hybrid Drives (SSHDs) are a relatively new category of data-storage device introduced by Seagate in 2011. They combine the data-density and low cost of the HDD with the performance of an SSD for little more than the cost of a regular HDD. For example, in a data-centre application an SSHD with 32 GB of solid state memory can offer three times the data-retrieval performance of a 15,000 RPM enterprise-grade HDD (Storage Review 2014). Industry testing has shown the Seagate Enterprise Turbo SSHD is currently the world's fastest HDD. As SSD pricing continues to decline, SSHD technology could be seen as an intermediate gap technology that will extend the life of the spinning hard disk until the price and storage density of SSD perhaps becomes attractive for all applications.

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Massive Array of Idle Disks

A Massive Array of Idle Disks (MAID) can be used for short-term storage and staging of backup and archive data. MAID is based on HDD storage arrays where inactive HDD units are "spun down" to a lower speed or stopped altogether. MAID-enabled storage arrays are suitable for data that needs to be accessed infrequently and can tolerate high latency of accessibility. Given up to 80% of the power drawn by a storage array is consumed by spinning HDD units, powering down inactive HDD units can substantially reduce system power and cooling costs, increase HDD deployment density (saving data-centre floor space), and also prolong the service lifetime of the HDDs. However, when data is requested from a stopped HDD unit, it can take tens of seconds for the HDD to spin up and be ready for access. This has been seen as a significant negative performance impact on MAID 1.0 systems; subsequently, MAID 2.0 has been specified, which implements additional power states that enable disks to be more quickly "spun up" from slower-spinning states to being fully operational. MAID is a standard defined by the Storage Networking Industry Association (SNIA).

For example, SGI reports (SGI 2010) that its COPAN enterprise MAID storage has a maximum of 25% of HDDs powered at any one time and is therefore at least 75% more energy efficient than traditional, always-spinning HDD storage solutions. It also reports that the service life of the HDDs is extended by more than six times. Where there are industry concerns regarding HDD reliability (e.g. ability to reliably start up after long periods of inactivity), SGI array management software periodically exercises all disks to monitor and maximise HDD health and data storage reliability.

While MAID may extend the service lifetime of HDDs, warranty periods are currently 3 to 6 years and, as such, HDDs can only be considered a short-term (up to 6 years) archival storage solution before the data needs to be migrated to other storage media (or purged).

Magnetic Tape and Virtual Tape Libraries

Magnetic tape data storage is used for data backup and for medium-term (up to 30 years) data archiving. The dominant formats today are LTO (Linear-Tape-Open) and Super-DLT (Digital Linear Tape), which use tape cartridges and auto-loaders to form a large volume tape library. Magnetic tape can experience problems with media degradation (e.g. due to tape spooling) and tape media management (e.g. lost tapes, incomplete backups). There are just two predominant tape manufacturers remaining today, Fujifilm and Sony.

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The magnetic tapes themselves use no power when stored in an archive, although there is a small amount of continuing energy use by the tape libraries and systems used for archiving and retrieval. Power is only used, if ever, to retrieve data or to re-write on the tape.

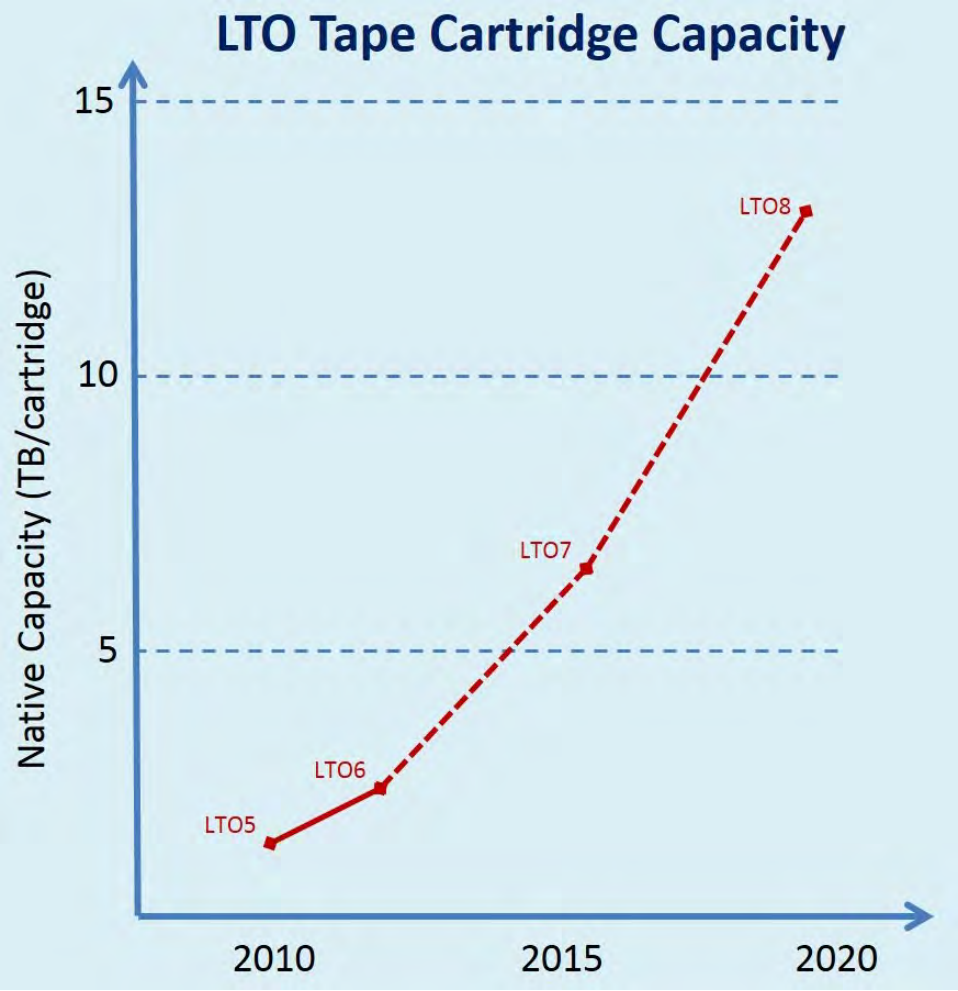

Figure 4: Magnetic Tape Cartridge Capacity Trends
(IDC 2014b)

Rather than using physical tape cartridges, there is some industry move towards Virtual Tape Libraries (VTLs) using HDD storage arrays or as a cloud service. A VTL cloud service simply emulates the physical tape drive functions across a network and can potentially connect to backup and archiving applications provided as cloud storage services. This is an effective means of providing higher performing backup capabilities that shorten data backup processes. While VTLs can be considered a good short-term (up to 5 years) backup solution, they are not able to provide long-term reliable and cost effective archival storage due to the risk of drive motor failure and the difficulties of warehousing the media outside of the data centre.

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Optical Disk

Optical disk technologies provide a means to archive data that is infrequently accessed (e.g. in years, if at all) and needing a long lifespan (e.g. 50 to 1,000 years!). Optical storage media is more durable than tape (which needs to be spooled backwards and forwards) and offers greater read performance for the retrieval of individual files. Similar to tape, its relatively low density, portable media format is reliant on robotic, automated media retrieval systems to store large volumes of data and to retrieve it when required. When stored in an archive, optical disks require no power. If the disk is required for reading, power is then consumed as part of the retrieval, reading and replacement in the archive.

Large-scale automated disk retrieval systems are still in development. Most recently, Facebook has developed an open source prototype optical disk storage solution (Broadkin 2014), which uses more than 10,000 100-GB Blu-ray disks to store a petabyte of archival data. This prototype is estimated to be 50% cheaper than HDD archival storage and 80% more energy efficient.

Latest generation BD-XL Blu-ray media is able to store up to 128 GB of data in 4 optical layers on a 120 mm diameter disk (StorageNewsletter 2014a). A higher density format of 300 GB is due to be available in 2015 and 500 GB and 1 TB formats are under development. Compared to current generation magnetic tape, optical disks are lower in physical data density but do offer much greater archival longevity. It is expected that optical disk technology will eventually supersede magnetic tape as the preferred archival data storage media.

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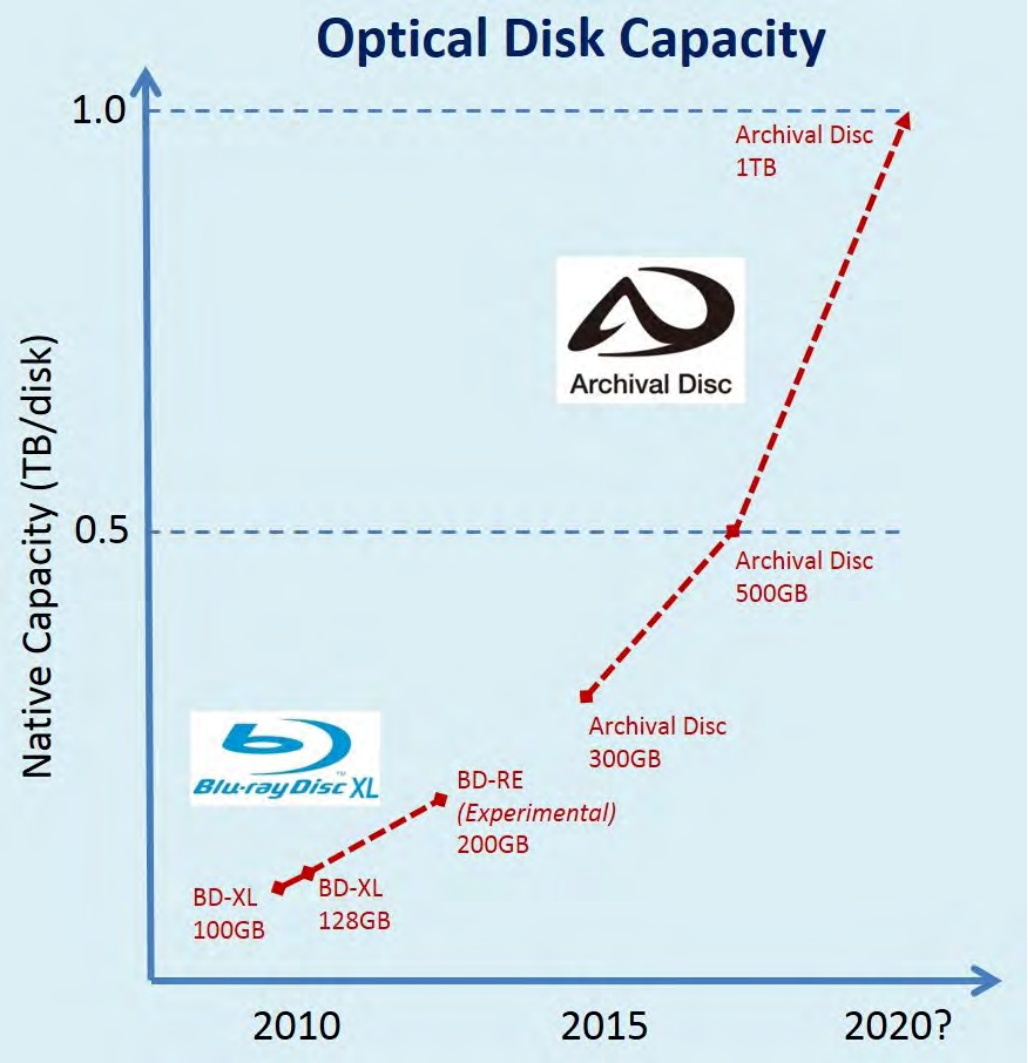

Figure 5: Optical Disk Capacity and Technology Trends
(Storage Newsletter 2014a)

Technology Summary

HDDs will remain the most cost effective, reliable and highest density means to store large volumes of online and near online data for the period to 2020. SSDs, while offering both performance and energy saving benefits (in terms of bytes delivered), will likely remain expensive when compared to HDDs. Beyond 2020, it is possible SSD acquisition costs will approach (but not necessarily be less than) those of HDDs, justifying their general purpose deployment with benefits in performance, physical data density and energy saving.

Storage Tiers

The deployment of storage tiers recognises that the need for data availability depends on the data itself and changes over time. Some data must be immediately available; much active data must be stored where it can be retrieved in milliseconds; and archival data may only require retrieval in days or weeks. Data is often perceived as migrating over time from

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immediate availability (in tier 0 or tier 1) through intermediate availability (tiers 2, 3 etc.) to archival storage (tier 4). There are a number of definitions of storage tiers (Latamore 2012).

For the purpose of describing energy consumption, we define six tiers of data storage, as follows:

Tier 0. Implemented using SSD, this tier is used for data required near 'instantaneously'. This may be data in a cache or data replicated for on-demand and multi-stream availability.

Tier 1. Implemented using high-performance HDD or SSHD, this tier is also for data required with low latency. The data is most likely cached or replicated from a main data store or may be intermediate storage in an online process.

Tier 2. Implemented using high-capacity HDD, this is where most online business or process data resides. This data is readily available but with higher latency than the lower-numbered, higher performing tiers 0 and 1.

Tier 3. This tier is implemented using MAID or other near-online HDD technologies. The data can be retrieved and made available online but with greater latency of seconds to tens of seconds. Data in this tier has mostly aged and is less likely to be required for day-to-day operations. HDD MAID provides good backup and is an intermediate step towards long-term archive. It is not a replacement for removable media (cannot be moved out of the data centre) and not a medium that is reliable beyond the short term (i.e. the 5 to 6 year lifetime of a HDD).

Tier 4. This tier is implemented in removable media such as tape or optical disk. It can be retrieved in minutes or longer, either by robotic systems or human intervention. The data is essentially offline until it is required.

Tier 5. This tier is implemented in tape or optical disk. The media have been removed to long-term storage and are not immediately retrievable, but are available as an archive from a warehouse outside of the data centre. Retrieval may take days or weeks.

These tiers are depicted in Figure 6, where it is also noted that:

- The cost of storage increases as one proceeds to lower-numbered (more immediate) tiers;
- Data lifetime and retrieval times increase with the tier number;
- The energy efficiency of the storage technologies generally increases with tier number.

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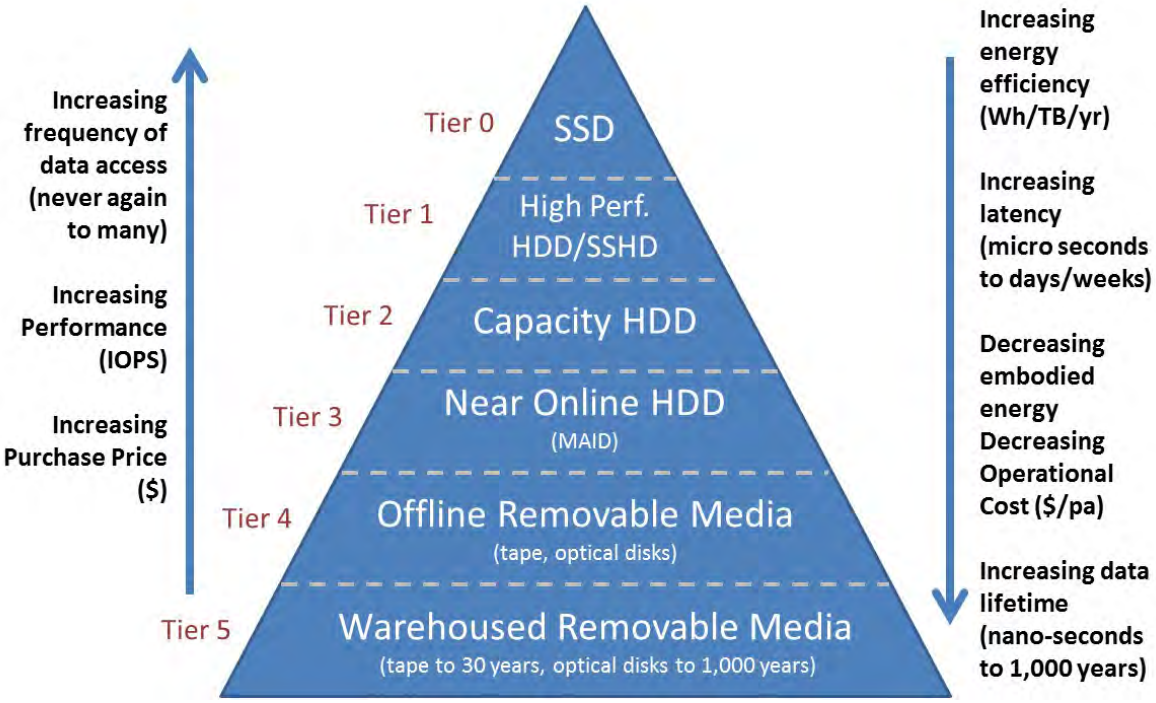

Figure 6: Data Storage Hierarchy

In addition to the storage technology itself, a data centre requires other features, such as a storage system array and associated management processes to catalogue and tag the data. In **Error! Reference source not found.**, which summarises this study's estimated energy efficiency of the various data storage tiers, an overhead of 20% of the storage energy has been included to account for these system array and data management overheads.

Table 1: Average Energy Efficiency of Data Storage Tiers for this Study

Tier	2013	2020
	Average Energy Efficiency (W/TB)	Average Energy Efficiency (W/TB)
0. SSD	3.0	1.0
1. Hi-performance HDD	15.0	2.0
2. Capacity HDD	12.8	2.7
3. MAID HDD	3.2	0.2
4. Removable	0.1	0.01

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Energy Consumption 2013 to 2020

There has been little study and detailed modelling to date of data storage energy consumption in global data centres (GDCs). Data centre studies, such as Koomey (2011) and more recently Van Heddeghem (2014), have used a top-down approach using IDC estimated physical server volumes and data centre Power Usage Effectiveness (PUE – the ratio of total data centre power to total ICT equipment power) metrics to calculate total GDC energy use. Koomey (2011) acknowledges that data storage, and network, "are treated at a very high level". Challenges with further extrapolating Koomey include the continued move of physical compute capacity to virtualised compute capacity. While more applications may be running on the same physical server, there will nonetheless be a greater number of disparate and potentially large data sets not directly aligned with physical server counts or types.

Data centre energy consumption forecasting for the GeSI Smarter 2020 study (GeSI 2012) has used Koomey (2011) as the basis for its 2011 baseline and forecast for 2020. As such, future forecasts of data storage energy consumption have followed the growth in overall data centre energy consumption (or vice versa). While this might be achievable (and desirable), the exponential data universe growth described in EMC (2014) would suggest the future mix of data storage technologies will need to change substantially to include a much larger proportion of offline "cold" data storage (i.e. tape, optical disk and MAID), in order to avoid significant increases in global data centre energy requirements. A key element of this study is the modelling of GDC data storage capacity in isolation from overall compute capacity growth.

Rather than repeating the top-down approaches, we have worked bottom up, based on the following forecasts:

- The forecast of the total size of the digital universe (IDC 2014a);
- The proportion of this data residing in data centres based on forecast shipped HDD capacity (Seagate 2014a); and
- A varying proportion of data storage technology types within each tier – in particular the capacity tiers 2 (HDD), 3 (MAID), and 4 (magnetic tape, optical disk).

Our analysis starts by establishing a credible 2013 baseline based on the following assumptions:

- Approximately 40% (Seagate 2014a) of the 4.4 ZB Digital Universe was stored in data centres in 2013;
- 1% of all data centre data storage is SSD;
- 5% of data centre data storage is high-performance HDD;

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- 64% of data centre data is stored on capacity HDDs of under 6 TB per unit, but predominantly 2 TB or less;
- 0% (or insignificantly little) of all data in data centres is stored on MAID HDD;
- 30% of all data stored in data centres is stored on removable media (i.e. largely tape);
- An average PUE of 1.65 in 2013 (Uptime 2013) and estimated average PUE of 1.38 in 2020 based on a -2.5% CAGR (GeSI 2012);
- All data forecast in the 2020 Digital Universe is preserved – i.e. no purging.

From the 2013 baseline, five future 2020 scenarios were developed to test outcomes dependent on the growth of data in the data centre and the data storage technology mix across tiers. The scenarios are described in Table 2.

Table 2: Description of 5 Potential Scenarios for 2020

Scenario	Description	Global Data Centres	
		Proportion of Digital Universe in 2020 (%)	**Data Centre Storage Growth 2013-2020**
1. "Business as usual (BAU) Continues"	Data centre data storage capacity grows in proportion with overall data growth (i.e. percentage of the digital universe in the data centre does not change). Distribution across technology tiers does not change, excepting some foreshadowed increase in the use of MAID for near-online data storage and backup.	40%	1000%
2. "GeSI 20x"	Data storage within the data centre grows 20 fold between 2011 and 2020 (GeSI 2012) - i.e. ~818% between 2013 and 2020. Distribution across technology tiers does not change, excepting some foreshadowed increase in the use of MAID for near-online data storage and backup.	33%	818%
3. "BAU 60%"	Distribution across technology tiers does not change, excepting some foreshadowed increase in the use of MAID for near-online data storage and backup.	60%	1500%
4. "Improved"	Distribution across technology tiers increases [i] near online (tier 3) data-storage to 20%, and [ii] offline (tier 4) data storage to 40%, of total data centre data storage capacity.		
5. "Best Likely"	Distribution across technology tiers increases [i] near online (tier 3) data-storage to 22%, and [ii] offline (tier 4) data storage to 50%, of total data centre data storage capacity.		

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Scenarios with lower growth of data centre storage

In the first two scenarios, the data storage capacity of data centres grows at the same rate, or less than, the growth of the digital universe overall.

"BAU Continues" Scenario 1: With GDC data storage capacity growing in line with the overall growth in the digital universe, but still at 40% of the forecast total, total GDC storage power consumption grows from an estimated 15.8 GW in 2013 to 26.8 GW in 2020, an increase of 11.0 GW (or about 11 nuclear power stations): in other words, a 70% increase in power for a 1000% increase in data stored. Compared to the GDC power consumption forecast in the GeSI Smarter 2020 (GeSI 2012) study, data storage power consumption would then be 49% of forecast total GDC power (480 TWh p.a.) and 68% of forecast GDC ICT infrastructure power.

"GeSI 20x" Scenario 2: In this scenario, data storage in data centres grows 20-fold from 2011 to 2020: from an estimated 0.27 ZB of data in data centres in 2011 (40% of 1.8 ZB – IDC 2011b), through 1.76 ZB in 2013, to 14.4 ZB in 2020. For the period from 2013 to 2020, a further 818% GDC data storage growth would occur, lagging the overall growth (1000%) of the digital universe. We estimate that the percentage of the digital universe in GDCs would decline in percentage terms from 40% to 33% of all data. Compared to the GDC power consumption forecast in the GeSI Smarter 2020 (GeSI 2012) study, data storage power consumption would then be 40% of forecast total GDC power and 58% of forecast GDC ICT infrastructure power. This scenario may come about if data remains highly distributed and the take-up of cloud-based services abates.

We have not estimated the power required to store the data outside data centres. If much of this data were held in offline storage or, indeed, the distribution of data led to an eventual natural attrition of low-value data (through lack of technology migration, reliable backup and no redundancy), then this scenario may be desirable from an energy perspective.

Scenarios with higher growth of data centre storage

Scenarios 3 to 5 all assume GDC data storage growth from 40% of the 2013 digital universe to 60% of the 2020 digital universe. As shown in Figure 7, scenario to scenario we have estimated that there would be a growing proportion of data stored on near-idle (Tier 3 MAID) or idle (Tier 4 removable) storage.

Estimated data storage power is then calculated and compared for each scenario, as shown in Figure 8.

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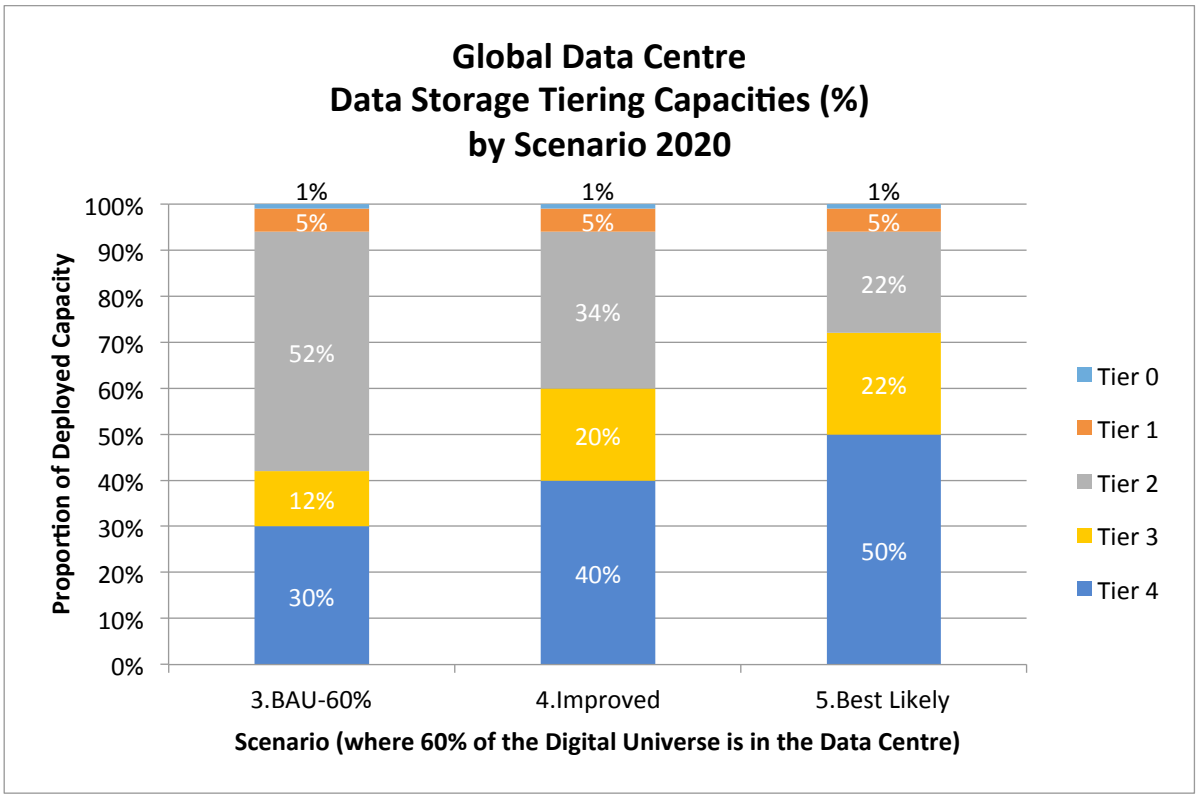

Figure 7: Global Data Centre Data Storage Tiering Capacities by Scenario 2020

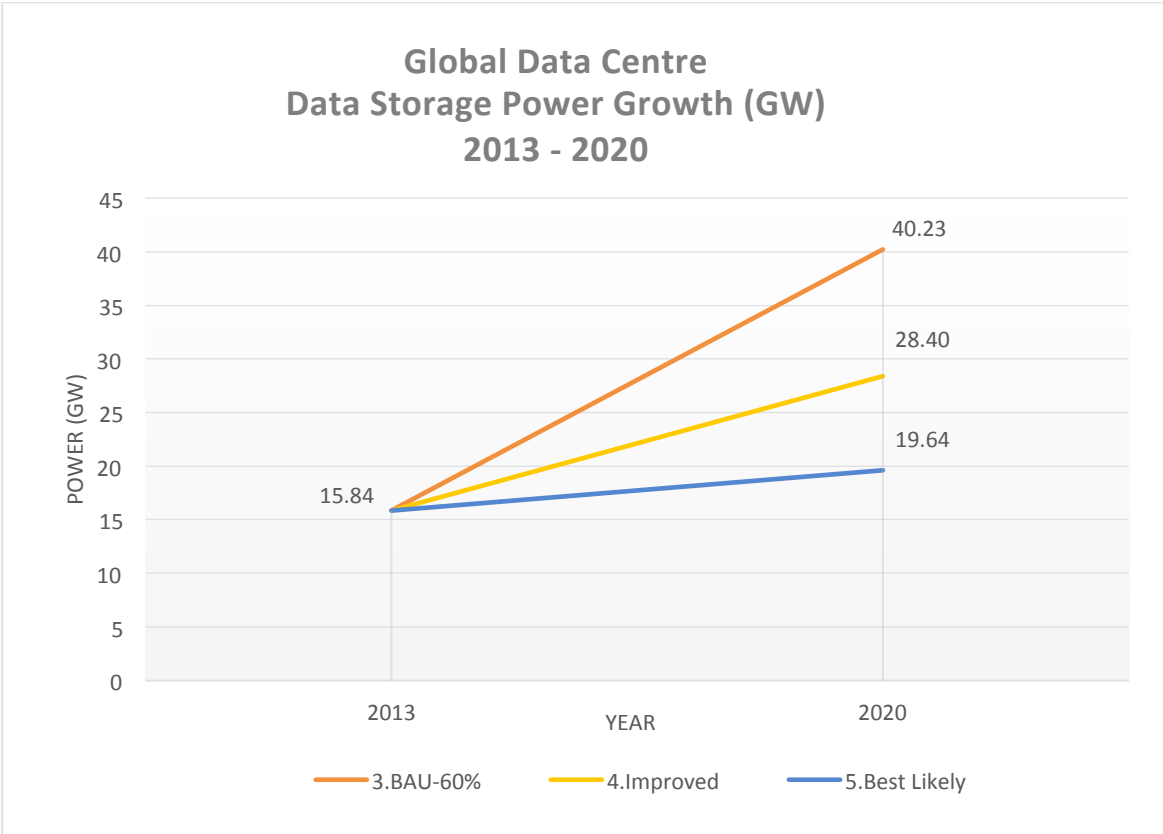

Figure 8: Global Data Centre Data Storage Power Growth by Scenario 2013-2020

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"BAU-60%" Scenario 3: With GDC data storage capacity growing up to 60% of the digital universe and the proportion of data stored on idle media unchanged from 2013, total GDC data storage power consumption grows from an estimated 15.8 GW in 2013 to 40.2 GW in 2020, an increase of 24.4 GW: in other words, a 154% increase in power for a 1500% increase in data stored. Compared to the GDC power consumption forecast in the GeSI Smarter 2020 (GeSI 2012) study, data storage power consumption would then be an unrealistic 73.4% of forecast total GDC power (480 TWh p.a.) and 106.6% of forecast ICT infrastructure power. Under this scenario, GeSI Smarter 2020 GDC power estimates would need to be revised substantially upwards.

"Improved" Scenario 4: With GDC data storage capacity growing up to 60% of the digital universe and 60% (20% MAID, 40% Removable) of GDC data stored on idle media, total GDC data storage power consumption grows from an estimated 15.8 GW in 2013 to 28.4 GW in 2020, an increase of 12.6 GW. This would represent a more modest 79% increase in power for the same 1500% increase in data stored. Compared with the GeSI Smarter 2020 (GeSI 2012) study, data storage power consumption would then be 51.8% of forecast total GDC power and 75.3% of forecast ICT infrastructure power. Under this more archive-focussed scenario, GeSI Smarter 2020 GDC power estimates are still expected to be a challenging target and will in all likelihood be exceeded.

"Best Likely" Scenario 5: With GDC data storage capacity growing up to 60% of the digital universe and 72% (22% MAID, 50% Removable) of GDC data stored on idle media, total GDC data storage power consumption grows from an estimated 15.8 GW in 2013 to 19.6 GW in 2020, an increase of 3.8 GW. This 24% increase in power for a 1500% increase in data stored assumes much of the generated data quickly loses its value and is rarely (if ever again) required after a short period of time. Compared with the GeSI Smarter 2020 (GeSI 2012) study, data storage power consumption would then be 35.8% of forecast total GDC power (480 TWh p.a.) and 52.1% of forecast ICT infrastructure power. Under this scenario, which strongly emphasises data archiving, GeSI Smarter 2020 GDC power estimates can be achieved, assuming also that ongoing improvements in compute and network infrastructure energy efficiency will occur. With more data on idle storage, the data management overhead, which itself requires compute and network resources, should also be reduced.

Conclusion

We have shown in this paper that there is *some* hope for containing the growth in use-phase energy required for data storage in data centres. Our calculations suggest that a "business as

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usual" approach would lead to growth in energy use for data storage in data centres of 79% in the face of a tenfold growth (1000%) in total data storage and a continuing growth in cloud storage. On the other hand, if more aggressive data archiving to offline storage were to be implemented, data centre energy for data storage would grow by only 24%. While this is beneficial, it still means that energy use is increasing rapidly, which will eventually be unsustainable.

All these estimates are, of course, hedged about with uncertainty. We have taken as our baseline the IDC estimate (IDC 2014a) for growth of the "digital universe" to 2020. Taking a bottom-up approach to the technology used for storage in data centres, we have been able to compare our calculated energy use with the top-down figures from the GeSI Smarter 2020 (GeSI 2012) study. The comparison suggests that the energy growth forecast by GeSI is achievable, but only if significant volumes of data is moved to offline "cold" storage. The common assumption that all useful data will be available instantly online for all time is not sustainable nor realistically achievable.

Our figures, too, are in some ways optimistic. Not all data will be held in energy-optimised data centres. Even in 2020, it is likely (Seagate 2014a) that about 40% of data storage will be outside data centres. This storage will be a mix of old and new technologies embedded in consumer electronics, for example, and will unnecessarily consume significant amounts of energy. Further work is required to determine the best trade-off between energy use for storage (in data centres and elsewhere), for computing and for communications. It is likely that the best mix will be service-dependent.

As is described elsewhere (Lambrechts 2014), good information lifecycle management practices can mitigate the need for ever greater data storage; especially when data is purged at the end of its useful lifecycle. For the data that remains in storage, there needs to be a clear division between that which should be available online and that which could be stored in long-term, less accessible cold storage. Essentially, there has to be a realisation that online data storage comes with a significant, ongoing cost: a trade-off between energy use and immediacy of access needs to be made.

It should be noted, too, that we have considered only use-phase energy. There is, in addition, significant energy used in the manufacture, shipping and disposal of storage equipment – the so-called embodied energy. Fortunately, the smaller footprint of future storage technologies suggests that the embodied energy per byte may decrease. A full analysis of this issue would be a significant study in itself.

Ever increasing data storage remains a key issue for future IT and communications services. Barring some unknown and unlikely breakthrough technologies, it is essential that better

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data management practices, clear service-dependent judgement about the need for online storage, and judicious use of energy-efficient technologies are all used to provide a sustainable future for data storage.

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Glossary

BAU	Business as usual
CAGR	Compound Annual Growth Rate
EB	Exabyte (10^{18} bytes)
GDC	Global Data Centre
HDD	Hard Disk Drive
IO	Input-Output
MAID	Massive Array of Idle Disks
NAS	Network Attached Storage
PB	Petabyte (10^{15} bytes)
PUE	Power Usage Effectiveness
RAID	Redundant Array of Inexpensive Disks
RFID	Radio Frequency Identification
SAS	Serial Attached SCSI
SATA	Serial Advanced Technology Attachment
SCSI	Small Computer System Interface
SNIA	Storage Networking Industry Association
SSD	Solid State Drive
SSHD	Solid State Hybrid Drive
TB	Terabyte (10^{12} bytes)
VTL	Virtual Tape Library
W	Watt
WORO	Write Once, Read Occasionally
YB	Yottabyte (10^{24} bytes)
ZB	Zettabyte (10^{21} bytes)

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The collision between Big Data and privacy law

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Summary: We live in an age where billionaires are self-made on the back of the most intangible of assets – the information they have about us. The digital economy is awash with data. It's a new and endlessly re-useable raw material, increasingly left behind by ordinary people going about their lives online. Many information businesses proceed on the basis that raw data is up for grabs; if an entrepreneur is clever enough to find a new vein of it, they can feel entitled to tap it in any way they like. However, some tacit assumptions underpinning today's digital business models are naive. Conventional data protection laws, older than the Internet, limit how Personal Information is allowed to flow. These laws turn out to be surprisingly powerful in the face of 'Big Data' and the 'Internet of Things'. On the other hand, orthodox privacy management was not framed for new Personal Information being synthesised tomorrow from raw data collected today. This paper seeks to bridge a conceptual gap between data analytics and privacy, and sets out extended Privacy Principles to better deal with Big Data.

Introduction

'Big Data' is a broad term capturing the extraction of knowledge and insights from unstructured data. While data processing and analysis is as old as computing, the term 'Big Data' has recently attained special meaning, thanks to the vast rivers of raw data that course unseen through the digital economy, and the propensity for entrepreneurs to tap that resource for their own profit, or to build new analytic tools for enterprises. Big Data represents one of the biggest challenges to privacy and data protection society has seen. Never before has so much Personal Information been available so freely to so many.

Big Data promises vast benefits for a great many stakeholders (Michael & Miller 2013: 22-24) but the benefits may be jeopardized by the excesses of a few overly zealous businesses. Some online business models are propelled by a naive assumption that data in the 'public domain' is up for grabs. Many think the law has not kept pace with technology, but technologists often underestimate the strength of conventional data protection laws and regulations. In particular, technology neutral privacy principles are largely blind to the methods of collection, and barely distinguish between directly and indirectly collected data. As a consequence, the extraction of Personal Information from raw data constitutes an act of *collection* and as such is subject to longstanding privacy statutes. Privacy laws such as that of

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Australia don't even use the words 'public' and 'private' to qualify the data flows concerned (*Privacy Act* 1988).

On the other hand, orthodox privacy policies and static data usage agreements do not cater for the way Personal Information can be synthesised tomorrow from raw data collected today. Privacy management must evolve to become more dynamic, instead of being preoccupied with unwieldy policy documents and simplistic technical notices about cookies.

Thus the fit between Big Data and data privacy standards is complex and sometimes surprising. While existing laws are not to be underestimated, there is a need for data privacy principles to be extended, to help individuals remain abreast of what's being done with information about them, and to foster transparency regarding the new ways for personal information to be generated.

When online innovations cross the line

Personal Information is the lifeblood of most digital businesses today and yet consumers commonly find digital practices to be 'creepy' (Tene & Polonetsky 2013: 61-68). Individual reactions depend on experience and computer literacy but different proportions of people are disturbed by phenomena such as tailored advertising appearing in their browser soon after they've sent an email about the very subject of the ads, or by an online social network automatically naming people in photos, or an Internet map service displaying reservation details alongside a hotel when a user simply searches for that property. Subjective reactions are useful pointers to privacy transgressions, and yet 'intuitions and perceptions of "creepiness" are highly subjective and difficult to generalize as social norms are being strained by new technologies and capabilities' (Tene & Polonetsky 2013: 59). And so we need objective tests of privacy breaches in order to codify and enforce reasonable rights.

Consider 'Pay-as-You-Drive' car insurance, a new type of cover, with premiums scaled according to how you drive. By analysing data from automobile 'black boxes', an insurance company can tell not only how far the car has gone (so that infrequent drivers can enjoy discounted premiums) but can also detect how fast it has been going and in what neighbourhoods it has been parked. Higher risk driving behaviours can attract extra levies or other forms of disincentive. Across the whole community, these types of innovative products can bring shared benefits, with more precise risk management, fine-grained risk figures as compared with traditionally coarse actuarial data, lower prices for lower risk customers, and eventually, lower average costs for everyone.

GPS signals could be used to inform 'smart' car insurance offerings, yet explicit vehicle tracking arouses privacy fears. Therefore, some Pay-as-You-Drive systems promise not to use GPS, and instead draw only on seemingly more innocuous speed and time

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measurements. And yet, the privacy picture is not so simple, for there remain alternative and less obvious ways to work out where a driver is.

Recent research in the United States (Dewri et al 2013) has shown that vehicle speed and time measurements, when combined with map data, can be used to infer the location of a car at any time with just the same precision that GPS coordinates provide. Therefore 'customer privacy expectations in non-tracking telematics applications need to be reset and new policies need to be implemented to inform customers of possible risks' (Dewri et al 2013: 267).

It is not known if insurance companies are in fact exploiting automobile black box data in this way, but the temptations of Big Data prove time and time again to be irresistible. If time and speed data can be accessed by third parties and linked to maps or other data sets to extract insights about drivers, it may only be a matter of time before this routinely happens.

When businesses go too far with advanced data analytics and leave users feeling violated or betrayed, then everyone suffers. Disillusioned customers won't just abandon the firms that have squandered their trust; they will also lose confidence in cyberspace more broadly and withdraw from other new and worthwhile services. The society-wide promises in e-government and e-health programs will be compromised if the proportion of citizens participating in them is reduced for want of privacy (Wilson et al 2005: 11-16).

The Big Business of Big Data

It's not for nothing that people use the term 'data mining'. Raw data is often likened to crude oil (Singh 2013), meaning the riches to be extracted from an undifferentiated ore-like matrix spread across cyberspace, comparable to the ground beneath our feet explored by traditional prospectors.

Consider photo data, for instance, and the rapid evolution of tools for monetising it. Techniques for extracting value from images range from the simple metadata embedded in digital photos which record when, where and with what sort of camera they were taken, through to increasingly sophisticated pattern recognition and facial recognition algorithms (Sawant et al 2011). Image processing and image analysis can extract places and product names from photos and automatically pick out objects. Biometric facial recognition can identity faces by re-purposing biometric templates that originate from social network users tagging their friends for fun in entirely unrelated images. Therefore it has become entirely feasible for social media companies to work out what people are doing, when and where, and who they're doing it with, thus revealing personal preferences and relationships, without anyone explicitly 'liking' anything or 'friending' anyone.

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The ability to mine photo data defines a new digital gold rush. Like petroleum engineering, image analysis is very high tech. There is extraordinary R&D going on in face and object recognition. Information companies like Facebook and Google (whose fortunes are made on nothing other than information) and digital media companies like Apple have invested enormously in their own R&D, and also in acquiring start-ups in this space. For example Google acquired the cloud photo storage service Picasa in 2004 (for an unknown price); Facebook bought photo sharing network Instagram in 2012 for approximately US$1 billion; and in late 2013, instant photo messaging service Snapchat turned down an offer from Facebook for approximately US$3 billion. These extraordinary investment decisions are not explained merely by users having fun taking photos and tagging them, but rather by the potential for extracting monetisable intelligence from images.

So, more than data mining, Big Data is really about data *refining*: the transformation of unstructured facts and figures into fresh insights, decisions and value.

Business models for monetising photo data are still embryonic. Some entrepreneurs are beginning to access photo data from online social networks. For example 'Facedeals', a proof of concept from advertising invention lab Redpepper, provides automated check-in to retail stores by way of face recognition; the initial registration process draws on images and other profile information made available by Facebook (with the member's consent) over a public Application Programming Interface (API see http://redpepperland.com/lab/details/check-in-with-your-face). It is not clear if Facedeals accesses the online social network's actual biometric templates, but nothing in Facebook's privacy and data use policies restrains the company from providing or selling the templates (Facebook: 2014). But as we shall see, international privacy regulations do in fact restrict the uses that can be made of the by-products of Big Data, should they be personally identifiable. Facebook has been taken to task by regulators for stretching social data analytics beyond what members reasonably expected to occur (Johnston & Wilson 2012:59-64). I believe more adverse surprises like this await digital businesses in retail, healthcare and other industries.

Big Data and the Law

It's often said that technology has outpaced the law, yet by and large that's just not the case when it comes to international privacy law. Technology has certainly outpaced the intuitions of consumers, who are increasingly alarmed at what Big Data can reveal about them behind their backs. However, data privacy principles set down by the OECD in 1980 (OECD 1980) still work well, despite predating the World Wide Web by decades. Privacy laws are strengthening everywhere (Greenleaf 2011). Outside the U.S., rights-based privacy law has proven effective against many of today's more worrying business practices (Johnston &

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Wilson 2012, OAIC 2012). Digital entrepreneurs might feel entitled to make any use they like of data that comes their way, but in truth, 30-year-old privacy law says otherwise.

Information innovators ignore international privacy law at their peril. In this article, I will show why, by reviewing the possibly surprising definitions of Personal Information, and that technology-neutral privacy principles are as relevant as ever.

Personal Information technicalities

Technologists in general know that the devil is in the details, and that technicalities matter. They need to know the definition of Personal Information, because the technicalities have the power to surprise.

'Privacy' can be a difficult topic. Indeed, a leading privacy scholar has said 'Privacy is a concept in disarray. Nobody can articulate what it means' (Solove 2006: 477). On the other hand, the smaller field of *data* privacy (also referred to as data protection) is tightly defined. Throughout this paper, privacy means data privacy. Different privacy regimes worldwide variously use the terms 'Personal Data', 'Personal Information' and 'Personally Identifiable Information'. Loosely speaking and for our purposes here, the terms are interchangeable. The important thing about all these terms is they do not require the data in question to be personally *identifying*; there is nothing in the respective privacy regimes that requires 'Personal Information' to point uniquely to any individual. Data privacy then focuses simply on regulating the handling and processing of a special class of information.

The U.S. General Services Administration (GSA) defines Personally Identifiable Information (PII) as 'information that can be used to distinguish or trace an individual's identity, either alone or *when combined with other personal or identifying information* that is linked or linkable to a specific individual' (*emphasis added*)(GSA 2014).

Recently updated Australian privacy legislation defines Personal Information as 'information or an opinion about an identified individual, or an *individual who is reasonably identifiable*:
(a) whether the information or opinion is true or not; and

(b) whether the information or opinion is recorded in a material form or not' (emphasis added)(*Privacy Amendment Act* 2012).

It is notable that the definition of Personal Information in Australian law and that of Personally Identifiable Information used in the American government are so close (for the rest of this paper, I will treat the terms interchangeably and use the acronym PII to refer to both). The Australian and American definitions both embody a precautionary approach. Items of data can constitute PII if other data can be combined to identify the person concerned. Note carefully that the separate *fragments* of data are each regarded as PII rather

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than the whole data that eventually might identify someone precisely. Laypeople may presume that PII stands for Personally Identifying (rather than Identifiable) Information. The difference is subtle but very important. The definition means that some data items can – and should – be classified as PII before they are ever actually identified rather than after, with due consideration to the context of the data flows and the potential for identification. This is only prudent; if personal data needs to be safeguarded, then it is best this be done before the data is identified and it becomes too late.

Classical data privacy controls

To set it apart from security, it is often said that privacy is more about 'control' than confidentiality or secrecy. So what does that mean?

The OECD Privacy Principles (OECD 1980) were developed in the 1970s to deal with the emerging threats of computerisation. Even in the decade before that, the burgeoning databases of governments, police forces and insurance companies were seen as a danger to civil liberties (Boeth 1970); the cover of Newsweek magazine on July 27, 1970 screamed 'IS PRIVACY DEAD?' Since that time, over 100 countries have legislated data privacy protections based on the OECD principles or the more advanced European Union Privacy Directive (Greenleaf 2011).

Despite this strong global trend, American legislators have declined to enact broad-based privacy law, although particular sectors, such as U.S. healthcare, feature some of the strictest data protection rules anywhere in the world. The Fair Information Practice Principles (FIPPs) of the United States have been adopted here and there, and reflect most of the OECD principles, though crucially not all.

Conventional rights-based privacy principles are relatively straightforward. They neatly sidestep philosophical complexities like the 'self', data ownership and the increasingly nuanced difference between public and private domains. Instead data privacy principles essentially require data custodians to be careful, restrained and transparent in how all PII is handled. As one US law professor put it recently, '"privacy" is shorthand for the regulation of information flows' (Richards 2014).

In the context of Big Data, two of the standard international privacy principles stand out:

Firstly, the Collection Limitation Principle requires that organisations collect only the Personal Information they need for legitimate and transparent purposes. Collection Limitation is about discipline rather than prohibition. Privacy regulations do not stop businesses collecting the information they truly need; rather, it requires that businesses justify what they collect. The starting point for the much talked about practice of 'Privacy by

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Design' should be conscious Collection Limitation. IT designers should habitually analyse their PII requirements and from there carefully specify systems that collect the PII which is needed, and nothing more.

Secondly, the Openness Principle requires that data custodians set out for all to see what PII they collect, why they need to collect it, how, when and where they collect it, and who else the PII may be shared with.

These privacy principles apply to all Personally Identifiable Information, whether it is collected directly by form or questionnaire, or indirectly through data analytics. And so we come to a central challenge in Big Data privacy: open-ended data analytics can lead to brand new discoveries which cannot be fully envisaged and outlined at the time raw data was collected. With the best will in the world, a Big Data company might not be able to spell out in its Privacy Policy what PII it expects to collect (via data mining) at all points in the future. Do we want the potential benefits of Big Data to be inhibited by the finality of the Collection Limitation principle? If there are shared benefits in the possibility of new PII being uncovered in raw data, how can the privacy promises of Collection Limitation and Openness be honestly kept? Answers may in part lie in organisations keeping up an open dialogue with their users and customers instead of trying to freeze a privacy understanding at the time raw data is gathered.

Big Data 'spills'

Here's another reason raw data is like crude oil: when it 'spills', it's expensive to clean up. On several occasions, data analytics and other innovative information business practices have led to major privacy breaches and costly non-compliance actions, in ways that have surprised the practitioners. And further surprises are in store for companies that do not grasp the meaning of PII and international privacy law.

Google finds that 'public' can still be private

While they drive around photographing towns and cities, Google's StreetView cars listen for Wi-Fi hubs and collect the geographical coordinates of any transmitters they find. Google collects Wi-Fi landmarks for its geo-location database, which underpins its maps and other important services.

On their own, the names and locations of Wi-Fi hubs (technically known as SSIDs, or 'Service Set Identifiers') have never raised significant privacy concerns, but in 2010 it became apparent that StreetView cars were also inadvertently collecting unencrypted Wi-Fi network traffic, which inevitably contained PII including user names, banking details and even passwords. Privacy commissioners in Australia, Japan, Korea, the Netherlands and elsewhere found Google was in breach of respective data protection laws. The company

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investigated, and responded that one developer writing StreetView Wi-Fi mapping software was responsible for conducting something of an isolated experiment. The collection of network traffic was said by Google to be inadvertent. The company apologized and destroyed all the content that had been gathered (OAIC 2012).

The nature of this particular privacy offense confused some commentators and technologists. Some have argued against me that Wi-Fi data in the public domain is not private, and categorically therefore could not be private. Such a line of thinking holds that Google is within its rights to do whatever it likes with such data, but the reasoning fails to grasp the technicality that data protection laws in Europe, Australia and elsewhere do not essentially distinguish 'public' from 'private'. If data is identifiable, then various privacy rights attach to it, irrespective of how it is collected.

Facebook over-automated photo tagging

Photo tagging is a popular feature of photo sharing services that helps users to better organise their albums. Tagging as offered by Facebook creates biometric templates that mathematically represent an individual's facial features, allowing other photos to be identified as being of the same person. When Facebook makes automatic 'tag suggestions', its facial recognition algorithms have been running in the background over all photos in the network's enormous database, making putative matches and flagging deduced user names against the analysed photos. When a photo containing an identified individual is next displayed to a member, the tag suggestion is displayed and the viewer is invited to confirm it. According to the definition of Personally Identifiable Information, when Facebook's software adds a name to a hitherto anonymous photo record, Facebook turns that record into PII; the tagging process therefore *collects* PII, albeit indirectly.

European privacy regulators in mid-2012 found that collecting biometric data in this way without consent was a breach of privacy laws (HmbBfDI 2012). By late 2012, German and then Irish authorities forced Facebook to shut down facial recognition and tag suggestions for all its European operations, and to delete all biometric data collected to that time. This was quite a show of force over one of the most powerful companies of the digital age.

So it doesn't much matter if data miners generate PII almost out of thin air, using sophisticated data processing algorithms; they are still subject to privacy principles, such as Openness and Collection Limitation. Crucially, until 2012, Facebook's privacy policy and data usage policy had not even mentioned that biometric facial recognition templates were created by tagging, let alone that they were subsequently used to automatically identify people in other photos.

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Target gets intimate with its female customers

In 2012, the New York Times revealed a carefully designed customer relations program at the department store Target that set out to identify customers who were likely to be pregnant, in order to subsequently direct-market lucrative early childhood products (Duhigg 2012). Because the U.S. has no data privacy laws governing the private sector generally (Greenleaf 2011) the rights and wrongs of retailers divining such intimate insights about their customers are difficult to arbitrate in that country. But in Australia, it would likely to be unlawful. Health information here is included in legislation amongst 'Sensitive' Personal Information. This category includes information (or opinion) about an individual's health or genetics, as well as their racial or ethnic origin, political opinions, membership of a political association, membership of a professional association, trade association or trade union, religious beliefs or affiliations, philosophical beliefs, sexual preferences or practices or criminal record (Privacy Act 1988:17). Special conditions apply to Sensitive PII. Most relevant for Big Data is that Sensitive PII in Australia can only be collected with the prior informed consent of the individual concerned. Should Australian stores wish to use Big Data techniques as Target did in the U.S., they may need to disclose up front the possibility of health information being extracted from shopping data and obtain customers' express consent for that to occur. Data miners need to be aware that rights-based privacy laws set a low bar for privacy breaches: simply collecting Sensitive PII may constitute a technical breach of the law even before that PII is used for anything or disclosed. For example, Google's breach of Australian law in the case of the StreetView Wi-Fi incident was confined to the Collection Principle; no use or further disclosure of the Wi-Fi data was found to have occurred (OAIC 2012).

More privacy shocks are likely to come

Digital businesses are availing themselves of an ever richer array of signals created automatically as we go about our lives online. Wearable technologies in particular, such as augmented reality eyewear and personal fitness monitors, measure a number of parameters more or less continuously, and typically transmit the data back to their manufacturers for processing and recording. Ostensibly the users of these devices benefit by way of automated reports, but it is worrying that the privacy policies of many technology businesses tend to be silent on what they plan to do with the by-products of the processing. Natural language processing of spoken commands, face recognition, object recognition and 'quantified self' monitoring equipment all generate rich traces and metadata about the devices' users, with enormous commercial value.

At the same time, informaticians are discovering ever more clever ways to de-anonymise us in cyberspace (that is, to undo the state of anonymity that users expect or have been led to

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believe applies). In one of the more spectacular recent examples, self-described 'DNA hackers' at MIT's Whitehead Institute for Biomedical Research in 2012 worked out how to combine publicly available genealogical data with anonymously donated DNA samples in the 'Thousand Genomes' research program, to identify a number of those donors (Bohannon 2013). This was despite reassurances given to donors in the informed consent form that 'it will be very hard for anyone who looks at any of the scientific databases to know which information came from you' (Thousand Genomes 2008).

Do these developments mean 'privacy is dead' after all? No. The fact is that *anonymity* is threatened by information technologies, but anonymity or secrecy is not the same thing as privacy. The act of undoing anonymity creates new named data records and thus represents an act of PII collection subject to privacy regulations in a great many jurisdictions. The de-anonymising of Thousand Genomes donors for instance can be seen to be a breach of certain privacy regulations, independent of the conditions of the original raw data collection (Wilson 2013). If law-abiding Big Data businesses are alert to the broad definition of PII and to the technology neutrality of data privacy regulations, then they can reduce the chances of more shocks to come.

Extended privacy principles to deal with Big Data

Big Data represents a qualitative shift in how business is done in the digital economy rather than just a quantitative change. The term 'Big Privacy' is used by some to describe an organised response to Big Data. Former Information and Privacy Commissioner for Ontario, Ann Cavoukian for example has written 'Big Privacy is Privacy by Design writ large' (Cavoukian & Reed 2013:6) implying that dealing with Big Data essentially requires just a redoubling of existing privacy measures. To the contrary, I contend Big Data demands some new ways of safeguarding PII flows, with an update to traditional privacy principles.

As we have seen, to many technologists' evident surprise, principles-based privacy laws have proven powerful in constraining Big Data processes, even though scenarios like facial recognition in social networks could not have been envisaged 30 years ago when the OECD first formulated its privacy principles. When we appreciate that generating PII out of raw data is a form of indirect collection of PII, orthodox privacy principles apply and can restrain what may be done with Big Data's outputs. The Collection Limitation Principle is perhaps the most fundamental privacy control; it is after all, the first of the OECD Privacy Principles (OECD 1980). And yet transparency is crucial too. Traditional privacy management entails telling individuals what information is collected about them, when it is collected and why. With Big Data, even if an information company wants to be completely transparent, it may

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not be able to say today what PII it's going to synthesise tomorrow. Any promise of openness with Big Data cannot be made once and forgotten; it needs to be continually revisited.

There is a bargain at the heart of most social media businesses today in which PII is traded for a rich array of free services. Sophisticated Internet users may know 'there is no such thing as a free lunch' and that the things they take for granted online – like search, maps, cloud email and blogging – are funded through the monetisation of PII. And there is nothing intrinsically wrong with business models that extract valuable PII from anonymous raw data; however privacy requires transparency. Today's service-for-PII bargain is mostly opaque, with personal data harvested seamlessly and covertly, with nary a mention in privacy policies.

The fact that there is a real price to pay, one way or another, for things like online social networking has led some privacy advocates to call for overt user-pays models of digital service delivery. The new 'Respect Network' for example, founded by a team of personal cloud and sharing economy advocates, aims to provide a social logon button which is 'not based on advertising or surveillance' but rather which is underwritten sustainably by crowd funding and subscriptions (Blum 2014). It remains to be seen of course just how many users are sufficiently worried about privacy and, moreover, aware of how their PII is exploited to make the switch to user-pays digital services. For others, ignorance is not bliss. Social network members in general deserve to be told about the PII exchange (including details of what information-based businesses do with all this PII) so they can make up their own minds about it.

Going beyond classic data privacy principles

While existing privacy principles are surprisingly powerful, they are limited by virtue of being framed for the static data collection and processing capabilities that characterised information and communication technology until recently. A traditional privacy policy properly sets out what PII is collected, why it is collected, when, where and how it is collected, and to whom it may be disclosed. A privacy policy reflects a business model in which PII flows into and about a business and tangible benefits result. A fair privacy policy accurately reflects an exchange of PII for value. But with Big Data, the PII-value exchange is shifting all the time, both quantitatively and qualitatively. For data protection to remain a good fit for evolving Big Data practices, certain privacy principles could be updated as follows.

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Super transparency

If basic data privacy means being open about what PII is collected and why, then privacy into the future, where business models and data mining techniques are evolving rapidly, should take transparency further. As well as telling people what information is collected and why, businesses should be candid about the business models, the emerging Big Data tools, and what sort of results data mining is expected to return. In keeping with better visibility, users should be offered ways to opt in and out and in again, depending on how they gauge the returns on offer from Big Data participation.

Engage customers in a fair deal for PII

The nascent digital economy is distorted to some extent by savvy digital citizens modifying their behaviours to protect themselves in ad hoc ways against online exploitation. Most pointedly, 30% of Australians have been found to have given a false name and 32% have given false personal details in an effort to protect their personal information (OAIC 2013:30). Many resort to covering their tracks with encrypting browsers like Tor or by maintaining multiple email addresses so when they register for disparate services, it's harder to join up their activities. There's nothing wrong with having multiple digital personae, but being forced to concoct them in order to hide from prying eyes is an unfair burden and ultimately counter-productive. Consumers and companies alike will do much better by engaging in a more overt deal which sets out what PII is really worth and offers a fair price for it, whether that is by way of tangible products, services, discounts or explicit payment.

Dynamic consent

As we've seen, when Sensitive PII like health information is collected – whether directly or indirectly – the prior consent of the individual is required. If such collection is going to be through the mining of relatively innocuous data like shopping habits, then we have a dilemma. Around the time of raw data collection, businesses could try to disclose all conceivable future outcomes of data mining, yet they may understandably be reluctant to confront customers with dense data usage agreements full of possibly hypothetical scenarios. Alternatively, as and when data custodians develop new data mining techniques and find they are able to extract fresh heath information, they could seek permission at that time.

It will take artful user interface design to present individuals with the types of PII that might be extracted about them, in a meaningful way, such that they can make sound decisions about whether or not to grant permission. There is a logical contradiction in the letter of the Collection Limitation Principle. Consider a hypothetical scenario where a Big Data company develops a way to predict from your travel patterns that you are at risk of a contagious

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disease, and they would like to bring that possibility to your attention. Strictly speaking, any determination about an aspect of someone's health (even if wrong) is a piece of Sensitive Personal Information, and working it out (i.e. collecting it) without consent is not permitted by Australia's Privacy Act. So by the time the company brings the risk of contagion to your attention, the company has already breached the law.

This Catch-22 could be resolved by giving users a purposefully vague indication of 'what we might know about you' in a sort of graphical dashboard. Such a user interface could serve to remind the user of the raw data that is available to the company, and illustrate how particular processing can extract more detailed information about them, such as diseases, without yet being specific. If the user perceives benefits from such processing, they could indicate their consent to proceed. In some cases, the quality of 'what might be known' about a user may vary in proportion to the amount of raw data the user is willing to give permission for. In the hypothetical case of predicting disease from travel data, the confidence limits on the prediction might be improved if the user agreed to provide more history or to link other data into the calculation; conceivably the user could be presented with graduated interactive controls over the amount of data they agree may be factored into the Big Data process and indications of the differential benefits to be expected.

Conclusion: Making Big Data privacy real

A Big Data dashboard like the one described could serve several parallel purposes in aid of progressive privacy principles. It could reveal dynamically to users what PII can be collected about them through Big Data; it could engage users in a fair and transparent exchange of value-for-PII transaction; and it could enable dynamic consent where users are able to opt in to Big Data processes, and opt out and in again, over time, as their understanding of the PII bargain evolves.

Big Data holds big promises, for the benefit of many. There are grand plans for population-wide electronic health records, new personalised financial services that leverage massive retail databases, and electricity grid management systems that draw on real-time consumption data from smart meters in homes, to extend the life of aging 'poles and wires' while reducing greenhouse gas emissions. The value to individuals and operators alike of these programs is amplified as computing power grows, new algorithms are researched, and more and more data sets are joined together. Likewise, the privacy risks are compounded. The potential value of Personal Information in the modern Big Data landscape cannot be represented in a static business model, and neither can the privacy pros and cons be captured in a fixed policy document. New user interfaces and visualisations like a 'Big Data dashboard' are needed to bring dynamic extensions to traditional privacy principles, and

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help people appreciate and intelligently negotiate the insights that can be extracted about them from the raw material that is data.

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Information Lifecycle Governance (ILG)

Maximise data value, reduce data growth, cost and risk

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Summary: Over-retention of data with no value leads to increased cost and risk, and reduces the capacity of organisations to identify and leverage valuable business data. Information Lifecycle Governance (ILG) provides a structured, strategic approach to reducing data growth, cost and risk, while providing the policies, processes and technology to move from a reactive to a proactive state of information management and maximise the value of information.

Introduction

Information Lifecycle Governance (ILG) is a strategic, structured approach which addresses the increasing volume and complexity of electronic information, and the associated increase in cost and risk to manage that information.

As the volume and complexity of electronic data increases, organisations face greater challenges in extracting business value, managing IT costs, and limiting the legal risks associated with managing and retaining that data.

Organisations without policies, processes and technology in place to address these issues will increasingly face the situation where their data becomes a costly liability to the effective operation of the business, rather than an asset to be leveraged.

Data may be located across multiple platforms, in various formats, across numerous geographical locations, and be the subject of a combination of business, legal, regulatory, security and privacy requirements.

The most effective way to manage this complexity is by implementing an ILG program, which takes a transparent, enterprise-wide approach to the management of data.

The outcomes of an ILG program are:

- Defensible disposal of data debris;
- Reduced risk and cost exposure from a legal, regulatory and privacy perspective;
- Improved business processes and efficiencies; and
- Reduced exposure to financial, reputational and operational threats.

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Data debris

In 2004, the Compliance, Governance and Oversight Council (CGOC) was founded in the U.S. as a discussion forum and professional think tank to address information governance issues. CGOC has over 2,900 legal, IT, records, privacy and information management professionals and hosts regular meetings in the U.S. and Europe to discuss discovery, retention, privacy and governance.

At the 2012 CGOC Summit, a survey of corporate CIO's and general counsels revealed that typically 1 percent of corporate information is on litigation hold, 25 percent has current business value, and 5 percent is in a records retention category. This means that approximately **69 percent** of the data most organisations keep has no legal, regulatory, privacy, security or business value. (See Figure 1).

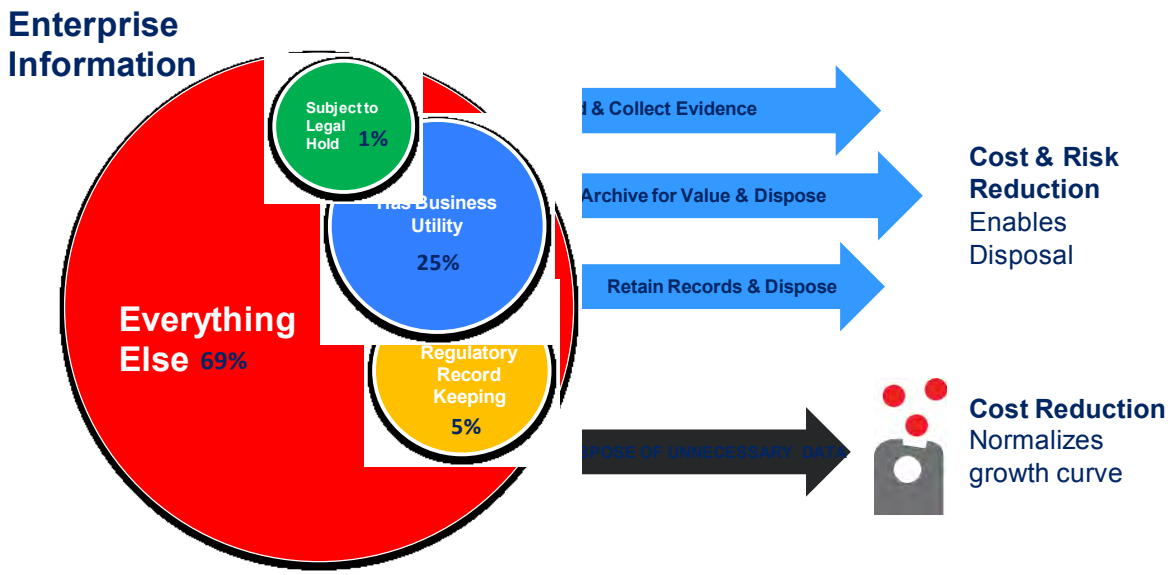

Figure 1 – CGOC Summit 2012 Survey

This overwhelming volume of data debris, i.e. data with no or low value, which still carries cost and risk, has significant implications for the business, legal, IT, records management, privacy, risk and compliance stakeholders in an organisation.

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Stakeholders

Business

Business stakeholders generate and use data for multiple purposes, including identification of new business opportunities, analysis of customer behaviours and preferences, competitors and market trends, and strategic decision making.

In order to maximise the value of business information as a strategic asset, the effort to locate the most relevant, valuable data must be reduced. In a scenario where 69% of data has no value, finding what you need becomes an onerous task. This can lead to lost opportunities, duplication of effort, lack of awareness of existing information, reduction in business efficiency, and inadvertent deletion of valuable data.

What is required is a more focused, managed, stable body of business information that can be leveraged to increase efficiency and profit. Improved access to and handling of information will allow the business to become less reactive and move towards a more proactive, even predictive management of information assets.

Legal

Legal stakeholders require potentially relevant data in anticipation of litigation or regulatory investigations to be identified, preserved (via legal hold), collected (in a forensically sound manner), processed, reviewed, analysed, and potentially produced and presented.

The typical steps in the eDiscovery process are encapsulated in the **Electronic Discovery Reference Model** as created by the EDRM (edrm.net) shown in Figure 2).

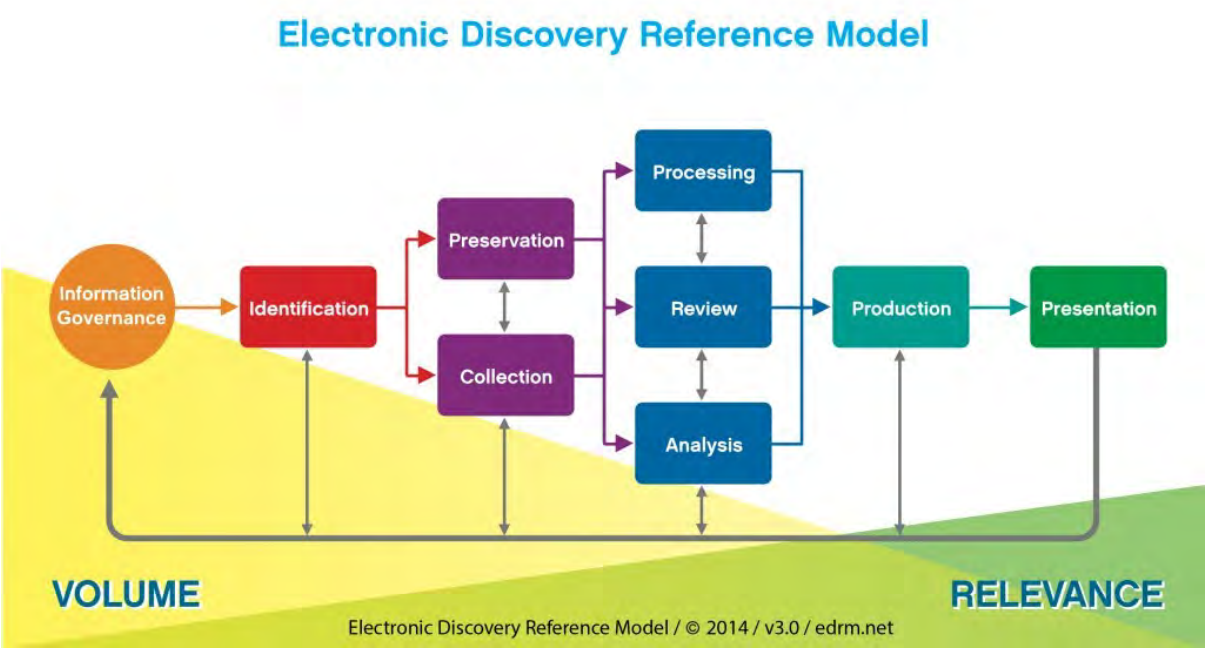

Figure 2 – Electronic Discovery Reference Model – Source: EDRM (edrm.net)

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The higher the volume of data debris, the higher the cost and risk associated with these processes. Increased legal costs will result from the legal department having to wade through a mass of irrelevant data to find the relevant data for each legal matter.

Increased legal risks could result from:

- Potentially relevant data being inadvertently modified, deleted or overlooked;
- Damaging evidence being exposed that should have been defensibly disposed;
- Data custodians and sources being missed in legal hold execution;
- Ineffective early case assessment and matter scoping; and
- Inefficient estimation of ongoing litigation exposure.

Privacy, Risk and Compliance

Privacy, Risk and Compliance stakeholders need to know what data an organisation holds, where it is stored, who has access to it, how it is secured, and how easily it can be retrieved, accessed and produced when required. This forms the basis for implementing the required practices, procedures and systems to ensure compliance with relevant legislative requirements.

The Australian federal *Privacy Amendment (Enhancing Privacy Protection) Act 2012* which came into effect on 12 March 2014 introduced significant changes to the existing *Privacy Act 1988* and places more onerous demands on organisations and agencies to manage their and their customer's personal information. Maintaining personal information beyond the end of its lifecycle increases the risk of privacy breaches occurring.

The *Australian Privacy Principles (APPs)* as encapsulated in the Act, require organisations to destroy or de-identify personal information at the end of its lifecycle, and to protect the information from (a) misuse, interference and loss; and (b) unauthorised access, modification or disclosure.

The more complex and voluminous a data set, the more challenging to locate, secure, produce or delete personal information to ensure compliance. This could lead to significant penalties of up to $1.7 million and reputational damage.

Records Management

Records Management stakeholders maintain a retention schedule that classifies records and prescribes retention periods based on this classification.

The limitations of a traditional retention schedule are that it typically only applies to records, does not include information that has business value, is not executable against data sources,

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does not have visibility to other stakeholders, and is difficult to keep up to date within an ever changing legislative environment.

In a data environment filled with debris, it becomes almost impossible to distinguish between data that has value and data that can be discarded, which in turn impacts the effective execution of a records retention and destruction schedule.

IT

IT stakeholders are saddled with the responsibility to store, secure, archive and delete data, typically without the necessary insight into the value and obligations associated with the data. Exponential data growth, increasing data complexity and over-retention of data with no value leads to a situation where numerous IT processes are impacted.

Managing too much data debris complicates elimination of legacy systems, reclamation of storage capacity, appropriate storage allocation according to data value, application decommissioning, and value based archiving. It further impacts application system performance, development and testing of new systems, increases back-up and processing times, and increases ongoing data storage costs.

Policy, Process and Technology

Over-retention of data with no value results from gaps in policy, process and technology.

A lack of association of value and duties to data leads to a situation where data is managed as if everything has value, where compliance is difficult to monitor and enforce, and where too much cost and effort is spent on managing, preserving and producing unnecessary data.

At a policy level, decisions have to be made with regards to what data must be kept, why, and for how long. These policies will require input from all relevant stakeholders and must have visibility across the enterprise to enable ongoing, transparent application of data retention and preservation requirements.

The main elements required at a policy level are:

- **Regulatory:** an updated and expanded retention schedule that applies across the enterprise;
- **Legal:** more precise legal hold management (data custodians and sources) and improved early case assessment
- **Privacy:** an up to date privacy policy, privacy and compliance obligations register, and business unit policies
- **Security:** a data source catalogue, data classification model, improved user and role based access controls

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Execution of policies must be supported by a maturation of business processes across the enterprise. Ad hoc, manual data management processes need to move to a more integrated, consistent and repeatable level of maturity to ensure that policy requirements are effectively implemented.

Policy and process improvements must be supported by a technology model that allows for the syndication and execution of policies on data sources, based on the mapping and classification of that data. Ideally, the underlying technology must enable some level of automation with regards to data retention, legal hold application, de-duplication, analysing data in place, value-based tiering of storage and disposal of data debris.

Information Governance Reference Model

In 2009 the EDRM (edrm.net) created the **Information Governance Reference Model (IGRM)** (see Figure 3) to provide a common, practical, flexible framework to help organisations develop and implement effective and actionable information management programs. The model enables linking of information value and duties to data assets and ties information demand to infrastructure supply.

An effective ILG solution is achieved through unified governance, policy integration and process transparency across all data stakeholders.

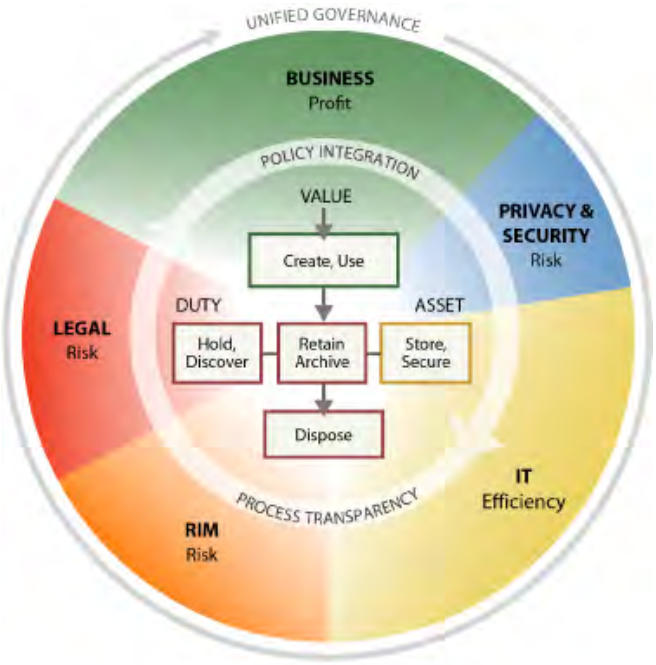

Figure 3 – Information Governance Reference Model – Source: EDRM (edrm.net)

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ILG elements

Data source catalogue

The first step towards an effective ILG program is to establish what data resides in which systems, and to track the relationship between data sources and supporting infrastructure. An updated data source catalogue should track data sources in a way that is understandable to non-IT stakeholders.

Data classification

Once a data mapping exercise has been completed, data must be classified according to business value, retention periods stipulated by law, privacy and security obligations, and legal holds.

This process will involve the extension and automation of retention schedules and increased automation of legal hold and eDiscovery processes.

Data classification then forms the basis for applying the most appropriate security and access controls, and identifying data of no value that can be defensibly disposed.

Retention management

The retention schedule must be updated to include not only records, but also data that has business value, i.e. the schedule should be dynamically mapped to legal and business requirements.

The intention is to retain data for no longer than is required and to include retention periods for all types of data, including unstructured repositories such as email, share drives, SharePoint and others.

Legal hold and eDiscovery

A more precise, actionable legal hold process will ensure that relevant data is not deleted, modified or overlooked.

Improved data analytics will enable more efficient early case assessment and the ability to analyse data in-house and in place, saving cost and lowering risk through the avoidance of unnecessary data collection, processing and review.

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Defensible disposal

There is no legal requirement to keep all data in perpetuity. Once data to be retained and preserved has been identified and classified, the remaining data debris can be defensibly disposed according to the relevant policy.

All relevant stakeholders should be in agreement that certain information has reached the end of its lifecycle and the resulting disposal instructions should be clearly communicated to the data owner who manages the information.

Value based archiving and tiering

Based on the classification of data, appropriate storage tiers can be applied, e.g. high value data on tier 1 storage, and low value data on lower tiers or back-up tape. This will maximise the efficiency and cost of data storage and ensure quick, easy access to key information by business users.

Storage reclamation, application decommissioning

Once data of no value has been disposed and data of low value has been archived appropriately, applications that are no longer required can be decommissioned and storage can be reclaimed.

Ongoing information governance

Once policies, processes and technology have matured, information governance practices that have been put in place for existing data should now also be applied to all new data that enters the organisation (via creation or collection). All new data should now be managed according to these upgraded policies and processes, enabling data to be managed by value, cost, risk and duties throughout its lifecycle.

Conclusion

ILG is not a stagnant process.

In order for an organisation to keep information governance policies, processes and technology up to date, it will require constant monitoring and auditing by executive management. New trends and technologies, combined with changing legal and regulatory requirements, have to be incorporated into the organisation's ILG strategy on an ongoing basis.

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The true benefits of an integrated ILG approach cannot be realised through occasional data clean-ups, but rather through structured, strategic implementation of governance, policy and process initiatives across the organisation.

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The Digital Universe

Rich Data and the Increasing Value of the Internet of Things

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Summary: The Digital Universe, which consists of all the data created by PC, Sensor Networks, GPS/WiFi Location, Web Metadata, Web-Sourced Biographical Data, Mobile, Smart-Connected Devices and Next-Generation Applications (to name but a few) is altering the way we consume and measure IT and disrupting proven business models. Unprecedented and exponential data growth is presenting businesses with new and unique opportunities and challenges. As the 'Internet of Things' (IoT) and Third Platform continue to grow, the analysis of structured and unstructured data will drive insights that change the way businesses operate, create distinctive value, and deliver services and applications to the consumer and to each other. As enterprises and IT grapple to take advantage of these trends in order to gain share and drive revenue, they must be mindful of the Information Security and Data Protection pitfalls that lay in wait – hurdles that have already tripped up market leaders and minnows alike.

Introduction – The Digital Universe

Welcome to the Digital Universe. "Growing at 40% a year and into the next decade (IDC 2014: 1)" it comprises not only the ever-expanding number of end users and enterprises which now do almost everything online, but also a raft of diverse smart devices which make up the fledgling but rapidly evolving IoT – the 'Internet of Things.' The trend towards the digitisation of businesses and social networks, coupled with the increasing social mobility provided by smart devices such as smart phones and tablets, is seeing an exponential boom in the growth of structured and unstructured data. This provides unprecedented Big Data opportunities for organisations with the foresight to extract insight from 'third platform' mobile devices, social media and 'smart' internet-connected devices.

And just how much data growth are we likely to see? According to current estimates, by the year 2020 the internet will connect "7.6 Billion people and 32 Billion 'things'" (IDC 2014a) all of which generate data. As a comparison, in the year 2000 the amount of Data generated totalled 2 Exabytes (2×10^{18} bytes). In 2011, 2 Exabytes were being generated every day. "By 2013, there were 4.4 Zettabytes (or 4400 Exabytes) of total data stored, and by 2020, the total amount of data in storage is expected to reach 44 Zetabytes (IDC 2014a)" – an astounding figure. Organisations that understand how to extract insight from this data will be in a position of strength.

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Figure 1 – The trend in the size of the digital universe. Source: (IDC 2014a: 2)

Structured and Unstructured Data

Gaining insight via data analysis is not as straightforward as it might seem. Unstructured data, the type generated via a tweet and which contains information about people's opinions and thoughts, is far more difficult to analyse than structured data which resides in a fixed field within a record or file. Organisations that have the applications and infrastructure specifically designed to analyse both structured and unstructured data – in concert and in real time – will be able to drive efficiency in their business operations, better cater to their users' needs, create new value and respond with agility and speed in the application development lifecycle.

The Changing Data Landscape

Data growth will not be uniform across mature and emerging markets. As an example, "in 2013 mature markets represented 60% of the Digital Universe. By 2020, the converse will be true, with emerging markets such as China, Russia, Brazil, India and Mexico set to represent 60%. Furthermore, the ties between consumer- and enterprise-generated data have never been stronger. In 2013, two thirds of all data was created by consumers with enterprises 'touching' or being responsible for 85% of the consumer data" (IDC 2014a).

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The Internet of Things

As for the IoT, while its impact on total data generated will remain lower than that of consumers, "it will still represent 10% of all data created in 2020, up from 2% in 2013" (IDC 2014a). The network-connected devices that make up the IoT are characterised by automatic provisioning, management, and technology and include intelligent systems and devices, connectivity enablement, platforms for device, network and application enablement, as well as analytics, social business and vertical industry solutions.

Mobility

A key driver in the Digital Universe, "in 2014, mobile-connected devices accounted for 18% of all data. By 2020, that figure will grow to 27%" (IDC 2014a). Mobile devices don't simply include your tablet or smart phone. RFID tags, GPS devices, cars, toys and even dog collars will all generate data. Enterprises now need to cater for the 'bring your own device' (BYOD) trend, as IT users demand access to every business application on any device.

Big Data in the Digital Universe

So when it comes to Big Data, how is business doing? "Currently, less than 1% of the world's data is analysed" (IDC 2014a). EMC sees this as a huge opportunity – an opportunity to analyse multiple data streams, do new things with IT and derive unique insights, hitherto invisible to business. Data, these days, tends to be unstructured, i.e. documents and text files – diversely formatted, of uncertain accuracy and unpredictable value, and often demanding real-time attention. To maximise the effectiveness of their Big Data strategy, organisations must implement new technologies and processes to change today's inflexible data structures and transition to more egalitarian and flexible 'Data Lakes'.

Trend 1: Correlation

Organisations will need to derive unique insights from dependent, correlated data sets through the prism of Big Data. Dependency consists of a statistical relationship between two random variables, and data analytics can uncover relationships between data sets that were previously invisible. For example, recently during the 'Used Car Defect Prediction Contest' hosted by San Francisco online Startup Kaggle, a spate of analyses of data sets previously thought to be unrelated was performed by the contestants, and it was unearthed that of all the cars within the data sets, orange cars proportionally had half the chance of being defective (Wohlsen 2012). While this is a simple example, it demonstrates that opportunities for insight abound in almost any organisation. Correlated Data Analysis enables you to see what your competitors can't and what you otherwise wouldn't.

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Trend 2 Prediction

As organisations find new sources of data and new ways of analysing it, they must move from traditional descriptive analysis to predictive analysis, performed in real time. This trend encompasses a move to self-service business intelligence and analytics, which will enable executives and employees alike to use software tools for data discovery, leading to timely decision making with fewer bottlenecks to action as they move increasingly to become software-defined enterprises. It is these software-defined enterprises that will be the most successful in the era of the 'Third Platform'[i] (defined by social mobility, billions of end users and millions of apps).

Trend 3 Telematics

Telematics, or the highly automated communications process by which measurements are made and other data collected at remote end points, subsequently sending data back for analysis, will be an increasingly important driver in the Digital Universe. While there may be a finite number of things that can be computerised and measured, "this number is already approaching 200 billion. Furthermore, there are already 50 billion sensors that measure this information, with scientists predicting a trillion-sensor network within the next 10 years" (IDC 2014a).

What does this mean for IT Pros?

While it can be said with a high degree of certainty that much of the IoT will be self-service and self-supported, someone will still need to architect the data stores, answer help desk calls and maintain the data farms. More importantly, IT skills and expertise will need to be developed to handle new data sources, formats and new technologies while IT budgets continue to shrink and CIOs are asked to do more with less. IT pros will have shoulder the storage burden that all this new data will create. In 2014 on average, "28 million IT Pros worldwide managed 230 GB of data per person, per year. In 2020, 36 million IT Pros will be expected to manage 1,231 GB of data per person year, and organisations will have to provide them with the tools and skills to manage and make sense of it" (IDC 2014b). This trend is shown graphically in Figure 2 below.

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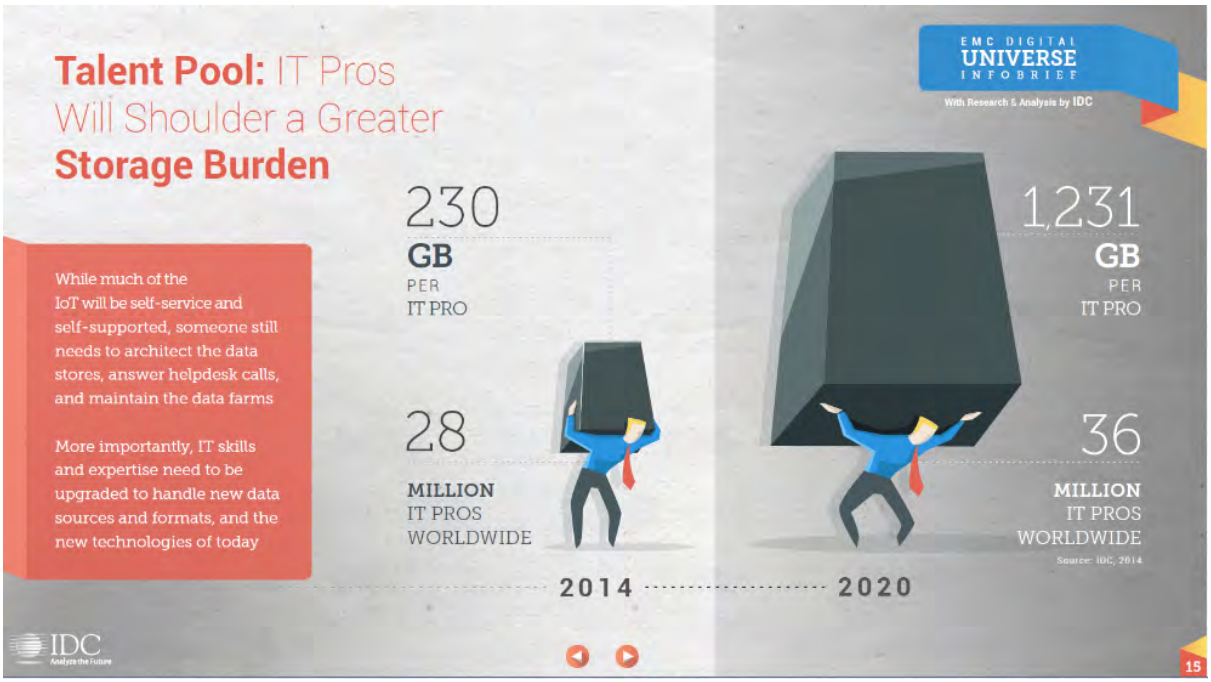

Figure 2 – Trend in IT storage per IT worker. Source: (IDC 2014b: 15)

Data Lake

Data traditionally fell into two buckets. Bucket One included utilised data, and Bucket Two consisted of new types of data, or data that the organisation may have already had, but which was not utilised for business purposes. In other words, these two data types can be referred to as structured and unstructured data. Traditional architectures, whereby storage pools attached to legacy applications would have to import structured data into a data warehouse, are insufficient for the modern age in two key ways. They have no ability to analyse unstructured data, and the data analysis they can perform takes too long to be of use, due to ETL (or 'extract, transform and load') to the Data Warehouse. In order to combat this problem, a new architecture was needed. Enter, the 'Data Lake'[ii].

Modern Data Lakes provide a new architecture for better managing and analysing massive amounts of data. Not only do they deliver superior performance via innovations such as 'In-Memory Compute', but if they are architected properly, they will be open source–based (Hadoop) and leverage NOSQL (which originated from the term 'not only SQL' and describes databases that are 'schema-less', meaning that they can be easily restructured and changed) providing simplicity of design, horizontal scaling and finer control over availability. Add a Data Scientist to the mix and all sorts of pertinent information can be extracted from both structured and unstructured data.

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Evolving Role of Information Security and Data Protection

As the Digital Universe evolves and grows, businesses face increasing challenges in the domains of Information Security, Data Protection and Disaster Recovery. According to current data, "43% of the Digital Universe requires some level of data protection. Here we're talking about corporate financial data, personally identifiable information (PII), medical records and user account information. 57% does not generally require data protection, for instance camera phone photos, digital video streaming data (i.e. the subset of video that doesn't need protection – for example, open YouTube videos and open data on blogs) public website content, and open-source data" (IDC 2014b). Surprisingly, or perhaps not given shrinking IT budgets, more than half of all the information that requires data protection is not currently protected (see Figure 3). This leaves many companies at risk of incurring critical data losses resulting in system downtime, customer turnover, in some cases irreparable damage to their brand and ultimately loss of revenue. The recent media storm and resultant resignation of Target's CIO following a data breach speak volumes about the potential risks CIOs face when their data is insufficiently protected and vulnerable to attack.

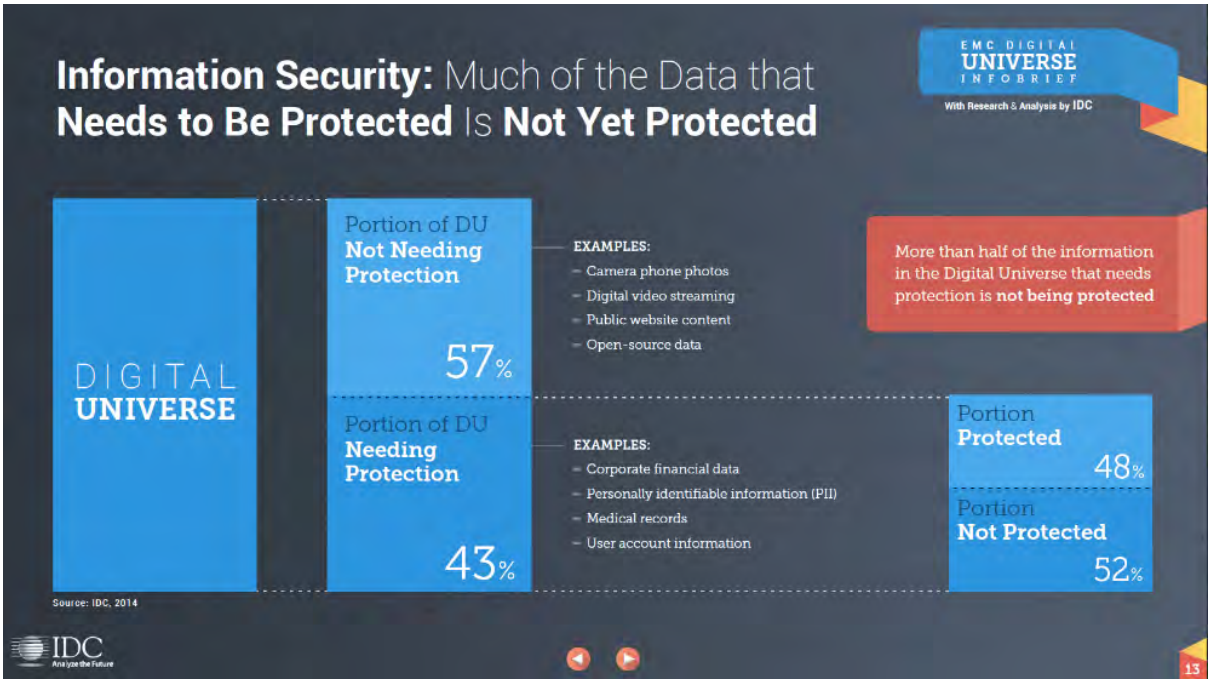

Figure 3 – Current level of data protection. Source: (IDU 2014b: 13)

Changing our Approach to Securing Information

In years gone by, the role of Security was one of prevention. Signature-based and IT-controlled perimeters protected enterprise infrastructures from attacks and for a time, served their purpose well. This was the age of the 2nd Platform, an age in which end users

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consumed Enterprise IT via the tried and tested means of LAN/Internet and Client/Server. In the Digital Universe, establishing a secure perimeter is no longer a possibility, and organisations must evolve their IT Security Strategy from one of prevention to one of detection. Over the years, threats have evolved from simple worms, viruses, DDoS attacks and phishing/pharming emails, progressing to the now almost ubiquitous advanced persistent threats, multi-stage threats and 'hacktivists' that enterprise organisations must deal with on an almost daily basis. Not only are cyber criminals now more sophisticated in their approaches, but the surface area of attack has never been greater. In 2007 most enterprises had just a handful of web-facing applications; a web site, maybe a customer support portal.

Today we are in the world of 'there's an app for that' with a huge proliferation of small apps that often come and go in a matter of months, and which can easily be built by non-IT users to access sensitive information from any device. By 2020 we'll be connecting these apps and smart-connected devices to more and more of our big data systems, all of which means more points of entry for those with nefarious intent. In order to detect threats early, Big Data and Security Systems must work hand in hand to alert, report, investigate, analyse, visualise and respond to threats in a timely manner – thereby providing organisations with public and private threat intelligence and ensuring data governance.

Next Generation Applications

As IT moves towards the Hybrid Cloud – built upon the Third Platform (see Figure 4 below) which is set to realise a 700% growth in applications by 2016 from the amount in existence in 2013 and is based upon the mega trends of Mobile, Cloud, Big Data and Social Media) – new applications are needed, applications that service billions of users while being data-loss-tolerant, HDFS/Object storage-compatible, and which provide software-based resiliency. Not only that, the way applications are developed is changing, as Platform as a Service (PaaS) becomes the application development framework of choice.

Historically, applications were developed according to the waterfall method with tools such as Java, COBOL and PL1. Now, under the PaaS framework, applications can be rapidly 'stood up', enabling businesses to respond to changing markets and competitive landscapes, to provide users with new functions, features and ultimately – value – in record time. PaaS is based on what Pivotal calls the virtuous cycle, consisting of applications, data and analytics. Here's how it works: Apps power businesses, and those apps generate data. Analytical insights from that data drive new app functionality, which in-turn drives new data and insight. The faster you can move around that cycle, the faster you learn, innovate and pull

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away from the competition, and that's where the tools and libraries inherent in PaaS deliver agility – enabling you to facilitate rapid service or application development without the cost and complexity of buying and managing the underlying hardware or software, and without the need to provision hosting capabilities.

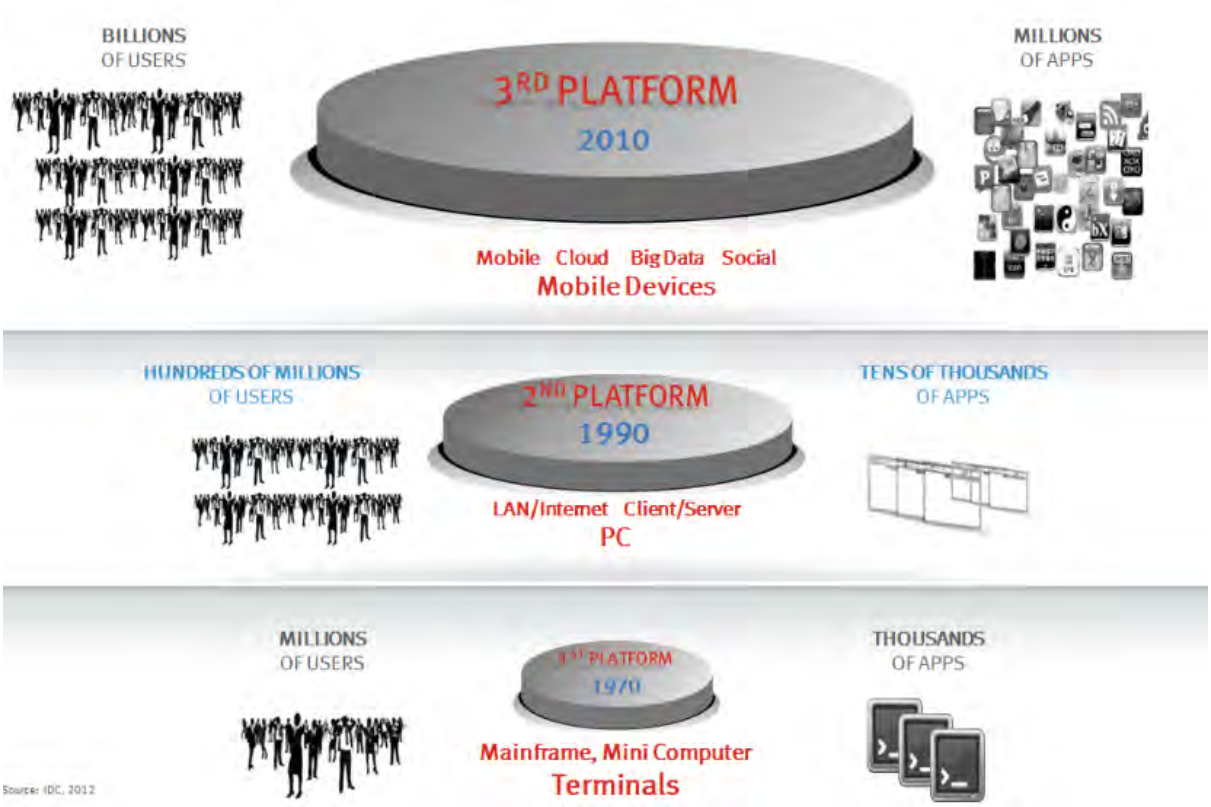

Figure 4 – The 'Third Platform' for data storage.

Conclusions/Recommendations

In order to meet the demands of the Digital Universe, organisations must rethink the way that data is collected, stored, analysed and acted upon. The disruptive technologies of Cloud, Big Data, Mobility and the IoT, combined with exponential data growth, are already changing the IT landscape and stretching IT resources and budgets. Organisations must leverage flexible architectures and platforms without falling into the trap of vendor lock-in, while at the same time ensuring data governance and compliance in a world where preventative security is no longer an option.

Organisations that flourish in this changing environment will be software-defined – leveraging best-of-breed, horizontally architected solutions that provide them with choice. Choice means the ability to sweat existing single or multi-vendor assets with seamless interoperability, while being able to upgrade or update hardware, software and applications to meet changing market demands with ease, agility and strategic insight. Today's software-

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defined enterprise must be based on Cloud, Big Data and Trust. Those that adopt and adapt early will be best positioned get ahead and stay ahead of the curve.

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Endnotes

[i] The third platform is a term coined by IDC which defines the technology trend towards building applications that run on mobile devices, are built on the Cloud, in many cases leverage Big Data repositories and often connect to social networks. The first platform that we built in the 70s and 80s,

[ii] The 'Data Lake' is an enormous, readily and easily accessible data repository that is built on (relatively) inexpensive computer hardware for storing 'big data' and performing real-time analytics, in place, to provide insight to the business.

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Disruption and Experimentation

The interplay between printed newspapers and their online websites

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Summary: This paper is in two parts. It seeks to contextualise the myriad changes occurring to newspaper websites through consideration of a body of literature that explores the implications of the media disruption caused in part by the continual rise of digital media. The paper then reports on a study of six Australian newspaper websites, which were all analysed on the same day in July 2014. The study focused on several elements of each website, including their architecture, story form and content, as well as their business models and use of multimedia. This analysis seeks to assess how newspaper websites are adapting to change and how they are relating to both their own readers and to the printed versions of the same masthead.

The Internet and the business of news

Recognition of the potential of the Internet for news and information came early in its adoption. The Pew Research Center for the People and the Press began a report in 1996 by saying:

> *The numbers are still modest but the Internet is beginning to play a role in the news habits of a significant number of American consumers. Over one-in-five Americans now go online – either at home, work or school. Nearly three-fourths of this group sometimes get news from the World Wide Web or from a commercial service.* (Pew Research Center for the People and the Press 1996: p1)

The Internet posed a double threat to newspapers. Firstly, it threatened sales as people began to use the Internet as an alternative source of news and information (even if often provided by the very newspapers that were under threat). Secondly, and perhaps more important, the Internet threatened to undermine the advertising revenue that was so vital to newspapers. Paul Starr (2009) pithily comments: 'Newspapers increasingly sold not just

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news to readers, but also readers to advertisers' (p3). Starr traces the Internet's role in undermining the newspapers' traditional major revenue source to its dual ability to provide alternative means for advertisers to reach consumers, and for consumers to seek out product information. Online there is no necessary relationship between news and advertising, nor are newspapers the only source of news and information.

As the Internet developed, this pincer movement began to bite. *The Economist* ran a leader for a section on the future of newspapers in 2006 under the headline 'Who killed the newspaper?' (*The Economist* 2006). This reported that employment in the US newspaper industry fell by 18 percent between 1990 and 2004, and that: 'The business of selling words to readers and selling readers to advertisers, which has sustained their role in society, is falling apart' (p9).

While Australian newspaper publishers may have been slow to recognise the threat of the internet to their businesses, the evidence of declining printed circulation and advertising revenue is now clear. All major Australian newspaper titles recorded a significant fall in average daily print circulation in July to September 2013 on the same period in 2012. *The Age, The Sydney Morning Herald, The Sun-Herald* and *The Daily Telegraph* all recorded decreases greater than 15%. The smallest decrease was the weekday *The Australian Financial Review* at 6.07% (Knott 2013).

In relation to print advertising, the story is just as dramatic. Franco Papendrea of the The News and Media Research Centre based at Canberra University estimates that print advertising revenue in Australia fell by 17.7% between 2011 and 2012 (Papendrea 2013). In 2008, newspaper advertising accounted for 30.1% of media advertising in Australia. This fell to just 21.6% by 2012 (Papendrea 2013).

The death of news or newspapers

If there has been a shift away from printed newspapers towards use of the Internet to gather news and information in the last few years, there remains a 'So what?' question. In summary, there have been three key points put forward as to why substitution of the Internet for printed newspapers is a concern.

The first is an argument which has similarities to those made about the demise of the public sphere. Some writers argue that print newspapers are forced by the need to maximise circulation or a commitment to representing multiple viewpoints to attempt to achieve some notion of balance among (at least mainstream) points of view (McChesney & Nichols 2010). Citizens, it is argued, are exposed through their newspaper reading to alternative viewpoints and disparate voices, whereas online they are more likely to visit websites that reflect their particular worldview (Sunstein 2007). This critique, sometimes referring to an echo

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chamber, is also used in reference to television and the demise of the mass audience (Jamieson & Cappella 2008).

In a second, related argument, writers such as Markus Prior (2007) have claimed that decreased reliance on daily printed newspapers is leading to a schism between news 'junkies' who are prepared to seek out vast amounts of news and information online, and an apathetic mass who, having broken the newspaper habit, do not seek out news online. Political information in the current media environment comes mostly to those who want it. In the starkest terms, broadcast television reduced the importance of individual content preferences, while cable and Internet raise them to a level of importance not seen before. (Prior 2007)

The third line of argument is that the print media perform some special task that is vital for democracy and good governance. Alex Jones, in his book *Losing the News,* uses the analogy of a cannonball to describe what he calls: '...serious reported news, the iron core that is at the center of a functioning democracy' (Jones 2009: p1). This core is 'accountability news' or 'news of verification' that, according to Jones, is the base upon which almost all opinion and commentary rests. He maintains that almost this entire base is created by newspaper journalists (he estimates this at 85 percent). Jones goes on to outline a hierarchy of core news, that starts with 'bearing witness', through 'following up', on to 'explanatory journalism' and ending almost inevitably with 'investigative reporting' at the top of the reporting chain. (Jones 2009)

Starr develops this line to argue that we risk a new era of corruption if we cannot find a means to fund investigative journalism. He makes the argument that most online sources of news are essentially parasitic on the old media infrastructure, or, as he puts it more positively: 'The new social media add value when they are a supplement to professional journalism.' (Starr 2009)

While recognising the power of 'non-market collaborative networks', he is sceptical that 'voluntary networks' have the wherewithal to train reporters, pay and resource them to undertake the long and arduous work needed to investigate stories in depth. Without the 'gushing profits' of monopolistic print newspapers, neither the declining print media nor the burgeoning online news-related sites can carry out the necessary investment to continue to play this role. Starr concludes that the potential end of the newspaper age would fundamentally change the relationship between citizens and the state because newspapers traditionally played a role in exposing corrupt practices of both the state and business:

If we are to avoid a new era of corruption, we are going to have to summon that power in other ways. Our new technologies do not retire our old responsibilities. (Starr 2009)

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In response Yochai Benkler largely agrees with Starr's analysis on the likely demise of printed newspapers, but goes on to disagree with his dire warnings (Benkler 2009). Benkler argues that one needs to be realistic about the limited nature of the press's record on 'corruption-busting'. Further, through a variety of means, web-based news services will be able to provide a similar (imperfect) brake on corruption and abuse of power. These means include: existing offline providers strengthening their web presence and increasing the revenue they derive from these activities; the emergence of more small-scale commercial media able to set up due to much smaller start-up costs in an online environment; and the harnessing of social production, often of ideologically committed participants and the emergence of new independent models for not-for-profits that will undertake serious journalism. Many commentators, including Benkler (2011), have seen in the 'Wikileaks' episode a positive sign of the new era of online scrutiny of the rich and powerful. Bill Dutton, in his work on the potential for online networks to create a 'Fifth Estate' of networked social accountability forecast this possibility (Dutton 2007). He concludes that this Fifth Estate can be a check on the 'other' estates, including the press potentially increasing the diversity of voices and opinions that can be heard (Simons 2007).

Newspaper websites

The remainder of this paper reports on a study of six Australian newspaper websites, which were all analysed on the same day in July 2014. The publications were the *Australian Financial Review,* the *Herald Sun,* the *West Australian,* the *Age,* the *Australian* and online-only *Guardian Australia*. The study focused on several elements of each website, including their architecture, story form and content, as well as their business models and use of multimedia. This analysis seeks to assess how newspaper websites are adapting to change and how they are relating to both their own readers and to the printed versions of the same masthead.

The study focuses in greater depth on Melbourne's two daily newspapers, *The Age* and the *Herald Sun*, comparing and contrasting their content across both online and print platforms. By analysing two papers – with both broadsheet and tabloid sensibilities – we gain insights into the dynamic tensions at play in this evolving news presentation format. In doing so, we briefly review the history of these platforms, from early perceptions of them as rivals to their current coexistence.

The timing of our review turned out to be significant in that July 17, 2014 was the last day for several weeks when news coverage was not dominated by the slow-developing stories of Israel's 2014 Gaza war and the political, military and diplomatic fallout from the downing of Malaysia Airlines Flight MH17 over Ukraine. Both events would have their inception several hours after our review window closed.

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In the first part of this paper we sought to establish that newspapers are in trouble. We provided a brief history of the process through which newspapers lost their dominance under competition from digital media. We also demonstrated that this poses risks, particularly to the process of gathering news and the funding of serious journalism. It also threatens to alter the news consumption habits of newspaper audiences. In this part of the paper we begin the discussion about how the new news environment is developing. We do this by comparing and contrasting printed and online newspapers.

There is an emerging orthodoxy around the architecture of newspaper websites. Each of the sites we observed had organised its pages in coherent and ordered ways to prioritise the most important content and showcase its particular strengths and areas of interest.

Their homepages combined a mixture of text and visual elements that created a sense of activity and vibrancy and enticed readers to engage with the material. The content was arranged so that readers could easily navigate their way to the stories they were most interested in and skip over other categories of information.

The *Financial Review*'s website published its most important breaking story near the top of the homepage. In printed newspapers this prominent position is described as 'above the fold'. The *West Australian* had reserved this space on its homepage for a striking image of a proposed new stadium. In a printed newspaper this type of story is described as the 'splash' and, in much the same way as a front-page picture-based story in print would 'spill' to another news page, the website picture is accompanied by a link that takes the reader to the related text story. However, the decision to place a picture-based story so prominently above the fold relegated the day's biggest breaking news to the lead item among the news tabs below the image.

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Figure 1 – The Front page of the West Australian on the day of the study.

Guardian Australia, hereinafter referred to as the *Guardian*, made it clear that repeal of the carbon tax was its main story, giving it prime position and around twice the size of other major stories with an accompanying picture that would have taken up around a third of most people's view of the front page. The *Australian* had the story as its lead but did not give it more prominence than other stories, although there was an accompanying opinion piece to the right of the story that had a larger accompanying graphic linked to a related video piece.

It was notable that not one of the three leading articles run by the *Age* in its daily print edition was among the leading three posted on the newspaper's website.

The websites generally placed a premium on rolling news content, with the most important breaking news taking up prime position. Many traditions of print newspaper design and reporting were reflected in the placement and treatment of major breaking stories.

The stories followed the traditional inverted-pyramid form with the most important information contained in the first paragraph. For example, on the day of our study, the most important story concerned the abolition of the carbon tax in the Senate. This had occurred in

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the hour before we began looking at the websites. The first paragraph of the lead news story on the *West Australian* website declared: "The Parliament has repealed the carbon tax after days of lengthy debate and negotiations." The *Guardian* went with "Australia's carbon price has been repealed, leaving the nation with no legislated policy to achieve even the minimum 5 percent greenhouse emissions reduction target it has inscribed in international agreements." The *Australian* made the story about Prime Minister Tony Abbott, with the front-page headline 'PM's promise fulfilled as tax is axed'. The story then opened with quotes from Abbott.

The *Financial Review*'s reportage was even more succinct. It said: "After two years in operation, the carbon tax is dead." Its story was labelled an 'update'. This hints at the versatility and durability of the inverted-pyramid news-writing model, which has been retained as the most common newspaper story form on new platforms, including newspaper apps, tablets and websites.

The inverted pyramid was originally conceived as a means whereby printers could reduce the length of news stories while they were being laid out in hot metal presses, but without requiring the typesetter to read the inky text. If a story needed shortening, it would simply be cut from the bottom in the safe knowledge that the most important information was contained at the top of the story. The Internet has removed this constraint because news stories that run into sub-pages are not limited by space constraints. However, the inverted pyramid remains the news-writing model of choice because it allows for two important factors, both of which are vital for newspaper websites. The sites only include the first paragraph or two before the link takes the reader to the sub-page. The inverted-pyramid story form ensures the most important information is contained in the visible paragraphs and allows the reader to make an informed decision about reading on. It also allows for information in rolling updates to be added above the old text, with the new lead paragraphs containing the most important new information.

The newspaper websites' homepages embody many of the other elements of printed newspaper front pages. The mastheads are prominent at the top of the pages and the main news stories are highly visible. There are compelling images across the homepage and they follow a reasonably predictable format from one day to the next. Interestingly, the homepages do not generally display the day's date, underscoring that the websites operate in a permanent state of change. Stories, however, are date-stamped because this is an important element for readers seeking to fully understand the information within them.

Equally interestingly, the advent of the 'eternal now', as evidenced by the abolition of the fixed dateline, has led to the virtual disappearance of the word 'today' from Internet news coverage. In its place we see either the term 'this day' or the date itself. While this may

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irritate the reader in an online newspaper's hometown, it is presumably welcome to readers in the US, Europe or at an Internet cafe on the backpacker trail in Africa, because it removes a source of confusion for those in other time zones. The semantic shift has another implication: the end of today, yesterday and tomorrow not only shrink-wraps chronology itself but helps to establish a newspaper's credibility in the global media community. There is no reason why the *West Australian*, indeed aided by being situated on an East Asian meridian, shouldn't market itself as a global newspaper. However, as we shall soon see, there is a tension – born of its actual and perceived maximal readerships – between a global perspective and a lingering (perhaps even justifiable) provincialism.

By convention, the indexes of printed newspapers are generally located on either the left or right columns of the second page. However, newspaper websites elevate their indexes by using tabs across the top of their homepages. These tabs directly reflect the publications' various emphases. For example, on the day of the study, the *Financial Review*'s tabs were National; Opinion; World; Technology; Markets; Personal Finance; Lifestyle; and Interactives. The *West Australian* had two tiers of tabs with Sport; Business; Life + Style; Entertainment; Travel; Countryman; Motoring; Regional and More on the top row, and, somewhat confusingly, a second tier of links called Latest; WA; National; World; Full Coverage; Anzac; Galleries; Video; Weather; Health; Real Estate; Jobs; Funerals; and Place an Ad.

Like all newspapers in their choice of homepage-heading tabs, the *Age* signalled that it knew and looked after its own. Left to right, they could have been a mind map drawn by any middle-class professional: after the predictable News and Sport they read: Business; Politics; Comment; Tech; Entertainment; Life & Style; Travel; Cars; Property; Multimedia. The last in the list, Subscriptions, made a more direct plea to reader loyalty.

The *West Australian*'s Regional tab steered readers to a site hosting several country papers owned by the same company. Each of those papers was, in turn, reached through a secondary suite of geographically designated tabs, rather than tabs bearing the names of the individual mastheads. For example, clicking on the Goldfields tab automatically took readers to the homepage of the subsidiary *Kalgoorlie Miner* newspaper.

The *West Australian*'s website sought to capitalise on the material at its disposal. Although the regional tabs were essentially just links to affiliated newspapers, it seems that the site was designed to look as if it was providing state-wide coverage. So too, the website's links to video content created a sense that the *West Australian* website was a multimedia news outlet. However, it soon became apparent that virtually all the video stories were cut-down segments of reports from news bulletins produced by the newspaper's affiliate, the Seven network.

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The *Australian* also relied heavily on footage from Fox Sports and Fox News that News Corp partly owns. A number of stories were accompanied by studio-based pieces to camera from their leading journalists and at least one lead story had a video attached that was only tangentially related to the print story it accompanied. On the other hand the *Guardian* had no obvious Australian video content and only one of the news stories on its front page had accompanying video. This was, however, compelling video taken by a journalist recording an Israeli bomb strike that killed four children. More broadly in relation to video content, *The Guardian* has used its reach to develop regular series of video programming, including movie and television reviews. These longer-form videos (10 to 15 minutes long) are prefaced by a 30-second advertisement.

Websites and the printed edition

By early afternoon on the day of our study, it was apparent that the websites bore little resemblance to the printed editions. The breaking news about abolition of the carbon tax, which ran on every website we studied, ensured that the websites' lead stories no longer matched the lead stories in the printed editions. In most cases the latter were reflected somewhere in the content on the website homepages, but not universally. On the day in question, the above-the-fold news story in the printed version of the *West Australian* was entitled '$300b black hole' and reported details about Treasurer Joe Hockey's attempts to find other cuts after elements of his Budget had been blocked in the Senate. This story did appear on the *West Australian*'s website homepage, but it had been relegated to the last news story. Meanwhile the splash story about the new stadium, which dominated the website homepage, appeared nowhere in that day's printed version.

A notional visitor to two websites during our review 'window' could easily have been left baffled by just how parlous the nation's finances actually were, for with that '$300b black hole' fresh in her mind our website visitor might have felt relieved when clicking on the *Financial Review* site to see the headline 'Hockey's budget hole heading to $41b'. Only on closer inspection might she have noticed that these two news items were not actually contradictory.

The smaller projection related to the deficit forecast for the last quarter of the current financial year; the alarming news that the nation is 'facing a $300b black hole' is contained in the *West Australian* story's lead paragraph: only five paragraphs further down would the eagle-eyed site visitor discover that $300 billion is how much 'further in the red' the economy is expected to descend 'over the next decade'. It would appear that over in the West it is not only the miners, but a less than scrupulous media, that dig themselves into deeper holes than anyone else's.

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In The *Australian*'s print edition the two main stories were 'Rich will bear load of petrol excise' and 'Returned radicalised jihadis "a significant risk" '; on the website the former was still the most prominent article after the carbon tax repeal but the latter article had slipped down below the second banner ad to a position that was not visible without scrolling down.

The lead story in the *Financial Review*, concerning a financial inquiry conducted by ANZ chief executive David Murray, was not on the website homepage at the time of our study. It was accessible via the Financial Services tab, but readers searching for it would have been disappointed to discover that it was blocked to non-subscribers. It appeared that access to approximately half the stories on the site was conditional on payment of a subscription.

Were it a matter of one or two articles being replaced by a developing story, that might be explicable by reference to normal story churn, but this was not a particularly fast-moving news day, which leads us to conclude that either the perceptions of editors as to 'what is news' under the printed masthead and the electronic masthead are drastically divergent, or that the same decision-makers are consciously setting out to attract different audiences to their separate platforms.

The banner headlines to the lead stories carried on that day's front page of the *Age* were, in descending order of importance, 'Tamils on high seas', 'Napthine pressing Transurban for M1 toll revenue' and '*Les Misérables* original manuscript coming to Melbourne'. Online, the *Age*'s three main headlines were: 'Carbon tax axed', 'ATO's $200,000 tax bill, corrected to $8000, sparks $5.8m lawsuit' and 'Mexican "house of horrors" raided: 596 living in captivity'. As if extra evidence were needed of distinctive news judgments being made across the platform divide, it is worth observing that in the print version of the *Age* an article about a man 'punching' a teacher took up nearly half the front page (even without a very prominent headline, a clear calculation by a news editor that this is a story worth 'splashing'). Yet the same story, under the same byline, rates only fifteenth out of twenty-six in terms of prominence in the online version. To understand why, we could reflect on how Internet news has evolved within the spectrum of news presentation formats over the past two decades.

Paywalls

The *Financial Review* has trialled several business models and had to step back from early experiments with high paywalls when they were deemed too extensive and too expensive. The paper was an early adopter, by Australian standards, of limiting access to content and paid a price for seeking to exact income from readers. Its website now has a mixture of free and locked stories – a model now common among newspaper websites and news blogsites. On the day of our study, several lead stories, including reports about Rupert Murdoch's bid for Time Warner and Treasurer Hockey's call for G20 nations to lift productivity, were

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blocked. When the reader clicked on the link, a banner appeared with the message: "Already a subscriber? Please LOGIN HERE." If not, the reader was assured he could "STAY WITH THE STORY for less than $1.90 a day". A *SUBSCRIBE NOW* tab took the reader to a site where he could sign up.

The *Australian* operates a similar paywall that restricts access to 'premium' content. On the day of our study, the first three stories and related stories were all behind the paywall. Overall, some two- thirds of the content on the first page was inaccessible to non-subscribers.

Figure 2 –*The Australian* newspaper has active paywalls. On the day of the study six of the top seven stories were behind paywalls.

The *Herald Sun* and *Age* have both erected paywalls that enable a certain number of visits for free. The *Herald Sun* enables five visits per week for unregistered users and ten for those

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who do register. The *Age* allows non-subscribers thirty visits per month. The *Guardian*, in keeping with the policy of the organisation, does not use paywalls.

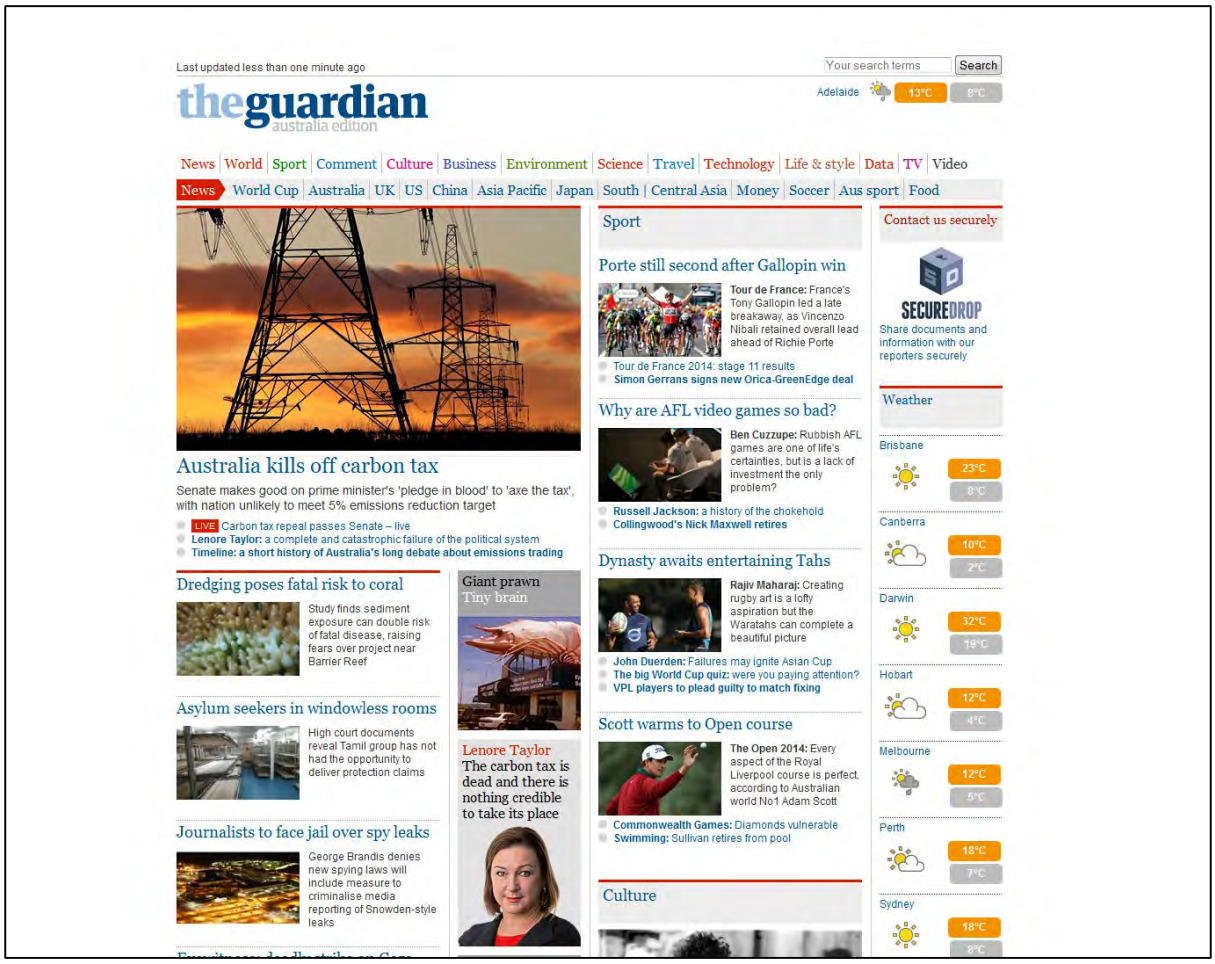

Figure 3– The Guardian front page on the day of the study when all content was freely available.

The process of choosing what goes behind a paywall and what remains free to readers is, we suspect, more a black art than a science. There are several competing factors to consider. All reporters want their stories read, so those who become editors have a natural tendency towards open publication. However, business imperatives are increasingly important and there is a greater acceptance by reporters of the need to operate commercially. Editors know that publications thrive on relevance, and that this depends on the impact stories have, which is in part based on the access readers and other media outlets have to those stories. So placing an important story behind paywalls can damage the publication, even though the significance of the story might drive large numbers of people to pay for the material. Against this, editors must consider – for it is usually editors and not business managers who make these decisions – whether the nature of the material might appeal to a section of the readership with a greater capacity or imperative to pay for it. In other words, will the material attract new and generous subscribers? Then there is the desire to reward

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subscribers, by providing content for them alone, in recognition of their investment in the publication.

Most newspaper websites make these decisions around the clock, placing some content in the public realm and other content behind paywalls. Our study indicates that the criteria driving these decisions are complicated, subjective and inconsistent.

The *Financial Review* did leave several stories in the public domain. Perhaps in making these choices, the publication considered the ubiquity of the material in question. If a similar story could be read somewhere else for free, there would be little point denying a reader access to it on the *Financial Review* site: in fact, it could drive readers away to other publications. This would explain why the breaking story about the abolition of the carbon tax and the aforementioned report about Treasurer Hockey's black hole – however large it turned out to be – were offered free of charge.

Newspaper websites must also maximise the capacity for their stories to 'get legs' and generate follow-up stories by other publications. This could explain why other stories on the day of our study were freely available, including a column by former federal Opposition Leader Mark Latham, which detailed the findings of a controversial Supreme Court decision.

Other stories are offered freely for more obvious reasons. Tabs such as Personal Finance and Life + Style have a greater tendency to open platforms for advertising. It is clearly in the publication's interest to drive as many readers as possible to these sites, especially as billing rates for online advertising are often indexed to page views by readers.

In contrast, the *West Australian* appeared to have no paywalls. If content was promoted on the site it was fully accessible to the reader. The catch was that stories on the site tended to be older news, as if the website was regarded as the place where stories were put out to pasture when they had had their day in the printed version. Nevertheless the website was populated with a great deal of material – sourced, as we have reported, from the *West Australian* itself as well as the media group's affiliated regional papers and TV network. This provided a powerful platform for advertisers to promote products and services to readers. This is a variation of the long-tail business model, which recognises that publishers can generate considerable revenue by archiving and indexing their products and making them available long after the material has ceased to be current. The *West Australian* appears to have decided to create such a platform, without taking the step of constructing paywalls to force payment readers to pay for these stories. To protect the competitive advantage of the printed newspaper, it has opted to withhold the most current content from the website, effectively driving readers back to the printed edition.

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A focus on one market

This section focuses in greater depth on Melbourne's two daily newspapers, the *Age* and the *Herald Sun,* comparing and contrasting their content across both online and print platforms. By analysing two papers in the same geographic market – one with both broadsheet and tabloid sensibilities – we gain greater insights into the dynamic tensions at play in this evolving news presentation format.

Pam Williams's *Killing Fairfax* and Ben Hills's more recent *Stop the Presses!* both describe at length how the challenge posed by the Internet to 'business as usual' was routinely under-estimated. These authors observed that over the past twenty years those working in the online sections of newspapers were viewed with contempt by their older and 'superior' print-based siblings, most of whom were determined to maintain their primacy in each publishing house. At the *Herald Sun* and the *Age* during this period, the authors witnessed how 'Internet staff' were regarded as a hybrid between "kids barely out of school" who were playing at making newspapers and an interesting experiment that was but a sideshow to serious journalism.

Today, largely because online is the main source of news for most Australians, older heads dare to hope it may end up saving the entire family of newspapers from ruin.

Such hopes may yet prove justified, if a snapshot of viewer interest in the Melbourne newspapers' online product holds true in the months and years to come. In June 2014, the *Herald Sun* claimed more than 1.7 million unique visitors to its news website. For the same month, the *Age* told us that, according to Nielsen, its website received 2.027 million unique visitors.

This is paradoxical, given that the *Herald Sun* has a print circulation of 340,000 per weekday, at least three times that of its rival, and suggests – provided that the *Age* monetises its online presence at least as successfully as its hometown competitor – that launching news into cyberspace is the first healthy response to the Internet evinced by Fairfax since the invention of the Web a quarter of a century ago.

In the online world, as demonstrated by both newspapers, homepage editors prefer the 'flattened' landscape on which no one story soars above the others, with the lead indicated only by its placement at the head of a story list and the deployment of a slightly bigger headline than the one used for other items.

In both newspapers' lead stories, we found that, as with the other news sites reviewed, the "storytelling' approach to news reportage adheres steadfastly to the inverted-pyramid model.

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As to content, we could not conclude that either paper on the day of review had significantly dumbed down its news or opinion columns, regardless of platform. The *Age* used its screen space to roll out seventeen compelling paragraphs by Walkley-winning feature specialist Tony Wright under the headline 'PM leads cheers for Murdoch "gift" ', which as it was celebrating the fiftieth anniversary of a significant competitor to the *Age* in the *Australian*, appeared at first blush to be evidence of either high-minded fairness or commercial naivety. Reading Wright's critical opinion of the *Australian*'s performance in recent years suggested a third interpretation: the *Age* was offering a gratuitous opinion on some of the perceived shortcomings of its competition, commonplace in the history of proprietorial fulminations ever since David Syme was the 'new kid on the block'. (See Figure 4 below.)

Significant space was also given to occasional columnist and former staff writer Julie Szego who eviscerated PM Abbott for channelling previously unnoticed Australian admiration for the efficiency of Imperial Japanese Army soldiers.

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PM leads cheers for Murdoch 'gift'

July 16, 2014 - 6:46PM

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Tony Wright

National affairs editor of The Age

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Words and Pictures

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Changing outfits

Glynis Traill-Nash on the Paris trends [PERSONAL OZ P16]

Bring him home

The plot to lure Bennett back to the Broncos [SPORT P36]

PAUL KELLY A carbon price has already destroyed two Labor PMs. What is Shorten thinking? [COMMENTARY P12]

Throw open our doors to those who cherish our values: Murdoch

INSIDE 50 THE AUSTRALIAN

Friends in high places: Tony Abbott helped *The Australian* celebrate its 50th birthday.

Every Australian political leader since Black Jack McEwen and John Gorton has cosied up to Rupert Murdoch – or tried to – but none has done it quite so publicly or effusively as Tony Abbott.

The Australian newspaper, according to Mr Abbott during his enthusiastic celebration of the paper's 50th birthday on Tuesday, has been Mr Murdoch's gift to our nation.

Mr Abbott has every reason to enthuse about Mr Murdoch and his newspaper, of course. Mr Abbott, as a young journalist, wrote editorials for *The Australian*, and Mr Murdoch's media empire went boots and all at the Labor government during the last election, endor

Figure 4 – *Age* columnist Tony Wright in his on-line commentary piece featuring a print version of the opposition *Australian* newspaper.

On July 17 the *Herald Sun* was making full use of its most (in)famous columnist, Andrew Bolt, whose thousand or so words were summarised for its online audience with a nine-word proposition: "Carbon tax goes, snow falls in Melbourne: sceptics rejoice'.

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Rolling out 'big guns' from the worlds of media and politics could be seen as the *Herald Sun*'s preferred approach to running a serious marketing campaign: on this day Andrew Bolt shared the computer and tablet screens with Jeff Kennett and Eddie McGuire, both practised controversialists.

Yet, ironically, the evidence from our review period leads us to conclude that the *Age* runs a more opinionated news website than the *Herald Sun*.

By coincidence, each site published 53 articles in the six hours under review. Of the *Herald Sun*'s 53, just over three-quarters (77 percent) were factual articles without any admixture of authorial opinion, whereas the *Age* ran only two factual articles for every opinion piece (64 percent to 34 percent). Fewer than one in five (19 percent) of *Herald Sun* online articles were totally or partly expressions of opinion as opposed to reports of fact.

Whether by design or default, on this day the *Herald Sun*'s male columnists wrote on more 'serious' topics, their female counterparts on 'lighter' ones. Anyone uninterested in Bolt mirroring Wright of the *Age* with his own take on internecine media warfare (Bolt's column ran under the headline 'Why is the ABC barracking for Hamas?') could turn for relief to Susie O'Brien's 'think piece' on stay-at-home mums – a serious topic handled in what might be considered a dumbed-down way – or to Wendy Tuohy's observations on 'princesses and sluts', a stream of consciousness so lightweight it seemed in danger of floating off the screen.

Contrary to the opinion of some media commentators, the *Herald Sun* does not eschew investigative journalism altogether. On this day it continued to run an eight-day-old opinion piece – news websites extending the life of its content products far beyond the use-by date of those in its print counterpart, which tends to be the same as the date of the paper itself. This opinion piece, written by Charlie Bezzina, was tagged 'The Investigator', but there was no investigation involved in the piece, notwithstanding that.

Conclusion

The Internet has disrupted the business model of traditional printed newspapers. This disruption has been obvious for at least five years and news organisations, to a greater or lesser degree, have been grappling with this for the best part of a decade.

This study has identified that orthodoxies around the construction, architecture and form of websites have developed and there are common approaches to story treatment. There are new traditions around the use of links and video and even advertising which may give new life to old stories or bring new dimensions to storytelling. However, studying newspaper websites is not an illuminating experience for we do not get to glimpse a new paradigm that somehow amounts to a vision for the future prosperity of the news industry. Instead we see

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innovations and modifications that amount to little more than tinkering. We have seen the disruption: what we now need is another wave of innovation and creation.

None of this adds up to a sustainable model, to the extent that there are as many commonalities across newspaper sites as there are differences between them. And these differences underscore the fact that newspaper websites are still experimenting with a broad spectrum of business models. As the editorial content is crucial to the business success of printed newspapers, so too the news content of newspaper websites is shaped by commercial considerations. How that content is archived, displayed, retrieved and accessed is largely determined by the business model being used.

It is because the business model does not translate neatly from old ways of content delivery to new ones that advances in how the media harness the power of the Internet continue to be driven by experimentation rather than collected wisdom.

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Project-Based Management Technique for Radiofrequency Spectrum Planning and Allocation

Part One: The Business Case

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Abstract—Spectrum Management is the regulatory action of defining the use of the radiofrequency spectrum. Often this requires the clearance of a large number of incumbent systems to make way for new technologies such as Fourth Generations Mobile Broadband (4G). While great economic benefits may be derived from the new technologies the clearance of any band will come at a cost. It is important both costs and benefits be quantified and compared. In many administrations including Australia these processes are carried out without a defined project management structure. In the first of a series of two papers the Authors combine over 40 years of radio systems and planning experience to suggest a methodology for project-based management of spectrum planning activities.

Keywords—project based spectrum management;

Introduction

Spectrum Management is the combination of a number of key fields to produce a 'spectrum product'. The product is the technical and administrative definition of how a particular block (or band) of frequencies may be used. The art of spectrum management draws on the four areas of engineering, allocations, economics and policy to produce the final outcome as shown in Fig. 1 below.

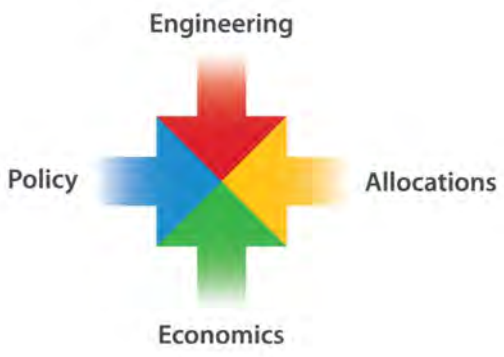

Fig. 1. Skill-sets in the Spectrum Management Process (Kerans 2011)

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Bringing these four areas together within the project environment is a difficult task as each discipline is usually in a separately managed area. Because the technical frameworks behind a block of spectrum and the technologies that define these are resident in the engineering world, engineers tend to be the first to suggest the need for a change of use of a particular band and are the ones who then define the technical parameters. However economists must decide if there is a total net benefit to be gained and policy officers must 'wrap' the spectrum for allocation. This is a complex multi-disciplinary problem requiring expert through-life management. Spectrum Planning as a profession could benefit from a project-based management approach which requires the development of a specific technique suited to the somewhat arcane art of spectrum management. As the first part of this process this paper presents a suggested methodology for the development of the initial spectrum planning business case.

Spectrum management, is it a project?

First, using the definition from the Project Management Institute (2014) a spectrum planning process can be compared to more common projects (text from PMI in italics):

> *More specifically, what is a project? It's a temporary group activity designed to produce a unique product, service or result.*
>
> *A project is **temporary** in that it has a defined beginning and end in time, and therefore defined scope and resources.*

A spectrum management exercise has a defined beginning and end where it comprises the replanning of a band for a new technology. Traditionally it begins when the need for change is first proposed and the consultation process begins, which includes putting the team together and developing the project plan and it ends when the spectrum is reallocated.

> *… a project is **unique** in that it is not a routine operation, but a specific set of operations designed to accomplish a singular goal. So a project team often includes people who don't usually work together – sometimes from different organizations and across multiple geographies.*

While the inputs to the project are known and the skill-sets well defined, like shipbuilding, in the case of a spectrum planning process they have been brought together to produce a defined objective, the refarming of a particular band or bands. If carried out correctly this process is unlikely to occur again for at least two decades, if at all, thus the project is indeed unique.

> *And all must be expertly managed to deliver the on-time, on-budget results, learning and integration that organizations need.*

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Therefore a spectrum planning exercise meets the PMI criteria and is indeed a project requiring expert management using recognised project management principles.

The spectrum management business case

> *A business case is a recommendation to decision makers to take a particular course of action for the organisation, supported by an analysis of its benefits, costs and risks compared to the realistic alternatives, with an expectation of how it can be best implemented* (Gambles 2009).

In an average spectrum planning exercise the actual planning team including engineers, policy analysts and economists will rarely exceed ten people, so with associated overheads such as travel the 'hard' costs of a project management exercise will rarely be significant when compared with the economic impact of the project.

This paper therefore concentrates on the 'soft' and 'hard' costs and skills associated with a successful spectrum management process and the 'sale' of that process to the decision-makers as the key stakeholders who will eventually decide whether it proceeds or otherwise.

The 'hard' costs of a spectrum project

In developing a business case spectrum planning engineers must present the facts as they stand along with the hard and soft costs. The hard costs can be simply stated as the number of full time equivalent (FTE) personnel that will be needed for the project. Assuming an 'average' overhead for each FTE the hard cost of the project can be defined. This is then the opportunity cost lost to potential other spectrum projects in undertaking the project being presented and this opportunity can be taken into account by the decision makers.

The 'soft' costs of a spectrum project

The soft costs of a spectrum planning exercise are much harder to define. In the case of mobile broadband; the sought after bands are generally between 500 MHz and 4.2 GHz. None of these bands is unused and many are home to a significant amount of installed and operating equipment. The cost to retune or in many cases abandon or completely replace this equipment must be estimated along with the value of any lost services to the economy.

On the other side of the ledger both the return to government from the sale or lease of the spectrum should be combined with an estimation of the additional economic benefit that will be derived from the new use.

In Australia the spectrum regulator is the Australian Communications and Media Authority (the ACMA). The ACMA is a world leader in spectrum management and is well advanced in

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defining the economic decision that are needed in spectrum planning. In its 'Principles for Spectrum management" and in many spectrum consultations the ACMA states:

> *"In determining what actions maximise the public benefit, the ACMA uses a Total Welfare Standard (TWS). The application of a TWS enables the ACMA to adhere to a consistent conceptual framework when assessing the public interest impact of any regulatory proposals it considers. A TWS requires consideration of the total benefit (economic surplus) of a regulatory decision. The approach that results in the greatest net benefits is regarded as the approach that best promotes the public interest. The impact of a decision on particular groups should be evaluated as part of the analysis, but issues associated with the distribution of benefits and costs between different parties should be addressed as a separate and distinct policy question.*
>
> *In formulating proposals and ultimately deciding on future arrangements in the band in future stages of the review, the ACMA will consider the costs and benefits associated with any potential changes in line with a TWS"* (ACMA 2009).

Lobbying: the greatest risk of failure

Associated with a large installed equipment base is the potential for political lobbying, particularly when large influential users such as the Defence Department of the broadcasting industry is affected. In any modern spectrum planning exercise this represents the greatest risk to the project and may even see a viable project fail due to political influence or intervention.

This should be addressed as a high risk in the risks and opportunities section of the business case along with a thorough and convincing mitigation strategy.

The mitigation of this particular risk will be of particular interest to all government decision makers and indeed their political masters. The only true mitigation will consist of a thorough and well prepared and articulated communications strategy based on a sound business case.

A spectrum communications strategy

Traditionally in Australia the communications strategy has consisted of a number of consultation papers aimed at gathering the information required to make an informed decision on change. However as spectrum access becomes more fraught with more and more systems being affected by the seemingly insatiable demand for mobile broadband, both the economic analysis and the communications strategy should now be developed prior to the commencement of the project and presented in the business case.

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A spectrum planning communications strategy will need to be two-pronged. One avenue of communication should be dedicated to openly informing incumbent operators and potential beneficiaries of the change of the processes and the outcomes of an economic analysis of the project. Communication should be open and honest and feedback should be verified and where a change is suggested, that change made or the suggestion taken into account.

The second avenue of communications should be to management, politicians and the general public. In a democratic society politicians will try to do what is best for as much of the community as possible. So if a positive message is sold to the public, this will benefit the political process and provide a buffer to any possible political intervention.

The public will want to know what they get from the project, for example faster mobile broadband, and will need to understand how what they lose (if anything) will be replaced.

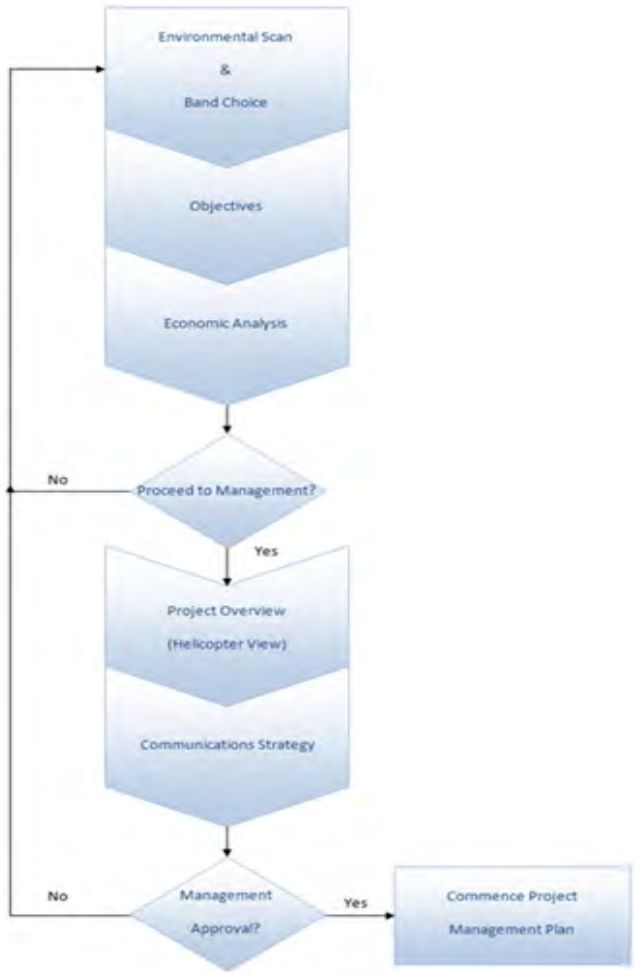

Fig. 2. Spectrum Management Business Case Process (Authors)

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Selling the project- a suggested process

The spectrum planning business case should present information in an easy to follow manner with reasons, costs, risks and strategies well laid out and documented in a way that all levels of management can understand. This is particularly important in engineering or spectrum projects which are usually engineering based.

The first piece of information a decision maker will want about the proposed change is 'why?' To address this, the project manager must define the mission, what is the objective and the timeframe over which the project is expected to run?

The second part of the answer to 'why?' is the economic appraisal or the cost benefit analysis of the project taking into account actual costs (costs of equipment and return to government) as well as the overall economic cost or benefit using a methodology that takes into account real benefits such as income from the sale of the spectrum and resulting from its use as well as public good benefits (such as the loss or provision of a capability in a public service entity such as police or defence).

Assuming the economic ledger is favorable and the project return is greater than other projects seeking access to limited resources, the project manager should recommend that the project proceed but that management should examine the risks and mitigating factors.

The risk analysis, telling it like it is

The risk analysis must be an honest and forthright presentation of any major risks to the success of the project, and particularly those that could cause actual or reputational harm to people, politicians or the regulator. Opportunities would also be identified as part of the risk analysis as they are seen as positive risk events rather than those with negative outcomes.

A major risk to any spectrum management process, providing the engineering work is thorough and peer reviewed, is likely to be the risk of political intervention (Chirgwin 2012). As previously discussed the mitigation strategy is a thorough communications strategy combined with open and honest consultation.

Other risks that may be addressed include the risks that the economic analysis was flawed or that elements were omitted. If this were to be the case incumbents would discover it and that would be evident in their lobbying.

Another risk may be that the environment was not properly scanned and the band chosen is not the best band for the purpose. This would result in a bespoke spectrum arrangement which would not attract the economies of scale evident in a harmonised approach.

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The plans of other countries or regions should be considered. There is a risk that even if the right band is chosen, a plan developed prematurely or in isolation may not be widely adopted, again affecting the cost of equipment and the ability of users to roam internationally.

There are many other risks and the entire (proposed) project team along with any other identified expertise should be brought together to identify risks and mitigation strategies and decide if they warrant inclusion in the business case. However while some risks may be insignificant no real risk should be ignored or omitted as without a strategy the project may suffer and the project manager held to account.

Each risk should be paired with a strategy to combat it commensurate with the likelihood of it happening or the outcome if it did. A common risk management matrix is useful in this exercise. (See for example (DMO Liability Risk Management Process)

Strategies for success

In this element the basic strategies that the project team will use to ensure a successful outcome should be presented. At the business case stage these should be well considered but need not be fully developed.

Examples of strategies would be the number and purpose of each consultation stage, where the project would be re-evaluated in an iterative process and any particular strategic elements to the overall communications strategy reviewed based on the responses to each stage.

Strategies to 're-home' displaced systems should be considered at this stage as co-mitigation along with an effective communications plan. There is also the potential for compensation, either directly or indirectly via incentive auctions (see for example Cramton 2011), which may mitigate the risk of stakeholder opposition.

This is also a time for individual milestones to be identified and any initial plans to deal with slippage and float presented.

What is known as a 'helicopter view' of the entire project from inception to allocation should also be presented as a part of this stage so that the decision-makers can see the use of resources over time and gain an understanding of when certain risk elements may require special attention.

These elements are combined in the business case development process pictorially described in Figure 2. This process also defines two 'decision points' at which a decision is made whether to proceed to the next stage or otherwise.

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Go or no-go? - The business case decision making criteria

Using Fig. 2 as a guide we can step through the proposed spectrum business case flowchart.

In a spectrum management process certain bands are allocated to certain services in the International Telecommunication Union (Radiocommunications Sector, ITU-R) table of allocations (ITU 2012). This table is generally reflected in each Administration in a similar document, for example in the Australian Radiofrequency Spectrum Plan (ACMA 2013). This is at a high level the first indicator that a band may be suited to a new use.

Beyond that there need to be standards to support equipment manufacture. In mobile telephony there are a number of these, such as those made by the '3rd Generation Partnership Program' (3GPP). This is the first step in ensuring economies of scale and thus economic return. The final stage is harmonisation to enhance economies of scale and enable device roaming. This is vital as a 'bespoke' spectrum arrangement can isolate an Administration.

Once a band has been chosen the final arrangements may be suggested or work may be needed to negotiate them internationally. Regardless at this stage the objectives of the process should be set and tested against an economic analysis (or cost benefit analysis). At this stage the effects of various allocation techniques, such as incentive auctions, can be tested.

Of course the entry of a new technology need not be based on clearance of the old. Where sharing is possible this should be explored. However sharing spectrum means that an element of risk is passed to both the incumbent and new entrant and in this scenario the opportunity cost of this risk needs to be analysed.

Now the economic analysis described in section 5 should be undertaken and at this stage the project sponsor should, based on the outcome of the analysis, decide if the development of the business case should proceed and be taken to management for decision.

If the decision is made not to proceed, but spectrum is still required the environmental scan should recommence and the same process followed.

If the economic analysis suggests the project should proceed a helicopter view of the project should be developed outlining the basis of the project management plan, the risk analysis and the outcome of the economic analysis.

At this stage the combined stakeholder management plan and communication strategy should also be developed and presented, along with the helicopter view, to management for final approval.

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A loop back to environmental scan is shown at this stage, assuming management approval is not given. However non-approval may be due to a number of factors and a return to environmental scan should only be taken if the reason for refusal was the band choice. In many cases simple adjustment to the economic analysis, risk analysis or communications plan may seal approval at a second pass.

If approval is given to proceed, a full project management plan (PMP) should be developed which incorporates elements of the business case, stakeholder engagement plan, risk analysis and communications plan. Resource implications, timelines and project flow should be examined in the PMP. Management may or may not wish to examine the full PMP prior to final go ahead, and this decision will most likely hinge on the risk analysis and mitigation strategies presented as part of the business case.

Conclusions

Spectrum is an increasingly valuable natural resource which best serves society when allocated to the highest value use (ACMA 2009). However with the increase in demand for mobile broadband empowered by portable devices such as the ubiquitous 'smart phone' (Deloitte 2014), access is becoming more and more challenging. Decisions by regulators will in the future be potentially challenged by adversely-affected stakeholders and the ability of the regulator to make decisions that are fully defensible will depend on thorough project management planning and implementation. Alternatively decisions to not make change may be challenged by proponents of new technologies and again the ability of a regulator to regulate will be weakened.

Spectrum access is becoming increasingly difficult as new mobile technologies vie for access to bands where existing, often stationary systems are already deployed. In addition as entities such as public safety agencies realise that spectrum access is being exhausted they vie for access to blocks that they see will meet their needs into the future, often using emotive arguments rather than substantiated facts (Police Federation 2013).

Even where an incumbent is not required to move, but just accept more risk of interference via sharing a thorough project based management process may both alleviate political and regulatory processes and calm the nerves of the incumbents.

Pressure from incumbents may drive increased political scrutiny of spectrum management in the future. In order to mitigate political intervention, senior management within individual regulators is likely to require through cost benefit analysis, risk analysis and stakeholder management plans prior to committing to the refarming of a band for new uses. However provided these are undertaken diligently and the reasons for change made evident

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the political process should realize that change is the right option for economic development and allow the regulator to undertake its task unhindered.

This paper has outlined a suggested business case development method which may gain sponsor support and lead to project approval. Hopefully this method could streamline processes through a Westminster style regulatory process and lead to more efficient and timely release of spectrum for new technologies. The development of the various parts of a spectrum project management plan will be dealt with in subsequent papers.

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Towards Green and Soft: 5G Design Considerations

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Abstract—As the commercial deployment of 4G systems is picking up, technologists worldwide are beginning to search for next-generation wireless solutions to meet the anticipated demands in the 2020 era given the explosive growth of mobile Internet and the Internet of Things (IoT). This article presents our perspectives of the 5G technologies with two major themes: *Green* and *Soft*. By rethinking the Shannon theorem and traditional cell-centric design, network capacity can be significantly increased while network power consumption is steady or even decreased. The feasibility of the combination of *Green* and *Soft* is investigated through five interconnected areas of research: energy efficiency and spectral efficiency co-design, no more cells, rethinking signalling/control, invisible base stations, and full duplex radio.

Introduction

With the maturing of the fourth generation (4G) standardisation and the ongoing worldwide deployment of 4G cellular networks, research activities on 5G communication technologies have emerged in both the academic and industrial communities. Various organisations from different countries and regions have taken initiatives and launched programs aimed at potential key technologies of 5G: 5GNOW and METIS launched under the European Union's Seventh Framework Programme for Research (FP7) study new waveforms and the fundamentals of 5G to meet the requirements proposed for 2020; the 5G Innovation Centre was established in the United Kingdom to develop a world-class test bed of 5G technologies; the Third Generation Partnership Project (3GPP) has drawn up its draft evolution roadmap out to 2020; and China has kicked off its IMT-2020 Promotion Group to start the study of user demands, spectrum characteristics, and technology trends (see http://www.miit.gov.cn).

Since the research on 5G networks is still in an embryonic stage, there are no clear answers for questions such as what 5G is and what the enabling technologies are. However, the broad consensus on the 5G requirements includes higher spectral-efficiency (SE) and energy-efficiency (EE), lower end-to-end latency,

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and more connection nodes. From the perspective of China Mobile Research Institute, the world of 5G should reflect two major themes: *Green* and *Soft*.

As global carbon emissions increase and sea levels rise, global weather and air pollution in many large cities across the world are becoming more severe. Consequently, energy saving has been recognised as an urgent issue worldwide. In 2012, the annual average power consumption by information and communications technologies (ICT) was over 200 GW, of which telecoms infrastructure and devices accounted for 25 percent (The Climate Group 2008). In the 5G era, the mobile traffic in wireless communications networks is no longer solely generated by traditional mobile terminals. Increasingly, driven by the widespread applications of IoT, mobile networks are being used to gather data from or to transfer data between machine-type devices. These devices include, for example, intelligent wearable devices, various environmental sensors for temperature, humidity, metering devices, and vehicular sensors for navigation, safety, and traffic management etc. Machine type communications (MTC) are typically characterised with small packet size, low tolerance of transmission delay, low mobility and low frequency of use, etc. It is forecast that the number of connected MTC devices will reach tens of billions. The massive connectivity involved in MTC may not be handled efficiently by the current wireless communication networks, like 3G and 4G. Meanwhile, networks trend to become denser and denser to provide high data rate. Dramatic improvements in EE will be needed and new tools for jointly optimising network SE and EE will be essential.

Several research groups and consortia have been investigating EE of cellular networks, including Mobile VCE, EARTH, and Green-Touch. Mobile VCE has focused on the BS hardware, architecture, and operation, realising energy saving gains of 75–92 percent in simulations (The Climate Group 2008). EARTH has devised an array of new technologies including low-loss antennas, micro discontinuous transmission (DTX), antenna muting, and adaptive sectorisation according to traffic fluctuations, resulting in energy savings of 60–70 percent with less than 5 percent throughput degradation (Skillermark & Frenger 2012). GreenTouch (http://www.greentouch.org) has set up a much more ambitious goal of improving EE 1000 times by 2020. Several operators have been actively developing and deploying green technologies, including green BSs powered solely by renewable energies, and green access infrastructure such as cloud/collaborative/clean radio access network (C-RAN) (China Mobile Research Institute 2011).

Soft is the other critical characteristic of 5G networks. Carrier-grade networks are complex and composed of special-purpose nodes and hardware. New standards and features often require a variety of equipment to be developed and integrated, thus leading to very long launch cycles. In order to accommodate explosive mobile Internet traffic growth and a large number of new applications/services demanding much shorter times to market, much faster turnaround of new network capabilities is required. Dynamic RAN reconfiguration can handle both temporal and spatial domain variation of mobile traffic without over-provisioning homogeneously. Soft technologies are the key to resolve these issues.

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By separating software and hardware, control plane and data plane, building software over general-purpose processors (GPPs) via programming interfaces and virtualisation technology, it is possible to achieve lower cost and higher efficiency using software defined networks (SDNs) and network functions virtualization (NFV) (Chiosi *et al* 2017). The OpenRoad project at Stanford University introduced Open-flow, FlowVisor, and SNMPVisor to wireless networks to enhance the control plane. Base station virtualisation from NEC concentrated on slicing radio resources at the medium access control (MAC) layer. CloudEPC from Ericsson modified the Long Term Evolution (LTE) control plane to control open-flow switches. CellSDN from Alcatel-Lucent considered a logically centralised control plane, and scalable distributed enforcement of quality of service (QoS) and firewall policies in the data plane. C-RAN implements a soft and virtualised BS with multiple baseband units (BBUs) integrated as virtual machines on the same server, supporting multiple radio access technologies (RATs). A soft end-to-end solution from the core network to the RAN can enable the 5G goals of spectral and energy efficiency.

In the following sections, this article will elaborate on a *Green* and *Soft* 5G vision. In addition to the traditional emphasis on maximising SE, EE must be positioned side by side for joint optimisation. We present an EE/SE co-design framework. The concept of 'no more cells' is highlighted later with user-centric design and C-RAN as key elements of a soft cell infrastructure. The rationale for a fundamental rethinking of signalling and control design in 5G, especially for the MTC communication is provided. This article further discusses the idea of invisible BSs incorporating large scale antenna system (LSAS) technology. Two major issues are investigated, an N by M hybrid beamforming structure, and an irregular antenna array. Finally, the fundamental interference management issues in networks based on full-duplex technologies and potential solutions are identified followed by a summary.

Rethink Shannon: EE and SE Co-Design

Given limited spectrum and ever-increasing capacity demand, SE has been pursued for decades as the top design priority of all major wireless standards, ranging from cellular networks to local and personal area networks. The cellular data rate has been improved from kilobits per second in 2G to gigabits per second in 4G. SE-oriented designs, however, have overlooked the issues of infrastructure power consumption. Currently, RANs consume 70 percent of the total power. In contrast to the exponential growth of traffic volume on mobile Internet, both the associated revenue growth and the network EE improvement lag by orders of magnitude. A sustainable future wireless network must therefore be not only spectrum-efficient but also energy-efficient. Therefore EE and SE joint optimisation is a critical part of 5G research. Looking at traditional cellular systems, there are many opportunities to become greener, from the equipment level, such as more efficient power amplifiers using envelop tracking, to the network level, such as dynamic operation in line with traffic variations both in time and space. For the fundamental principles of EE and SE co-design, one must first revisit the classic Shannon theory and reformulate it in terms of EE and SE. In classic Shannon theory, the channel capacity is a function of the log of the transmit power (P_t) noise power

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spectral density (N_0), and system bandwidth (W). The total system power consumption is a sum of P_t and the circuit power P_c, that is,

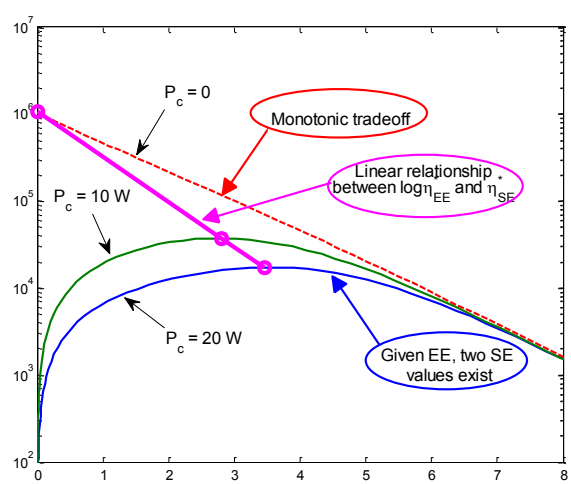
$$P_{tot} = P_t / \rho + P_c$$

where ρ is power amplifier (PA) efficiency defined as the ratio of the input of the PA to the output of the PA. From the definition of EE (Li *et al.* 2011), EE is equal to the channel capacity normalised by the system power consumption. SE is the channel capacity normalised by system bandwidth. The relationship of EE and SE can be shown as a function of PA efficiency and P_c in Fig. 1a. From Fig. 1a, it can be observed that when P_c is zero, there is a monotonic trade-off between η_{EE} and η_{SE} as predicted by the classic Shannon theory. For non-zero P_c, however, η_{EE} increases in the low SE region and decreases in the high SE region with η_{SE} (for a given η_{EE}, there are two values of η_{SE}). As P_c increases, the EE-SE curve appears flatter. Furthermore, when taking the derivative of η_{EE} over η_{SE}, the maximum EE (η_{EE}^*) and its corresponding SE (η_{EE}^*) then satisfy the following:

$$\log_2 \eta_{EE}^* = \frac{\log_2 \rho}{N_0 \ln 2} - \eta_{SE}^*.$$

This means there is a linear relationship between $\log_2 \eta_{EE}^*$ and η_{SE}^*, and the EE-SE relationship at the EE optimal points is independent of P_c. This observation implies that as P_c decreases, an exponential EE gain may be obtained at the cost of linear SE loss. Fig 1b compares the EE-SE performance of current Global System for Mobile Communications (GSM) and LTE BSs. LTE performs better than GSM in terms of both SE and EE; both, however, are working in a low SE region, indicating room for improvement.

a) SE and EE relationship for different circuit powers



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b) SE and EE relationship for current cellular networks

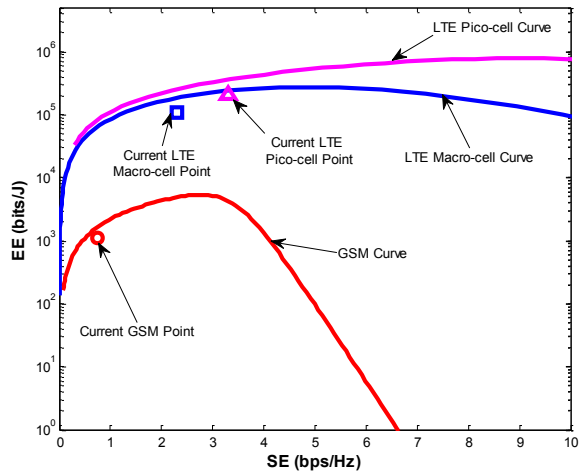

Fig. 1. SE and EE relationship for different circuit powers and current networks

Antenna muting is proposed in EARTH to improve EE, while LSAS stipulates EE improvement by increasing the number of antennas. These seemingly contradicting conclusions are actually consistent with the analysis presented above where the difference is that the former operates in a low SE region, whereas the latter operates in a high SE region. While some progress has been made in EE and SE co-design investigation, there is still a long way to go to develop a unified framework and comprehensive understanding in this area. Especially, new techniques, like spatial modulation (Renzo *et al* 2014), can utilise the antenna resource more efficiently. Ideally, the EE-SE curve in future systems should achieve the following criteria:

- The EE value should be improved for each SE operation point.
- The EE-SE win-win region should be enlarged and the EE-SE trade-off region should be reduced.
- The slope of the EE-SE curve in the tradeoff region should be reduced.

MIMO systems have been studied under these criteria. As shown in Fig.2, besides the linear relationship between $\log_2\eta_{EE}^*$ and η_{SE}^*, the slopes of the EE-SE curve are also affected by different parameters. We can see that when SE approaches zero, the slope depends only on the bandwidth and circuit power, and is independent of the antenna configuration and the knowledge of CSI at the transmitter. From the solid curves, we can see that reducing the circuit power can improve the EE in the low-SE region significantly. When SE approaches infinity, the slope is only related to the number of data streams, i.e. multiplexing gain, and independent of circuit power. From the dashed curves, it can be observed that when increasing the number of antennas, the EE improvement mainly happens in the high SE region. This observation implies that reducing circuit power has advantage in the low SE region while developing transmission techniques can improve the EE in the high SE region.

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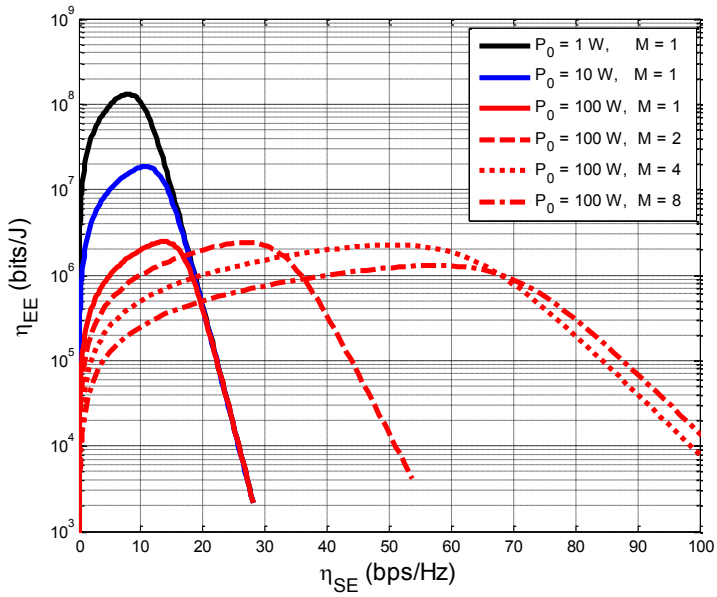

Fig. 2. The impact of the circuit power and the number of antennas on the EE-SE curves.

Rethink Ring and Young: No More Cells

The concept of cellular systems was proposed in 1947 by two researchers from Bell Labs, Douglas H. Ring and W. Rae Young. Since the first generation of cellular standards, this cell-centric design has been maintained through every new generation of standards including 4G. The nature of a homogeneous cell-centric design is that cell planning and optimisation, mobility handling, resource management, signalling and control, coverage, and signal processing are all assumed to be done either for or by each BS uniformly. In a practical deployment, it is clear this system does not match with traffic variations and diverse environments. Relay, coordinated multipoint (CoMP), distributed antenna systems, and heterogeneous networks (HeteNet) have been implemented as short-term solutions to amend these issues. Recently, Beyond Cellular Green Generation, liquid cells, soft cells, and phantom cells have surfaced as potential radio access architectures. These paradigms all lead to the principle of no more cells. 5G design should start with such a paradigm shift, departing from cell-based coverage, resource management, and signal processing, and leaning toward user-centric coverage facilitated by a C-RAN architecture.

User-centric Design

The concept of no more cells is user-centric with amorphous cells, decoupled signalling and data, and decoupled downlink (DL) and uplink (UL). For example, a macro BS would become a signalling BS while small cells would be data-only BSs. In a HetNet scenario, the small cell is within the coverage of a macro cell. Even if the small cell has no traffic, it cannot be turned off in the traditional cell paradigm. But with a control and data decoupling scheme, the macro cell is responsible for control and the small cell only for data. Thus, when there is no data traffic in the small cell, it can be completely turned off to save energy.

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New users can access the macro cell, and then the macro cell can coordinate with the small cell for possible data transmission. Based on the channel conditions, service types, and BS traffic loads, the DL and UL can be decoupled to facilitate better resource allocation between cells. This can be illustrated in the following example: Consider two cells where cell 1 is heavily loaded in the downlink and cell 2 loaded in the uplink. In the traditional cell concept, if one user equipment (UE) device is located at the cell boundary with symmetric DL and UL data requirements, and the serving cell is cell 1, its DL requirement may not be satisfied. If the UE device's serving cell is cell 2, its UL requirement may not be satisfied. If there is a user-centric network design, the UE device's DL can be from cell 2 and UL to cell 1, meeting the UE device's data requirement for symmetric DL and UL.

C-RAN

Building on the architecture of distributed BSs where radio units are placed outdoors closer to the antenna and baseband units (BBUs) are placed indoors at cell sites, C-RAN goes one step further by bringing BBUs from multiple BSs to a central pool location. The GPP servers perform baseband processing using virtual machines running on real-time Linux. The centralisation of the baseband processing leads to more energy-efficient cooling, making the C-RAN network architecture an essential part of the design of energy-efficient networks. Energy savings of 70 percent in the OPEX of the BS infrastructure have been realised in 2G and 3G trials inside China. By virtualising the baseband processing, new features can be added to the network within months, as opposed to years in the traditional infrastructure. The centralised baseband processing allows for soft technologies such as CoMP processing, multi-RAT virtualisation, as well as soft and dynamic cell reconfiguration [6]. C-RAN is a revolutionary new type of radio access architecture and another essential element of 5G.

Rethink Signalling and Control: Trillions of Nodes for 5G!?

Existing mobile networks are designed more specifically for conventional and streaming applications such as voice and video. As mobile data traffic grows exponentially, more diversified traffic profiles have emerged. They have brought new challenges to mobile networks, especially small-sized persistent bursty traffic types, such as instant messaging (IM) traffic, that contain frequent texts, photos, and periodic pings. These mobile applications would cause frequent transitions between the Connected and Idle states. As a consequence, these transitions not only increase device battery drainage, but also cause excessive signalling overhead in mobile networks.

Analogous to the small-sized traffic types, the massive connectivity involved in MTC may not be handled efficiently by the current wireless communication networks, like 3G and 4G. The most challenging issue is not that the aggregated MTC data traffic demand is beyond the system capacity but that a large number of devices may access the network simultaneously or an even larger number of small packets might be generated sporadically and sent to the network independently. More importantly, it is estimated that only 7%

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of the total wireless traffic will be from IoT nodes in 2020. Therefore, it is well-motivated to design a new signalling mechanism that is optimised to handle such a traffic profile with tens of billions nodes or even trillions of nodes in the IoT networks.

Aggregation of Packet Data from Multiple MTC Devices

There are a number of efforts in this direction. For example, various signalling optimisation schemes have been discussed by Taleb and Kunz (2012) to reduce the signalling load, which is generated during certain procedures and scenarios, like random access etc. Also, considering the fact that many MTC applications are delay-tolerant, low-access priority indication (LAPI) is introduce(ed to alleviate the problem of an overloaded network with MTC devices (3GPP 2011). . Jian Zhang *et al* (2012) introduce a new network convergence approach, where the converged cellular network and wireless censor network architecture is evolving from layered to flat to decrease the hierarchical signalling exchange between the two networks.

One interesting MTC communication model is proposed in Fig. 3, where the MTC devices are controlled by an aggregator, which functions as the wireless gateway to the cellular network. The services aggregated can be both homogenous and heterogeneous, and sent to the aggregator in a scheduled manner or sporadically. The aggregator will then relay the aggregated data packets to the cellular network in an aggregated manner. Correspondingly, based on the aggregated packet types and data relay modes, the aggregators will request for aggregator specific RRC mechanism. The involved signalling overhead is significantly reduced and the RRC signalling efficiency is dramatically improved. Note that the service aggregation of MTC devices is analogous to the service aggregation of small-sized packets from various applications running on multiple mobile devices.

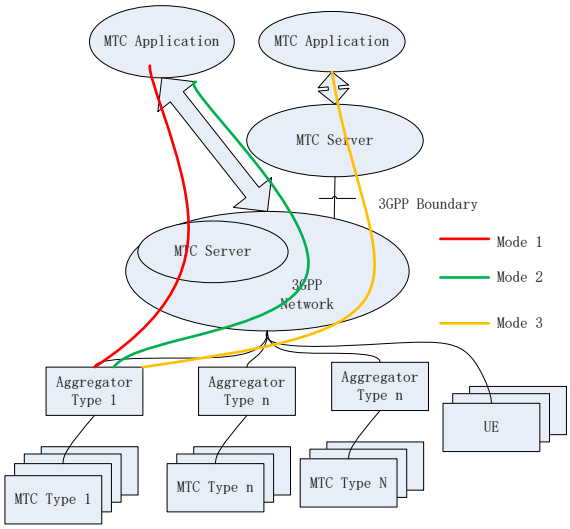

Fig. 3. Aggregation of Packet Data from Multiple MTC Devices

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Multiple MTC devices are able to connect to each specific aggregator via local transmission technologies, which could be cable, fibre, WiFi, Bluetooth, ZigBee and even 3GPP cellular access. It is assumed that the connection between MTC devices and aggregators doesn't significantly influence the operator's mobile network and thus, the impact of MTC device's access to aggregators is not considered in this paper. Two relay modes of the aggregators are presented in this paper:

Two proposed relay modes for aggregators

Mode 1: No RRC State Transition (Always Connected)

Suppose in the network (e.g. within one base station), there are N aggregators with same MTC traffic and relay behavior (mode 1) on orthogonal resources, e.g. on different frequency bands (with same bandwidth), and are simultaneously transmitting to the network in a frequency division multiple access (FDMA) manner. Before relaying the aggregated k packets in some time window T, the aggregator is already in connected mode. After packet transmission, the connected mode will be maintained, i.e. there is no need for RRC connection setup in the following windows.

Mode 2: RRC Connection Mode Switched to Idle Mode within Window T

In mode 2, we assume there are N simultaneous aggregators equally sharing the time resource in each window T. The base station allocates all frequency resources to each aggregator, i.e. in a time division multiple access (TDMA) mode. Before transmitting the aggregated packets to the network, each aggregator will enter into connected mode in the time window T. The k packets will be transmitted to the cellular network in window T_{tx} (which is smaller than T) within each window T. Then, after T_{tx}, the aggregator enters into RRC idle mode directly.

For the above two relay modes, the same traffic is relayed in time window T. However, the signalling overhead of these two modes can be different. One analysis can be found in Chih-Lin *et al* (2014).

Invisible Base Stations with Irregular Antenna Array

Massive MIMO or LSAS has been a research focus since Marzetta'a seminal paper (Marzetta 2012). Among the open issues still pending in LSAS, two issues are investigated in this section. Firstly, when a large number of antennas are implemented to achieve better BF gains, implementing the same number of transceivers may not be feasible due to excessive demand on real time signal processing for high BF gains, high power consumption and cost (especially the high cost and power consumption of mixed-signal devices in mm-Wave systems). The hybrid BF structure with much smaller number of digital transceivers than total antenna number will therefore be more practical and cost-effective to deploy. Secondly, although LSAS elegantly addresses the capacity and power consumption challenges, the physical size of an LSAS BS is of concern. The much larger physical footprints of LSAS BSs will not only bring significant tower construction

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challenges but also lead to greater confrontation. LSAS BSs with irregular antenna array can help to better adapt to the physical environments, thus easing the antenna installation as shown in Fig. 4.

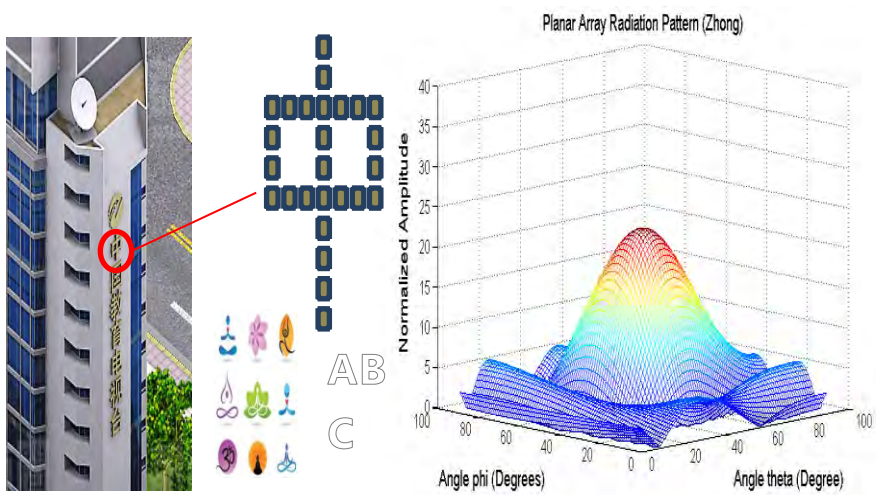

Fig.4. An illustration of invisible base stations

EE-SE Analysis of N by M Active Antenna Structure

Although the generic LSAS requires a complete transceiver chain for each antenna element, for practical considerations, a much smaller number of transceivers than that of antenna elements may be adopted. Unlike current BS RF structures, where each transceiver is connected to a column of antenna elements generating a fixed coverage beam, the LSAS system under investigation is an LSAS system of size $L = N \times M$, where N is the number of transceivers and M is the number of active antennas per transceiver.

An accurate power model is needed to calculate the EE. However, this is not straightforward, since base stations have different types (macro, pico, femto) and are generally produced by different vendors with various implementation technologies. In this section, the following simple power model is used, i.e.,

$$P_{total}=NP+P_{static}=NP+NP_0+P_{common}+NMP_{rf\_circuit},$$

where P_{total} is the total power, NP is the RF power of N transceivers, P_{static} is the static power of the base station, including component NP_0 which scales with the number of transceivers, P_{common} which is common for any transceiver number, and $NMP_{rf\_circuit}$ which scales with total antenna number NM. The EE-SE relationship can then be written as:

$$\begin{aligned}\eta_{EE} &= C / P_{total} \\ &= \frac{\eta_{SE}}{\left(2^{\frac{\eta_{SE}}{N}}-1\right)\frac{N_0}{\eta_{PA}}\frac{N}{M}+\frac{NP_0+P_{common}+NMP_{rf\_circuit}}{W}}\end{aligned} \quad (1)$$

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EE-SE Relationship at the Green Points

As shown in Li *et al* (2011), the EE-SE relationship based on Shannon's theory is monotonic, where a higher SE will always lead to a lower EE. When the circuit power is considered, however, there exists a green point on the EE-SE curve where the maximum energy efficiency η^*_{EE} is achieved. Two cases are discussed here for the N by M hybrid BF structure, the case when $NM=L$ (i.e. the total antenna number is fixed to be L, but N and M are variable) and the case when N and M are independent. The analytical goal of the first case is to find the optimal number of transceivers and correspondingly the optimal number of antennas per transceiver given the total number of antennas, while the investigation on the second case is to explore how the independent N and M should be jointly optimised.

It can be derived (Shuangfeng *et al* 2014) based on Eq.1 that there exists only one green point on EE-SE curve for each case, i.e., there exists only one η^*_{SE} which maximises the EE performance. The relationship between η^*_{EE} and η^*_{SE} is further given as

$$lg(\eta^*_{EE})=-\eta^*_{SE}\, lg2/N+lg(M\eta_{PA}/N_0 ln2)$$

i.e., $lg(\eta^*_{EE})$ scales with η^*_{SE} linearly with a slope of $-lg2/N$. Similar to the EE-SE relationship with classic Shannon theory, a higher η^*_{SE} will always lead to a lower η^*_{EE}. Interestingly, the relationship between η^*_{EE} and η^*_{SE} is independent of P_0, P_{common}, $P_{rf\_circuit}$ and W, though, as can be seen from Eq.1, η^*_{SE} and η^*_{EE} are determined based on all the other parameters.

How does N affect EE-SE?

When the required SE is pre-determined, it is desirable that the transceiver number N is optimised, yielding the highest EE performance with the minimum transceiver number. Based on Eq.1, it's found that in the cases $NM=L$ and independent N and M, for any given SE, there exists only one optimal N to yield the best EE. A detailed proof can be found in (Shuangfeng *et al* 2014). The practical meaning of the existence of the optimal N is that with a given SE, a system designer doesn't need to implement too many transceivers to achieve the best EE performance.

Assume $P_{rf\_circuit}$ =1W, P_{common}=50W, P_0=1W, W=2×10^{7}Hz, N_0=10^{-17}dBm/Hz, and a channel gain of -100dB. Considering the NM=500 case, the impact of N (from 1 to 10) on EE performance is shown in subplot 1 of Fig. 5, where five SE values are simulated. Note that since N and M are integers, there are only 5 valid (N,M) combinations for NM=500, that is, (1,500), (2,250), (4,125), (5,100) and (10,50). It can be observed that on each curve there exists one optimal N that yields the highest EE. For example, when SE is 20bps/Hz, the optimal N is 4. When SE is 8bps/Hz, the optimal N is just 1. The case when N is larger than 10 is not shown in the figure, since it may be difficult to schedule users with negligible inter-user interference when M is very small.

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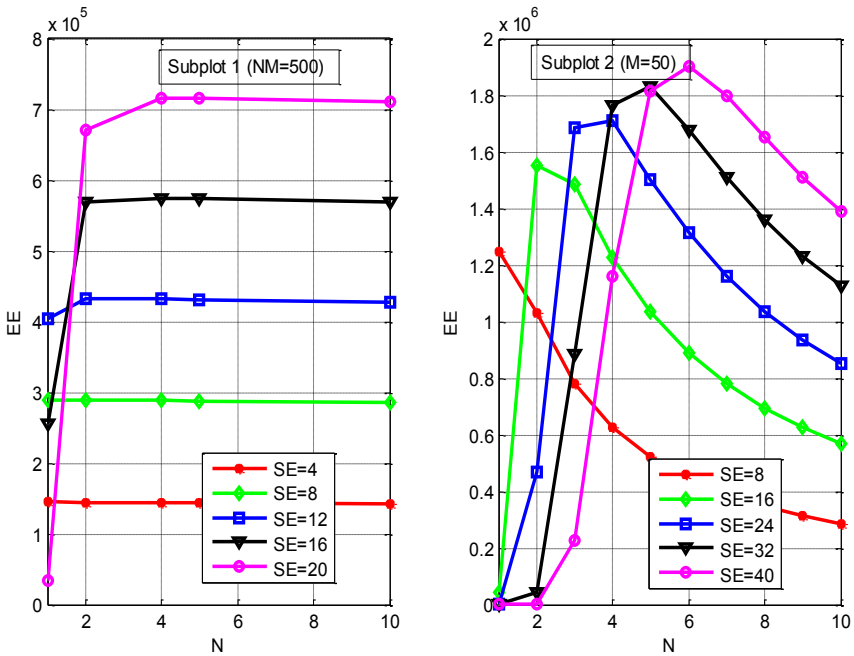

Fig.5. N vs. EE with different SE values

When *N* and *M* are independent, the impact of *N* on EE performance is shown in subplot 2 in Fig.5, where *M*=50 and other parameters are the same with that in subplot 1. Similar to the fixed *NM* case, on each curve there exists one optimal *N*. For example, when SE is 40bps/Hz, the optimal *N* is 6. Different from the fixed *NM* case, the EE performance is very sensitive to *N*, because the total antenna number scales with *N*.

In a practical system operation, the SE requirement may vary according to the traffic load and service types. For example, as shown in subplot 2 in Fig. 5, with the maximum 40bps/Hz SE requirement, the optimum *N* should be designed to be 6. But when the SE requirement is reduced to 8bps/Hz, the optimal *N* should be 1. Therefore, it is important that for the possible SE range, the system can be designed with the largest optimal *N*, and selects the best *N* according to the SE requirement via transceiver on/off. This can help to further enhance the EE performance according to the system traffic load.

Irregular Antenna Arrays

By integrating the antenna elements into the environment, the BSs can be made virtually invisible. Instead of constructing fake trees, which are often eyesores, multiple active elements can be built in the form of tiles. By separating the single LSAS panel into multiple tiles, the LSAS can be flexibly deployed in an irregular fashion as part of the building facade or signage, and thus blend into the environment. Irregular antenna deployment in a practical environment requires a different system design and adaptive signal processing algorithms. As predicted by sparse antenna array theory, the sidelobes of the sparse array have increased, and due to the smaller number of antennas, the main lobe peak has decreased. Advanced

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algorithms regarding subarrays, orthogonal placements, or parasitics can help optimise the beamforming performance of irregular arrays.

In addition to beamforming optimisation, there are several other challenges for irregular antenna arrays. Synchronisation, broadcast, and cell common reference signals in cellular systems are generally transmitted in an omnidirectional manner for better coverage, whereas LSAS panels can only create radiation patterns in front of the panel. Cell coverage will be more challenging since for a given antenna placement, there are many possible coverage scenarios. Another issue is channel modelling for irregular antenna deployment. 3D channel modelling is being investigated in 3GPP and various study groups like WINNER, where generally a regular antenna configuration is assumed. On top of the 2D channel model in WINNER or 3GPP, the elevation angle is added for each ray, where the angle of arrival/angle of departure (AoA/AoD) and the large scale fading with regard to different antennas are assumed to be the same due to the regular spacing in the traditional 2D array. With irregular antenna arrays, however, the spacing and relative position of each antenna may invalidate the above assumption where AoA /AoD and large scale fading may be different for each ray with regard to different LSAS antennas; therefore, modification to the current channel modelling is needed.

Full duplex Radio

Current cellular systems are either frequency division duplex (FDD) or TDD. To double SE as well as improve EE, a full duplex operation should be considered for 5G. A full duplex BS transmits to and receives from different terminals simultaneously using the same frequency resource at the same time. Self-interference cancellation is the key to the success of a full duplex system since high DL interference will make the receivers unable to detect the UL signal. Significant research progress has been made recently in self-interference cancellation technologies, including antenna placement, orthogonal polarisations, analog cancellation, and digital cancellation (Aryafar 2012). Most of the research, however, has been on either point-to-point relay or a single-cell BS scenario. In this section, FD network deployment scenarios and the interference conditions will be investigated.

FD Network Deployment Scenarios and the Interference Analysis

An FD system can be applied to many practical deployment scenarios. The simplest scenario is the point to point communication (P2P), where the transmission data rate can be doubled. In this case, the self-interference (from Tx to Rx of the same device) is the dominant form of interference. The other scenarios are in cellular networks (homogeneous or heterogeneous) where the base stations and terminals can work in either full duplex or half duplex (HD) modes. With current 3G and 4G networks, new FD BSs may not easily form a homogeneous network with continuous coverage. Rather, FD may serve as a first step for hotspot and indoor capacity enhancement in HetNet with discontinuous coverage, and in the long run may form a new homogeneous network.

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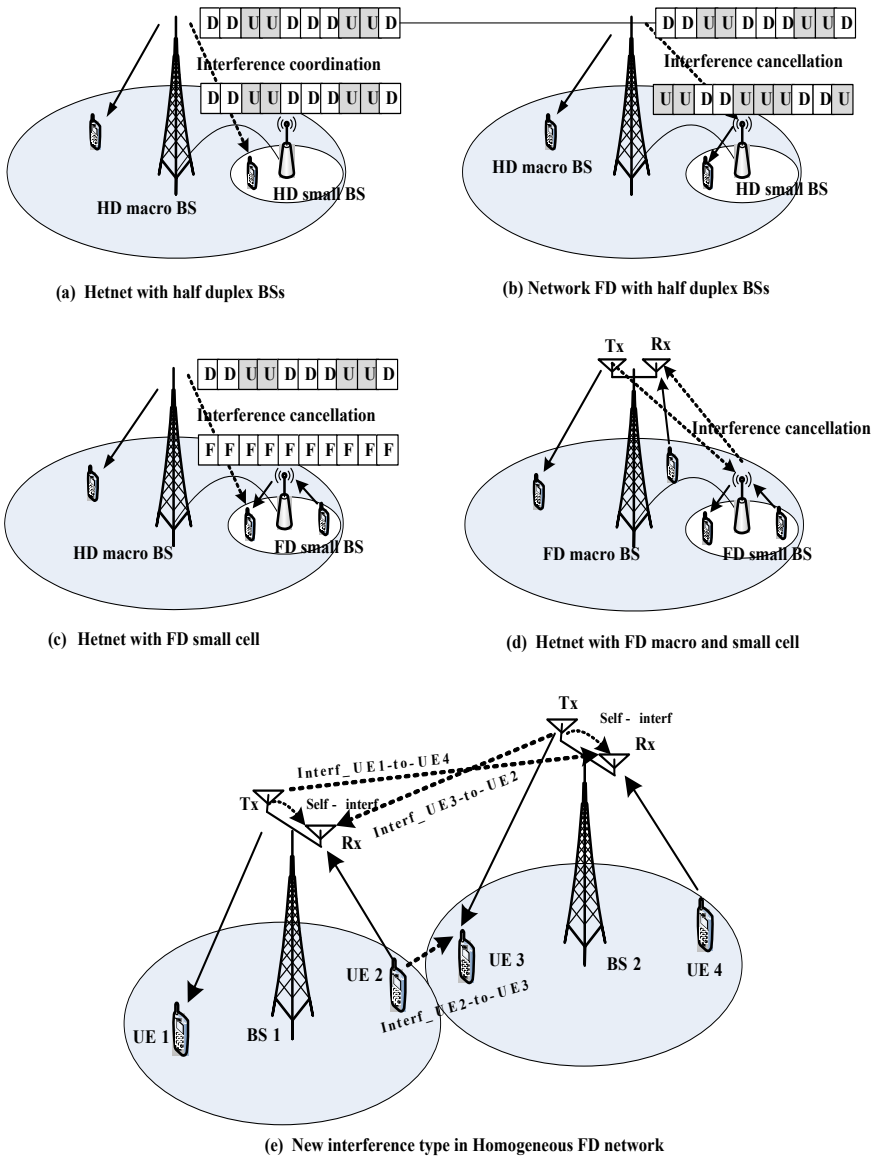

Fig.6. FD Deployment scenario and interference analysis

In the current TDD or FDD systems, the DL to DL interference received at UE and UL to UL interference received at a BS have been extensively studied in literature and standardisation bodies (e.g. CoMP in 3GPP LTE-A and IEEE 802.16m). In a FD system, the interference situation is more severe. For example, the new interference in an FD homogeneous network is shown in Fig. 6(e). (Note the following analysis can be applied to both HetNet and homogeneous networks). BS1 and BS2 are transmitting to UE1 and UE3 respectively in the DL while UE2 and UE4 are transmitting to BS1 and BS2 respectively with same frequency and time resources. In addition to the self-interference from Tx to Rx at each BS, there are intra-cell UL to DL interference interf_UE2_to_UE1 (from UE2 to UE1) and interf_UE4_to_UE3 (from UE4 to UE3), inter-cell UL to DL interference interf_UE2_to_UE3 (from UE2 to UE3), and DL to UL interference interf_UE1_to_UE4 (from BS1 Tx to BS2 Rx) and interf_UE3_to_UE2 (from BS2 Tx to BS1 Rx). These interferences have significant impact on whether an FD system works and must be mitigated

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properly. Note that DL to DL and UL to UL interference mitigation can readily utilise the CoMP schemes specified in LTE-A, like coordinated scheduling coordinated beamforming and joint processing. More efforts are needed to mitigate the interference for the other 3 types of interference (self interference, UL to DL interference and DL to UL interference). Self interference cancellation has been well studied in the literature (Ayrafar *et al* 2012), (Jain *et al* 2011), (Hua *et al* 2012), (Knox 2012). Antenna cancellation, analog cancellation, and digital cancellation can be jointly performed to reduce the self interference to a tolerated level. UL(DL) to DL(UL) interference cancellation is still an open issue to solve.

Conclusions

This article has presented five promising areas of research targeting a *Green* and *Soft* 5G system. The fundamental differences between classic Shannon theory and practical systems are first identified and then harmonised into a framework for *EE-SE co-design*. The characteristics of the "*no more cells*" concept are described from the perspective of infrastructure and architecture variations with particular emphasis on C-RAN as a typical realisation in order to enable various soft technologies. *Rethinking signalling/control* for the MTC communication is then explored, and initial redesign mechanisms are discussed. Virtually *invisible base stations* with irregular LSAS array are envisioned to provide much larger capacity at lower power in high-density areas when integrated into building signage. Optimal configuration of transceivers and active antennas is investigated in terms of EE-SE performance. Finally, deployment scenarios and new interferences in full duplex network are identified, and several candidate solutions are discussed. These five areas provide potential for fundamental breakthroughs, and together with achievements in other research areas, they will lead to a revolutionary new generation of standards suitable for 2020 5G deployment.

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Glossary

BF	Beamforming
BS	Base Station
CoMP	Co-ordinated Multipoint
CSI	Channel State Information
DL	Downlink
EE	Energy Efficiency
FD	Full Duplex
FDD	Frequency Division Duplex
GPP	General Purpose Processors
GSM	Global System for Mobile Communications
HD	Half Duplex
HetNet	Heterogeneous Networks
ICIC	Intercell Interference Cancellation
IM	Instant Messaging
LSAS	Large Scale Antenna System
LTE	Long Term Evolution
MAC	Medium Access Control
MIMO	Multiple-Input Multiple-Output
MTC	Machine Type Communications
NFV	Network Functions virtualisation
OPEX	Operating Expenditure
PA	Power Amplifier
RAN	Radio Access Network
RRC	Radio Resource Control
SE	Spectral Efficiency
TDD	Time Division Duplex
UE	User Equipment
UL	Uplink

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Public Wi-Fi

Space, sociality and the social good

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Summary: Public Wi-Fi services are rolling out across Australia, with city councils and telcos building large-scale networks in urban areas. Questions as to the value of public Wi-Fi have never been more significant in the Australian context. In this article we explore how free Wi-Fi services offered by cultural institutions and municipalities influence public spaces, and ask how such services can engender practices which promote the social good. Drawing on ethnographic research into six Wi-Fi equipped spaces in Victoria, we find a variety of issues which influence whether a service will be popular and hence have a significant influence on public space. Services which are popular enable a range of uses, and this can add to the appeal and atmosphere of a space. However, Wi-Fi has yet to truly facilitate the kind of social interactions and rich civic placemaking we associate with the social good.

Introduction

Free public Wi-Fi services supplied by cultural institutions, municipalities and telcos are rolling out across Australia (Lambert et al. 2013). Wi-Fi is taking its place alongside other concepts such as the 'smart city' and the 'Internet of Things' as a much hyped media future. However, despite this enthusiasm, relatively little is known about what effects free public Wi-Fi will actually have in the Australian context. In this article we consider public Wi-Fi as it relates to issues of public space and the social good. How do these services influence social life in public spaces, and is this influence cognate with a civic, inclusive, cosmopolitan and creative conception of the social good?

Between late 2012 and early 2013 we surveyed a number of free public Wi-Fi projects provided by municipalities and cultural institutions. We studied public policy and planning documents and interviewed representatives of the different institutions. We also conducted ethnographic research at six Wi-Fi equipped sites in Victoria to understand how and why people use free Wi-Fi. A variety of factors influence whether a Wi-Fi service will attract

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regular users and significantly influence a public space. There is also a variety of ways in which people use free Wi-Fi. In what follows we will explore these ethnographic findings within the context of current significant transformations in Australia's Wi-Fi landscape.

Wi-Fi narratives and debates

'Wi-Fi' is the popular name for the IEEE 801.11 technology standards which enable wireless networking between devices across the class-licensed 2.4 GHz spectrum band. The last 15 years have seen the rapid distribution and commodification of Wi-Fi technology in Internet routers and computers. Wi-Fi hotspots have appeared in homes, workplaces, and public spaces of consumption such as cafes, hotels and airports (Economist 2004).

Since its popularisation, Wi-Fi has been embroiled in quasi-utopian narratives of the digital city. For example, the P2P foundation imagines a 'wireless commons' which closes the digital divide, enlivens the city and fosters innovation and creativity (p2pfoundation.net/wireless-commons). Early supporters of this doctrine had a grassroots and often illegal character. Some took to mapping Wi-Fi by driving around looking for unsecured networks, a process known as 'wardriving', and posting these maps on the Web (Sandvig 2004). Yet these networks became increasingly unreliable as network owners became more savvy with password protections. Community Wi-Fi networks also emerged in which members meshed together hotspots they owned and managed in their homes. Yet licensing laws often prevent these networks from providing Internet to the public (Sandvig 2004). Some community networks have attempted to collaborate with governments to provide free public Wi-Fi. Yet these projects often fail due to a mismatch between the technologies, practices and ideals of community Wi-Fi members and government policy makers (Heer et al. 2010).

Overall, the early enthusiasm around free Wi-Fi can be critiqued for not appreciating the legal, institutional and technological problems which determine the outcomes of Wi-Fi networks in specific cultural and economic contexts (Goggin 2007). Municipal Wi-Fi initiatives, which took off in the United States around 2004, have also had to grapple with these issues: specifically, the contradictions that exist between the allure of free Wi-Fi and the often costly realities of implementing it. The US broadband landscape is dominated by a few incumbent providers whose monopolistic market effects are often blamed for broad swaths of the population lacking sufficient broadband (Crawford 2013). Municipal Wi-Fi services were justified as a response to this digital divide, and this began a significant economic and regulatory debate on the role of government in providing free Internet (Gibbons & Ruth 2006; Shaffer 2007). Within this context numerous studies focus on describing the value of different public/private partnerships in relation to network ownership, architecture and management (Bar & Park 2005; Evenepoel et al. 2012). Other

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studies decry municipal Wi-Fi outright, arguing such services are discriminatory and crowd out competitive ISPs (McClure et al. 2005).

Australia's economic and cultural environment has significant differences. Broadband penetration is higher, and the Australian mobile internet service sector is quite competitive. Australians have embraced wireless services. According to the Australian Bureau of Statistics (2013), as of December 2013 there were 20.3 million mobile Internet subscriptions. As Potts (2014) has argued in this journal, Australian cities cannot point to significant market failure as a justification for free public Wi-Fi. Potts goes on to detail how the provision of free public Wi-Fi could lead to negative outcomes. Like any attractive 'free' resource, public Wi-Fi has to be paid for by someone. Potts argues that the provision of free public Wi-Fi could increase local rents, which in turn could cause an increase in local prices. Costs will be passed on to visitors, and those with less disposable income might be excluded from free Wi-Fi equipped places. This conventional market-led argument seems limited on at least two counts. First, it is yet to be tested empirically as to whether the introduction of Wi-Fi in already populous and competitive areas will have a significant effect on rents and prices, or whether (as we predict) Wi-Fi will come to be seen as an integral part of public infrastructure alongside services such as electricity and telephony. Second, it treats the potential benefits of public Wi-Fi as accruing entirely to individuals, and ignores any collective benefit that might arise from the contribution that Wi-Fi makes to public space as a site of social interaction.

Overall much of the literature on municipal Wi-Fi lacks a grounded analysis of the social and cultural practices which free Wi-Fi engenders, and whether these practices contribute to the social good. We understand the relationship between the social good and public space through a range of processes and principles. Public spaces are important sites for fostering communities in contemporary society. They are sites for community members to socialise in serendipitous and unplanned ways, and can help to provide a sense of belonging and inclusiveness. Public spaces host creative cultural expression and are a vital site for different groups to express their diverse cultural identities and collectively negotiate differences (Carr et al. 1992). In this sense public spaces are important for fostering cosmopolitanism and cultural citizenship in an increasingly heterogeneous, globalised world (Binnie et al. 2006). Public spaces also host forms of public activism and protests, and hence are critical sites for informal democratic participation (Mitchell 2003). Nevertheless, there is a sociological concern that public space is in 'crisis', and that various structural forces are causing more social atomisation and cultural homogenisation (Mitchell 2003; Tonkiss 2005). A key question is how networked public spaces, including those with free public Wi-Fi, can avoid this state of affairs and engender the positive attributes mentioned above.

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The drivers of free public Wi-Fi in Australia

The factors which drive the implementation of a free public Wi-Fi service are important in determining the eventual characteristics of that service and, consequently, the influence it will have on public culture and public space. A number of Australian public institutions have established free Wi-Fi services for a variety of reasons. City councils are primarily concerned with how Wi-Fi will stimulate local economies, though it is also hoped that Wi-Fi will augment other city services. Sometimes more community-minded outcomes are also foregrounded in policy documents and press releases.

Most councils are primarily interested in using free Wi-Fi services to attract more visitors, such as tourists and students, and hence increase local business revenue. Hotspots are often rolled out in commercial precincts and near sporting venues. Cities such as Brisbane, Geelong, Adelaide and Canberra expect Wi-Fi will also lead to innovations in creative and technology industries, spurring on, in the words of ACT minister Katy Gallagher (2014), the 'tech savvy population' and 'small, innovative entrepreneurs'. Indeed, there is a common and frequently stated belief in Wi-Fi's potential as a powerful economic stimulus.

Councils are also using Wi-Fi to brand themselves as 'smart cities' in a global reputation economy which centres around the alluring aesthetics of digital urbanism. See, for example, Canberra's *Digital Action Plan* (2014). This form of branding is expected to assist in attracting business investment and knowledge tourism in the form of students and certain types of mobile professional.

Councils also hope Wi-Fi will augment the value of other city services. For example, many councils provide splash screens with community announcements, safety warnings, event promotions and free marketing for local businesses. Press coverage of the Victorian Government's Wi-Fi project reports that Wi-Fi will serve as a wireless backbone for health, education and transport services (Cowan 2014). We talked to Luu Nguyen, ICT Manager for the City of Adelaide, who told us the city intends to use its Wi-Fi service to support coordination between 'smart' city assets such as sprinklers, lights and parking spaces. Adelaide also intends to use wireless CCTV cameras which afford rapid deployment of surveillance infrastructure to trouble spots. The deployment of the Internet of Things throughout cities will undoubtedly have significant effects on public spaces.

Councils also value the potential for Wi-Fi to enhance communities, creating 'a more social environment' by allowing people to connect more in physical and digital spaces (Wollongong City Council 2012). Similarly, the *Canberra Digital Action Plan* states, '[Free Wi-Fi] can transform community centres and spaces into digital spaces where residents and visitors can check email, access government services, update social media and find directions' (Canberra

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Digital Action Plan 2014: 10). However, little is known about how these activities coalesce in such a way as to make communities more social and inclusive. As will be discussed later, it was the City of Moreland's intention to foster a safe and social youth community in Harmony Park, yet free Wi-Fi did little to help this cause.

Unsurprisingly, cultural institutions are more directly concerned with how Wi-Fi can enhance public space in partnership with forms of curation. Various art galleries and museums now use Wi-Fi in conjunction with mobile phone apps and RFID tagged exhibitions to support the delivery of exhibition content. Institutions which govern open public spaces, such as Fed Square P/L, which oversees Melbourne's Federation Square, also provide free Wi-Fi in partnership with interactive digital media events.

Overall, these various drivers for implementing Wi-Fi, if reflected in actual project design, could influence public spaces in a variety of different ways. For example, free Wi-Fi may help draw people to a location, but Wi-Fi supported surveillance may deter certain people and hence produce social exclusion. We discuss some early ethnographic findings about what makes a potentially popular Wi-Fi service later in this article.

Recent evolution of Wi-Fi in Australia

The primary period of research for this study was between December 2012 and March 2013, and preliminary findings were published in a White Paper for the Institute for a Broadband Enabled Society (Lambert et al. 2013). We found that free Wi-Fi projects, especially those offered by municipalities, were evolving in diverse and uneven ways across the nation. Most cities offered free Wi-Fi in municipal libraries, but at this stage only a handful offered Wi-Fi in other public spaces. Extant or planned services differed in a variety of ways. There were many small projects covering specific buildings, parks, squares and commercial streets, and a few emerging large-scale projects such as Brisbane City Council's (2012) implementation of Wi-Fi in 22 parks and the City of Perth's (2012) CBD project. Different locations tended to reflect council priorities, with commercial locations being favoured by small councils seeking to enhance local business districts. Councils varied in the business models they employed, resulting in different allocations of public and private ownership and control over the service. They also varied in the kinds of access limitations they placed on usage time, download volume, and controversial content such as pornography, file sharing and online gambling. It was difficult to ascertain the success of many of these projects. Usage statistics were hard to obtain and many councils were reticent in divulging actual capital and operating costs.

A year and half later, and the public Wi-Fi environment in Australia is going through a significant transition buoyed by a renewed interest from major telcos. State and city

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governments have partnered with telcos to provide large-scale free Wi-Fi services in Melbourne, Canberra, Perth and Adelaide. The Victorian Government has sought expressions of interest for a city-wide five-year free Wi-Fi trial (Cowan 2014). The ACT Government has partnered with iiNet to provide 700 hotspots across 12 business districts by June 2015 (Coyne 2014). Perth is extending its trial services in Murray Street, Forrest Place and Grand Lane to blanket the whole CBD (Robertson 2013). Adelaide is currently operating the most generous and advanced free Wi-Fi service, 'AdelaideFree', with 300 hotspots covering high traffic areas in the CBD, parts of residential North Adelaide, and some surrounding parklands. Representatives estimate approximately 30,000 daily users (Francis 2014). The service is run by Internode, an iiNet subsidiary.

While Perth's service is owned and operated by its city council, Adelaide and Canberra have opted to provide a one-time fixed portion of the costs while letting iiNet and its subsidiary Internode supply the remaining funds as well as own and operate the networks in both cities. How iiNet intends to sustain these large 'free to use' services is an interesting question. It may seek revenues from advertising, 'freemium' subscriptions, or through merely increasing the visibility of its brand. It is possible that iiNet will make cost savings if it chooses to offload its mobile broadband traffic onto the Wi-Fi network. More will be said on this below.

Alongside these large-scale municipal developments, telcos have also introduced plans for widespread commercial Wi-Fi projects. Since the announcement of the NBN, the second tier Telco industry has undergone expansive consolidation, with M2, TPG and iiNet emerging as challengers to Telstra and Optus across a range of services. In this context, mobile Internet solutions have become a significant area of competition and innovation. iiNet has introduced plans to install 30,000 Wi-Fi hotspots in Australian capital cities (Bingemann 2014a). This commercial Wi-Fi network will extend existing customer broadband subscriptions and likely provide premium subscriptions to new customers, thus competing with more expensive 3G/4G services. The existing hotspots iiNet has developed for Canberra and Adelaide's free Wi-Fi services will also likely be incorporated into this broader network.

Telstra has also announced an innovative Wi-Fi network combining residential and business customer hotspots with 8000 Telstra hotspots in high traffic areas (Bingemann 2014b). Telstra's fixed-line broadband customers will be given the opportunity to purchase a special modem which will allocate a portion of the customer's bandwidth to the general Wi-Fi network. All participating customers will be able to access the network, with non-participants able to establish access for a 'small fee'. Telstra is attempting a kind of Wi-Fi crowdsourcing, and predicts 2 million hotpots within five years, the world's largest Wi-Fi network.

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It could be that ever increasing demand for mobile broadband is a chief reason for telcos re-emphasising Wi-Fi. As demand increases beyond the capacity of spectrum allocated to 3G/4G traffic, carriers elsewhere in the world are seeking to offload data to Wi-Fi networks in high traffic locations. A report by Juniper Research (2013) estimates that 50 percent of 3G/4G data was offloaded to Wi-Fi networks last year. Telstra has denied building its Wi-Fi super network to alleviate 4G congestion (Colley 2014); however global trends suggest that mobile offloading will likely drive Wi-Fi infrastructure in Australia. Within the context of all these changes, questions of why, where, how and who regarding the use of free Wi-Fi, as well as what outcomes this has for public space, become increasingly significant.

Factors which make a free Wi-Fi service popular

The Wi-Fi discourse in Australia has recently become one of scale: blanketing entire cities, cornering markets and handling massive volumes of data. The danger here is that more nuanced factors which influence how and why people use Wi-Fi are diminished or covered over by the big picture. In this section we approach this problem by exploring the factors that make a particular Wi-Fi service 'work' in a particular public space. We begin by describing Victorian free Wi-Fi services we visited in the course of our research that could be said to have 'failed' in their attempts to enhance public spaces, largely because they garnered hardly any users. We are not criticising these attempts as they are in fact elucidating experiments in a relatively uncharted territory. These include projects in Darebin's Edwardes and Broadway Streets, the State Museum of Victoria, Moreland's Harmony Park and Geelong's Johnstone Park. Following this we describe services in Federation Square and the State Library of Victoria which attracted numerous users and hence had a notable influence on public space.

Edwardes and Broadway Streets are in the heart of Reservoir (a suburb of Melbourne) and contain various retail and lifestyle stores, restaurants, cafes, supermarkets, and health and fitness services. Darebin City Council (2012) commissioned this Wi-Fi service based on a 2006 census which indicated a lack of domestic Internet connection in parts of Reservoir. The service was thus originally intended to provide Internet to surrounding residences. However, by the time it was implemented in 2010 many of the surrounding houses had obtained private Internet subscriptions, reflecting the national intensification of broadband penetration in this period. The service was scaled back to the commercial streets and the justification of its existence became less civic and more commercial. Participant businesses can give customers vouchers with passcodes to access the service, and these businesses can in turn utilise the network. However, when visiting the area we found no-one using the service. In fact, the Darebin service logged 413 non-business users over 10 months, approximately 1.3 sessions a day if averaged over that period (Darebin City Council 2012). We suggest that spatial characteristics played a key roll in this outcome. Both streets are

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mostly pavement and lack open, comfortable places to sit down and use the Internet. They are utilitarian places for shopping and strolling, not for socialising or undertaking activities such as surfing the net. As will become apparent, Wi-Fi services come to life when augmenting recreationally designed social spaces.

The Museum of Victoria's service has a similar problem. The Museum occupies a large portion of the Carlton Gardens on the northern cusp of Melbourne's CBD. Surrounding the museum is a large, open concrete area with few places to sit in the shade. Beyond that, many visitors relax in the grassy gardens, though the museum's Wi-Fi service does not extend that far. The administration portioned off bandwidth from the internal staff network for public use to add value to the site, expecting the public network would eventually be integrated with exhibitions. However, when visiting the site we found no-one using the service in the public space outside of the museum building. Again we believe the spatial layout of this area is a primary cause of this outcome. The museum is surrounded by a stark, open, unshaded concrete exterior as shown in Figure 1, which provides few places to sit, socialise and browse the Web.

Figure 1: Exterior of the Museum of Victoria

Harmony Park in Coburg contains ovals, a playground, a skate bowl, and both shaded and unshaded picnic areas. A primary school and a kindergarten occupy the same block. The park is built around family and child-centred recreational activities, and this reflects the

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surrounding parts of Coburg and Coburg North, which consist mostly of family housing. Moreland Council funds an initiative called the OxyGen Project, which provides facilities and organises activities for the local youth community. Local youth requested free Wi-Fi in a 2010 council survey and so a hotspot was installed in Harmony Park. When we visited the park after school and on weekends we found families having picnics and youths skating. However, no-one was using the Wi-Fi service. There is no real need for Wi-Fi in Harmony Park, as the kinds of young people and families who come to the park are not there to surf the Internet but to skate and socialise. These other amenities construct the park as a particular kind of space in which Wi-Fi plays an insignificant role. Nearly every visitor spoken to admitted to being unaware of the existence of a free Wi-Fi service in the park. Compared to successful sites such as the State Library and Federation Square, the park does not attract a large amount of unique visitors, being in a comparatively quieter suburban neighbourhood. Harmony Park reveals how geographic and cultural location significantly influences the 'success' of a service.

Johnstone Park is in the centre of Geelong, close to a large commuter train station, Deakin University and a busy commercial district. Various municipal buildings containing a courthouse, a performing arts centre and the city library face onto the park. The library also has a Wi-Fi service, but this can only be accessed by guests inside the library building. Interestingly, despite the comfortable space and well-positioned location, we did not observe any users when visiting the site. The service is set up primarily as an information and marketing portal for tourists. Users can surf the council portal without any time or data restrictions; however, other forms of Internet use are severely restricted. The participating ISP offers a meagre 10 Mbit download limit with the hope it will attract visitors to a premium service. This case illustrates the distinction between an institution-centric service, which primarily provides council services and information, and a user-centric service which affords more unrestricted and data-hungry Internet practices. This service is unsuccessful, we argue, because it lacks a user-centric orientation.

Both Federation Square and the State Library are in the heart of the Melbourne CBD, opposite two of the city's largest train stations, and near heavy flows of students, workers, shoppers and travellers. Federation Square is marketed as a prime tourist location and cultural institution. It contains various bars and cafes, the Ian Potter Gallery, a National Gallery of Victoria studio, and the Australian Centre for the Moving Image. Outside, a large public screen faces an expansive stone piazza. Similarly, the City of Perth's Northbridge Piazza combines a large public screen and Wi-Fi service, and there are plans for similar spaces in Greater Dandenong (Barber 2014) and Canberra's Garema Place (Digital Canberra Action Plan 2014). The Federation Square service is robust and covers a large area, so people

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can be found using Wi-Fi all over the piazza, sitting on grass, concrete edges and steps, on fold-out chairs, and crowding on the steps in the eastern crook of the square where the signal is strongest. An example is shown in Figure 2.

Figure 2: Tablet user sitting in the complimentary beach chairs at Federation Square

The State Library of Victoria is opposite RMIT and the Melbourne Central Mall. Its free Wi-Fi service covers the interior of the library as well as a small foyer and a rectangular outside area with grass, benches, concrete platforms and stairs. (See Figure 3.) As with Federation Square, we found people using the service all over the outside space, though most users crowded on the stairs near the library entrance where the signal is strongest. We conducted our research in February 2013 when it was very hot, and we found many users escaping into the comfortable and air conditioned library foyer to use the free Internet.

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Figure 3: Lunchtime out the front of the State Library, Swanson Street.

Both Federation Square and the State Library attract a lot of users, with representatives estimating user levels averaging in the hundreds daily. Based on the short interviews we conducted with visitors in both spaces, we find most users to be either travellers, students or out-of-office professionals. Students and professionals come to use the Wi-Fi as a means of escaping the distractions and confines of home or the office. Some students come to the lawns outside the State Library because they intend to eventually go inside to use other library resources for study. Travellers come to both spaces because they are close to their accommodation. Hostels often charge to use Wi-Fi or have unreliable connections, making free services more attractive to travellers with tight budgets. The travellers we spoke to had also visited cafés to use free Wi-Fi, but many preferred the State Library and Federation Square as there was no obligation to buy anything.

Visitors also come to the State Library and Federation Square because of the other attractions these spaces and surrounding businesses offer. These other use values work with Wi-Fi rather than against it. For example, using the library complements the needs of students and out-of-office professionals to study and work. The media assets, such as the large public screen at Federation Square, work with the desire to use the Internet for entertainment and sociality. For example, we visited Federation Square when the Super Bowl

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was playing on the public screen, and many people were checking sport statistics on their devices while also communicating with family members in America.

Most participants reported coming because they liked the 'look and feel' of these places. They were described as 'comfortable', 'nice', and 'easy on the eye'. People reported enjoying the 'atmosphere', which one participant described as 'lots of people relaxing, looking happy'. Unlike the negative cases discussed above, both Federation Square and the State Library are busy spaces with numerous attractions and hence are capable of pulling in new visitors who seek this kind of atmosphere.

To summarise, both the State Library and Federation Square 'work' as free Wi-Fi spaces because they are located in busy areas, near people who have a demand for network services, are attractive spaces which have a social atmosphere, and have a confluence of other use values which work with Wi-Fi rather than against it.

How people use free Wi-Fi

Visitors to Federation Square and the State Library used laptops, tablets and smartphones and engaged in different forms of use which we conceptualise as 'supportive', 'productive' 'entertaining' and 'social'.

Travellers primarily engaged in 'supportive' forms of use. Many travellers had just arrived in Melbourne, were young, on a tight budget and had yet to find more permanent places to live and work. They valued free Wi-Fi to help support themselves in various ways, such as sending out job resumes and responding to online accommodation advertisements. Travellers also used free Wi-Fi for interpersonal support, emails and social media such as Facebook to communicate with friends and family.

Students and out-of-office workers come to use free Wi-Fi to complete study and work tasks. Mellissa Greg (2011) has explored the way in which mobile media accommodates an expansion of professional work beyond the office and the '9 to 5' time slot. Laptops, smartphones and tablets are the tools of entrepreneurs, freelancers and home workers who often do not have a specific work space and hence rely on Wi-Fi equipped spaces such as cafes, co-working hubs and places like Federation Square and the State Library. Free Wi-Fi is a key form of infrastructure which, in enabling 'productive use', transforms public spaces into 'productive spaces'.

Visitors also come to these places to 'chill out', 'relax', and use the free Wi-Fi to 'kill time' surfing the net. This is a form of digital leisure which can be conceptualised as 'entertaining use'. Because it involves data-hungry activities such as watching YouTube videos it requires user-centric services with low restrictions on download volume.

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Finally, visitors come to use free Wi-Fi to socialise with friends over the Internet via email, Skype, and social media. Most people were using some form of social media, with Facebook being the most common. Visitors upload photos, make or respond to updates, and scan News Feeds. Visitors also use free Wi-Fi in pairs and groups. Those engaged in supportive, entertaining and social forms of use were more likely to be with at least one friend compared to those who said they were studying or working. It was much rarer for people to have engaged in a social interaction with a stranger while using Wi-Fi. In cases when this did happen, it was usually to respond to a request for directions or a question as to how to log onto the service.

Discussion

This research has described a range of factors which influence whether a Wi-Fi service will be popular, as well as how and why people use a popular service. Not every space is appropriate for free Wi-Fi, as the design of a space, its material attributes and location, the existence of other amenities and attractions, and a proximate demand for free Wi-Fi all come into play in determining the 'success' of a service. CBD projects will likely be more successful than suburban ones by virtue of their greater population flows and densities. However, it is likely that there are many places within a CBD which are not appropriate for Wi-Fi because they lack the attributes discussed above. CBD-wide 'blanket' services such as those being constructed by Perth, Adelaide, and Melbourne may be providing Wi-Fi in places it will be rarely used, a potential waste of resources better spent elsewhere.

Looking at how people utilise free Wi-Fi in popular sites helps understand whether its introduction will enhance public space in line with a conception of the social good. Federation Square and the State Library of Victoria are successful in attracting people to a particular place and enhancing the perceived 'atmosphere' of space, which goes toward a kind of cultural place making. They are also successful in providing Internet to people in need, namely travellers, youth and out of office workers, and thus address issues to do with digital equity. They are user-centric services which enable a range of uses, discussed above, which are undertaken alone and in both physical and virtual social contexts. However, our initial observations found that users tend to be 'cocooned' within existing social relationships, which means they may be less open to chance public encounters and experiences, confirming previous theory and research (Habuchi 2005; Hampton et al. 2010; Humphreys 2007; Ling 2008). This kind of cocooning is potentially harmful to the cosmopolitan principles stated above. Public institutions that genuinely want to construct good public places supporting rich social interactions between diverse groups should be mindful of this, and should consider strategies for encouraging cross-group mingling. Federation Square often has events and, as the Super Bowl example reveals, these can work

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with Wi-Fi use. Public institutions have an explicit incentive to engage in this kind of cultural curation, stemming from their responsibility to the social good. Yet achieving these outcomes may require further advocacy and education in local government about the relationship between public space, network technology and mobile media.

It is also worthwhile contrasting this public and civic orientation with how commercial entrants into the Wi-Fi space have considered public space and, indeed, the public. Commercial providers tend to categorise space primarily in terms of demand for different services and the opportunities for market gain when considering competition, population and mobility statistics, usage volumes and access to broadband infrastructure. In this context 'the public' is defined as a collection of businesses and individual mobile consumers who are monetised through subscription plans and forms of surveillance which yield valuable data on patterns of use and consumption. While this orientation is understandable, it means that the question of the collective, public or civic benefit that might arise from networked public space are often ignored. An alternative provided by a cultural institution or municipality is in the position to treat the 'public' and public space differently and create places where users have collective experiences with less intensive forms of personal data surveillance.

Conclusion and questions for further research

Australia is transitioning from a diverse but unevenly developed public Wi-Fi landscape into a far more institutionalised and expansively capitalised one in which public and private players are cooperating and competing on large-scale urban projects. It may still be too early to say how these new Wi-Fi services will affect public spaces, cultures and the social good. Further research should focus on some of the key open-ended questions touched on in this article. Will Wi-Fi services significantly affect rents and prices in already populous and competitive urban areas, and will this have a negative, exclusionary effect on public space? How will the emerging large-scale, citywide free Wi-Fi projects influence the many different public places they cover in different ways? How will co-located free and commercial Wi-Fi services influence each other? What will users prefer, and how will the adoption of one over the other influence public spaces? Finally, how can local governments curate networked public spaces to foster more virtuous public experiences?

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The importance of circumstance: Digital access and affordability for people experiencing homelessness

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Summary:

Access to and affordability of digital technology for vulnerable and disadvantaged groups is an ongoing concern in an Australian context, however the digital needs, issues and barriers for consumers who are homeless are largely neglected in this literature. This paper presents findings from a research project on mobile phones and the internet in the lives of people experiencing homelessness and engages with some key issues of digital exclusion arising in the context of a general shift in connectivity to mobile media and the push by the Australian government to reform service provision around these changes.

The paper argues for the need to recognise the ways that life situations and circumstances of hardship, such as homelessness, factor into the patterns of mobile and internet connectivity, creating unique issues of digital access and equity. It argues for knowledge of these differences to inform digital delivery of government services and approaches to telecommunications policies and assistance programs, and puts forward a number of recommendations based on a study of 95 adults, families and young people experiencing homelessness which was carried out in Sydney and Melbourne in early 2014.

Introduction: 'Digital divide', digital inclusion and homelessness research

It is now well documented that deprivation of internet and mobile communication can extenuate or create new barriers for groups that are vulnerable and socially excluded (Helsper 2008; Kvasny et al. 2006; Lee et al. 2002; Willis and Tranter 2006; Vinson et al. 2007; Wise et al. 2012). Access to contemporary media forms such as the internet and mobile phones are understood to be fundamental for access to support networks and services, to social participation and civic identity formation (Arvanitakis 2013), as well as for achieving better health outcomes (Blanchard et al. 2008, Eyrich-Garg 2010; Rice et al. 2010; 2011a; Newman et al. 2010; 2012).

Earlier work in the 90s and early 2000s on the "digital divide" emphasised gaps in access to desktop based and wired internet services by some social groups as these technologies were broadly adopted. Since this time, not only has the media environment radically changed but also, research into this area has departed from the binary formulation of the 'haves' and the "have nots". The concept of "digital inclusion" is an approach which captures the additional issues of long-term affordability, usability and digital skills and literacy, and points to

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gradations in quality and level of access and use as more relevant for investigating contemporary "digital divides" (Warschauer 2002; Van Deursen and Van Dijk 2013).

Research on digital inclusion in Australia taking up these issues has focused predominantly on low income groups and groups marginalised by geographical barriers and literacy. Anglicare Victoria, for example, reported results among people accessing emergency relief and financial counselling services, which showed that in 2012, only 49 per cent of this group accessed the internet at home and 56 per cent used mobile internet (Wise et al. 2012). This compares to 83 percent of households with home internet in the general population, of which 93 percent had broadband access (ABS 2014). These results are further supported by household surveys, which report a gap in household information technology use based on income (Saunders et al. 2007).

Minority groups are also a focus of research into digital access and literacy covering newly arrived migrants and refugees (Leung 2014), remote Indigenous communities (Auld et al 2012; Johnson 2013; Radoll 2009; Vaughn 2011), people living with disabilities (Ellis and Ken 2011; Goggin and Newell 2003), rural and regional communities (Atkinson et al 2008; Goggin 2003) and seniors (Migliorino 2011).

Despite this burgeoning research, there is surprisingly little academic research on groups experiencing, or at risk, of homelessness. People affected by these circumstances tend to get subsumed into research on other vulnerable and disadvantaged groups if they are included at all. One exception to this was a localised study, undertaken by Goodwin-Smith and Myatt (2013) with Anglicare South Australia, which researched 17 homeless participants in metropolitan Adelaide.

One of the difficulties of researching groups who experience homelessness is access to these cohorts: many are hard to reach because they may be transient and lack a household phone or permanent address. While these groups have a high level of contact with government and other services (Baldry et al 2012), some don't access formal services at all: 60% of the 1.1 million adults who had experienced at least one episode of homelessness between 2000 and 2010 had not sought assistance from formal services, according to ABS figures (ABS 2010).

Another reason for this shortage of research is the way this literature has, up until now, emphasised demographic and socio-economic criteria, over circumstances and conditions that impact on access and use. Yet, in research where homelessness is the focus, these have been found to be significant factors shaping patterns and meanings of access and use.

The study by Goodwin-Smith and Myatt (2013), for example, identified a high ownership and level of importance given to mobile phones by their participants, but also found that

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smartphones were mainly used for calls and text due to high data costs. Of research carried out in the US and Canada, a similarly high level of digital connectivity was identified, with mobiles used to access social support and employers, and the internet for accessing social networking sites, especially for messaging and blogging (Rice et al. 2011; Guadagno et al. 2013). This research suggests that mobiles may play an even more important role for groups who are homeless, a suggestion backed up by support providers (Hensler 2003).

The 'Homeless and Connected' study reported on in this paper, responded to the need for a baseline study in an Australian context to understand and systematically document patterns of access and use among this group. It also set out to develop a situational understanding of mobile phone and internet access and use, adding to our understanding of the digital challenges, issues and barriers faced by homeless Australians, through a media consumption lens.

Media Consumption

Studies of media consumption stress the creative appropriations of users, whereby the meanings and uses of a technology are altered to fit within lived experiences and needs. We know that differences in consumption arise and play out according to users' gender and socio-economic status, and to the meanings and values activated according to specific interests and concerns. Dealing with homelessness and its related complexities is a 'focal concern' for those affected, in the way that media consumption is carried out and what it comes to mean. Homeless consumers, it is posited, have distinct ways of using and making meaningful contemporary media forms, and capacity to afford and capitalise on future digital technologies. This approach underlines life circumstances as an important but neglected feature of consumption processes and crucial for analysing and achieving digital inclusion.

Homelessness is a concept that describes a complex social condition and there is no consistent and universally agreed definition in use. Having said that, homelessness is generally accepted to be broader than not having a shelter or 'roof over your head'. It is a lack of what most people would think of as the core aspects of a 'home' such as a sense of security, stability, privacy, safety, and the ability to control living space (ABS 2010).

Homelessness is not always attributed to low income. Indeed, any person at some time in their life can experience homelessness resulting from an event or situation such as illness, disaster, being the victim of violence, financial problems or a shortage of affordable rental housing (ABS 2010). Nevertheless interrelated factors, such as poverty, lack of opportunities for education and employment, mental illness, disability and ill health can lead to

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homelessness, and are oftentimes effects of homelessness, especially long-term homelessness.

Homelessness is also embedded in a larger social and technological context that shapes the consumption and engagement with digital technologies (cf. Donald and Wajcman 1986). Two of the current developments with implications for people experiencing homelessness and other vulnerable and disadvantaged consumers are the digital reform of public services, and new patterns and technologies of mobile connectivity.

Digital Service Reform and Mobile Internet

The reform of public services through mobile and online platforms has taken on new momentum with the introduction of a number of cross sector initiatives. These include the *Australia's National E- Health Strategy* (2008), the *National Digital Economy Strategy* (2011) and the *Australian Public Service Mobile Roadmap* (2013). The government reform strategy, referred to as 'digital first', includes an aim to "require agencies to make key priority services available online, including on mobile platforms", with 2017 as the target date for all interactions that occur more than 50,000 times per year to take place online (Department of Finance 2013; Turnbull 2013).

One of the main drivers of reform in the delivery of a wide range of public services is the rise of the mobile internet (mobile phone handset internet, dongle, datacard or USB modem) and growth in the use of internet services via mobile phone handsets. The uptake of smartphones in the mainstream population is currently just under 64% of the population (ACMA 2013). Accompanying this trend is a decline in fixed line services and rise of what has been dubbed the "mobile only population", recorded as 3.68 million Australians aged 18 years and older as of June 2013 (ACMA 2013).

The rise of the "mobile only" population and general take up of mobile devices and online platforms are seen by many as an opportunity to reach new networked publics. Indeed, for homeless groups, who may represent an unaccounted for segment of the "mobile only" population, changes in the delivery of public services may indeed represent a new way that individuals can access information and services. A key risk, however, for these and other vulnerable and disadvantaged consumers, is the outright exclusion from services as a result of lack of technology access. As Sinclair and Bramley (2011) observed, when there is a general technology shift in the population, and this platform becomes the main gateway for government and commercial services, those unable to access or use that technology can become further marginalised. Moreover, as Napoli and Ogar (2013) have pointed out in relation to mobiles 'leapfrogging' in developing countries, even when internet-enabled

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mobile devices offer a means to skip traditional PC based fixed internet access, mobile access falls short in terms of opportunities for advanced usage, content production and dissemination.

Another risk, which tends to be obscured by the commitment to technological change as 'progressive' in and of itself is the way in which service changes in and through technologies affect the service relationship and potentially add to, or exacerbate particular barriers, financial burdens and forms of disadvantage experienced by service users. Whether and how mobile phones (including smartphones) are used, the sources and type of internet access and the activities conducted through mobile phones and other internet-enabled mobile devices all have implications for the overall impact of service change on particular groups of consumers and may have specific meaning for people at imminent risk of, or experiencing, homelessness.

The study: Homeless and Connected

The research project 'Homeless and Connected' was carried out from February to April 2014 and involved a survey of 95 families, adults and young people who were clients of specialist homelessness services located in inner and outer metropolitan Sydney and Melbourne. The study participants were homeless at the time they presented to services or at imminent risk of becoming homeless. The housing arrangements of participants encompassed emergency housing (8%), supported housing (32%), staying (temporarily) with a friend or family member (11%), living on the street, squatting or living in a park (12%), living in a boarding house (4%) and in private rental (22%).[i]

Participants were recruited with the assistance of support staff and caseworkers who distributed invitations to participate in the study. Surveys were also collected by directly approaching customers of a foodvan service at an inner city park in Sydney over a series of nights. Semi-structured interviews with clients and staff were conducted as well as interviews with government department personnel in the 'Future Service Design' section of the Department of Human Services, and the reform team of the Specialist Homelessness Services at the Department of Family and Community Services/Housing NSW.

The cohort sampled was made up of young people (15-24) (60%), families (defined as single parents with children or couples with children) (22%) and adults (over 24) (18%) experiencing homelessness, and a smaller number who were at risk of homelessness. The gender breakdown was: 53 (56%) female and 42 (44%) male. 30 (41%) participants were from culturally and linguistically diverse backgrounds (CALD), 10% were Aboriginal or Torres Strait Islanders, 19 (20%) identified as having a disability and 38 (43%) reported having or having experienced a mental illness.

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The aim of the sampling strategy was to provide an insight into the patterns of access and use of a range of groups within the homeless population to achieve a comprehensive snapshot rather than a representative sample. The sample sought information about users of mobile phones and the internet, with a separate survey delivered to those who indicated they did not have a mobile phone at the time of the study. The scope of this study was limited to groups living in metropolitan centres in Sydney and Melbourne, however early in the project it was identified that the digital experiences of groups in regional and rural areas experiencing, or at risk of homelessness, may have distinct patterns and needs, and warrants its own research.

Key Findings and Discussion

The study found a high level of mobile phone ownership. 95% of the homeless families, youth and adults surveyed had a mobile phone. Remarkably, this was higher than the rate of ownership recorded in the general population by ACMA (2013), which was 92% of all Australians over 18 in 2012. There was also a very high number of smartphones recorded. Of those surveyed, 68 (77%) had smartphones, which again exceeded the total rate of smartphone use in the overall Australian population by 13%.

While most participants had access to a mobile phone, the study found a large variation in the age and functionality of mobile phones and ways these were acquired. The majority of mobile phone users (57%) purchased their mobile handset new or second-hand from a mobile reseller, second-hand dealer or from an online platform trading in second-hand goods such as eBay or Gumtree. A significant proportion (32%) obtained their phones as a gift from a family member, friend, support service or other source. Only 6 (7%) of the mobile phone users surveyed purchased their mobile handset on a mobile plan.

The high level of mobile phone ownership and pattern of acquisition outlined is consistent with the way that participants negotiated the cost of their mobile. The majority used a mobile phone with a pre-paid service and participants explained this as the only way to avoid getting into financial difficulty. Nevertheless, for a small number, a mobile plan represented a way to get hold of a mobile phone urgently in a time of need. Barbara, a young woman in supported accommodation explained how, living on the street, when she had her phone stolen, broken or lost, she would then need to get hold of another phone. Signing up to a mobile plan was a way to obtain a mobile handset without the upfront cost. She also explained how this ultimately lead to connectivity problems as a result of not being able to make contract payments a little further down the track.

These high rates of mobile ownership might lead government and service providers to a view that people experiencing homelessness are as fitted out to participate online and interact

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with digital services as everybody else. Yet, the study also found that participants encountered significant difficulties affording their mobile services and internet connections, and these difficulties, though similar for other low income, vulnerable and disadvantaged groups, were also specifically related to their circumstances of homelessness.

For example, 32% of participants reported difficulty recharging their handset battery and described the efforts they went to in order to secure a reliable source, a basic condition of access that most people take for granted. One customer of an inner-Sydney Food Van service talked of a power point at Central station he visited to recharge his mobile phone. Other issues that affected connectivity included imposed service restrictions, breakdown and loss of mobile handsets, and most of all, shortage of credit for one or more mobile services. All of these limitations meant that participants had partial or discontinuous access to phone and internet services.

Despite appearances, having a mobile phone (recalling that many were smartphones) was not indicative of their affordability but rather the degree of their importance and priority given to them by participants because of their essential role for 'survival' when no ready alternative was available. Recent reports (Cowie 2014) on the diminishing number of public payphones (half that of a decade ago) starkly highlights the lack of alternative means for communication and heavy reliance on mobiles for those without household phones.

What do mobiles mean and how are they used

The results showed that mobile phones are essential for survival and safety, for gaining new skills and for moving out of homelessness. Participants identified using their phone to contact emergency services, support services and medical assistance as the most important uses of their phones after contacting friends and family. The internet played a lesser role for contacting emergency services and for safety but was identified alongside the mobile as very important for finding accommodation, employment and for maintaining professional ties, with 47% using the internet to look for a job, 33% for being contacted by employers and 33% for learning new skills.

Making and receiving calls were the main uses of mobile phones that had little or no support for web browsing or app downloads, but many participants used the tools that came built in with their phones like the 'memo pad' and 'calculator'. Jen, a young person in supported accommodation, offered two examples of how she used these features on her four year old LG phone to satisfy the income reporting requirements of Centrelink and to track her spending while shopping:

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> *I use the memo pad a lot. I write my work hours in my memo pad because I've got to report to Centrelink. So it helps me work how much I got paid because, unless they're really fast with the pay slip, I don't have my pay slip before I have to report…*

The ability to control communication – how and when it happens – was also an important aspect of the mobile's utility as an emergency and safety device. A support service worker who had provided support and assistance to clients escaping family violence explained that this control, and the ability to screen calls easily, is something that landlines don't easily offer, and is a really important way of engaging with young people because it is less confrontational when you can choose when and how you respond.

Smartphone users were taking advantage of the multimedia functions of their phones and engaging strongly in social media and content creation (e.g. photos). Family use of mobiles and smartphones was particularly striking – of the 21 families in the study, only 3 did not have a smartphone and smartphones were central to family organisation and communication.

The smartphone was also a tool for budgeting, for finding out about and scheduling school activities, accessing government services and for self-study. This latter use was stressed by two of the women with children interviewed, both of whom had recently engaged in formal learning. Melinda, a single parent with a five year old son, living in an outer Melbourne suburb, explained the use of her smartphone in this way:

> *The main things are the school stuff, my banking, job searches. I've got my Centrelink on there. I've got the deals, a lot of shopping deals, OurDeal, CatchofTheDay, Groupon, so if I can always buy something cheaper from somewhere else I'll do that…*

Indeed the findings made clear that managing everyday costs was a major focus of participants' strategies of mobile use – to make savings and budget for other costs and to keep the costs of the mobile down. At the same time, the smartphone also exposed participants to an increased risk of debt. Out of the 28% of all users who had reported a mobile phone debt, there was a higher proportion of smartphone users (86%) compared to non-smartphone users (75%), and families were more likely to have experienced a debt than young people and adults. Two of the known risk factors for debt are the high cost of data and difficulty monitoring children's data use and in-app purchases (NCYLC 2013), reasons cited by participants' for shifting over to a pre-paid from a post-paid plan.

The most common method participants used for accessing the internet was using a Wi-Fi hotspot with a mobile phone or other mobile device (43%), and a proportion used an alternative device with mobile broadband such as a tablet or laptop for accessing the internet instead of, or in combination with their mobile phone. But there was a surprisingly high

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number of mobile users who only accessed the internet from their mobile (22%) and where there was support for the internet through a mobile phone, even if in a limited way, users availed themselves of this source of access. This finding contrasts with some of the earlier studies of internet access among the homeless suggesting a shift in line with the general move in the population to mobile forms of internet access, which for many people experiencing homelessness might be the only way to get online.

This use of mobile phones as an internet platform had clear cost implications, and users shaped their use accordingly – relying on alternative free or less costly fixed or wireless sources of the Internet such as Wi-Fi hotspots, government centre 'self-service' terminals, networked computers at public libraries and the computers belonging to friends or family members. Staff of support services also commented on the heavy use of networked computers offered to clients for use within their premises – and observed their cost saving role.

This strategy of maintaining connectivity through a pastiche style is especially common and possibly unique to people who are homeless. Participants also reported a variety of other strategies and innovations for managing the upfront and ongoing costs of a mobile. Some of these included: usage monitoring tools/apps; tethering the mobile as an internet server; avoiding downloading/turning off features that use data; using Facebook messenger, Live Chat and Skype for free messaging: using available public/private power sources for charging; using SMS/text and call back and purchasing a low cost basic mobile for temporary use.

Many of the strategies discovered were very novel and had the dual role of maintaining continuity of access, standing in as temporary solutions or workarounds when a connection wasn't available, such as when a phone service was turned off or suspended because of credit shortages. At the same time, these strategies could in themselves affect service provision and lead to difficulties with getting in touch with clients, for example, when clients used temporary basic phones when their had been lost or stolen. These strategies drew attention to the partial way in which these practices were able to deal with fundamental structural issues of affordability of mobile and internet services in the context of the overall cost of living for people on little or no income.

The Cost of Contact

Strategies for maintaining connectivity and affording the cost of the mobile are indicative of the high cost and burden that these costs represent for people experiencing homelessness. Even without factoring in extra payments for internet access (which a number of basic and feature phone users reported having for their other mobile devices such as laptop and tablet),

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the monthly payment costs for a mobile service (which may or may not have internet capability) as a proportion of monthly income is considerably higher for a person on a government benefit than it would be for a person on an average salary (8.7%[ii] compared to 1.42%). Significantly, while many presenting to specialist homelessness services are on government supported incomes a sizeable proportion have no income at all.

One subset of the sample who, because of cost as well as other factors such as lack of interest and skill, were without a mobile and in most cases were also non-internet users. Single adult males (aged over 24 years) living in emergency housing, boarding houses, on the street or in temporary accommodation were ten times more likely than the other participants studied to be without a mobile phone. This group of non-mobile phone users relied on borrowed phones, public pay phones, phones provided by government agencies and accommodation centres for making and receiving phone calls. This group also had little or no Internet access – with 2 of the 5 reporting that they don't use the Internet at all and 3 reporting that they access the Internet from a public library or from a friend or family member's computer.

The affordability of mobile phone and data services must thus be considered not only in light of their cost compared to other utility appliances and services but rather in light of the overall income needed to meet housing and other essential needs and obligations in society. For chronically homeless males, a different set of issues are involved in addition to cost factors, with issues of engagement, skill and interest being as much of, if not more of an issue, for this group.

Compelled to contact and be contactable

One obligation that drives the need for a mobile phone is the contact and reporting requirements of government agencies and support services. As previously noted, people experiencing homelessness interact with a wide range of government services and agencies, and much of this by phone. 1800 and 13/1300 numbers, which many services use as their primary access point, were identified by study participants as a major expense and frustration. In some cases participants talked of attending centres in person just to avoid the cost of the call and wait time. Indeed, it was the combined effect of wait time and the timed nature of these calls that made this contact method so costly. In one case, a young woman living in a refuge without a pay phone had signed up to a mobile phone contract to try to meet Centrelink reporting requirements because her pre-paid mobile service kept running out of credit while on hold, only to end up in financial difficulty at the end of the billing cycle when she exceeded the cap on her mobile plan.

A range of institutions and government departments now recognise the impact of the cost of contact on service users. The Commonwealth Ombudsman, in a report investigating

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complaints made by customers of Centrelink (now integrated into the Department of Human Services (DHS)) identified access problems as a major cause of complaints to their agency.

Following reports such as these and concerted public campaigns, awareness of the cost of contact appears to be informing the way some services are being implemented as well as how 1800 numbers are charged. Under a new charging framework, individual mobile operators will make 1800 numbers free of charge from pre-paid mobiles from 2015 (ACMA 2014). However, 13 and 1300 numbers will continue to be timed. Unwittingly, this could lead to further confusion and unexpected charges since organisations such as banks, insurers and mental health support will likely continue to use these popular and easy-to-recall numbers.

The shift to digital service delivery by government agencies is another area for potentially new or additional costs. As part of a sector-wide program of service reform, many public service agencies are rapidly enlarging the volume and range of transactions that can be performed using online and mobile channels. The Medicare and Centrelink Express apps, launched by the Department of Human Services in 2012 are good examples of this digital reform program.

As options for interacting online and through mobile apps grow, the cost of contact goes up for mobile phone users where these options are additional to existing telephone services, due to new or higher data charges. For those already finding their mobile service payments difficult, this cost comes as an added burden, which may put interacting online out of reach. The implications is not only that it will have the paradoxical affect of pushing users back into staff intensive and costly (to services) contact centres, but will mean that for a number of users who have mobiles and are currently interacting online, as with the vast majority of participants in this study, they will miss out on the benefits of digital services and may find it increasingly difficult to comply with contact and reporting requirements.

Conclusions: Policy Implications

The study identified that for people experiencing homelessness digital inclusion is not just a question of getting hold of new technologies – indeed when it comes to mobile services, a sizeable portion of consumers who are homeless can be considered technology leaders. Not only are they able to get hold of technologies, these savvy consumers make use of their platforms in creative and innovative ways. The findings support the conclusion that there is a shift in internet connectivity within the homeless population and the idea that these consumers are a subset of the growing "mobile only" population, with many using smartphones to support a wide range of online activities and coordinate family life.

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Issues of inclusion nevertheless remain – these users have fewer options and reduced agency and power when it comes to obtaining and affording digital technology and in navigating the market. Indeed, lack of or inadequate control over space and social relations, which is characteristic of homelessness is key to, and possibly, an underestimated aspect of the capacity to engage with and use digital technology, operating alongside other recognised issues such as technological skill and literacy.

These barriers are not necessarily overcome through creative re-appropriations. Though these are similar to those of other low income groups, they are also shaped by circumstances of homelessness. In the context of evolving expectations and demands of connectivity and the push to online and mobile services, this reduced agency can become a new point of social exclusion. Imperatives of contact and being contactable are built into usage contexts and these come with a cost, one that is unequally born by people on low incomes and those experiencing hardship such as homelessness.

The findings provide further evidence of the need to develop targeted communication strategies that takes into account people's circumstances of homelessness, and to develop policies that recognise the importance of affordable access in telecommunications and broadband services (Bruce et al 2012; Morsillo 2012, Notley and Foth 2008). With this in mind, a number of recommendations are proposed to mobile providers and government and support agencies to improve on and develop existing assistance programs and policies. In summary these are:

Telcos:

- Recognise unique issues of people experiencing homelessness in hardship policies, contact methods and staff training.
- Ensure cost effective methods for consumers to reach staff and teams with responsibility for hardship.
- Create and extend aid and subsidy programs that work effectively across all mobile service providers, to support mobile and data services and make available to community services supporting people who are homeless and in crisis.
- Improve community phone and internet facilities to assist telephone/online access by people experiencing homelessness in partnership with support and housing providers, libraries, local councils and service users.

Government Agencies and Support Services:

- Ensure cost-effective access points to government services from mobile devices such as 1800 numbers, call back, live chat and text.

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- Preserve alternate contact and service points for non-digital and digital customers without online access.
- Build digital capacity of staff and services to support clients better online and via mobile.
- Improve community phone and internet facilities to assist telephone/online access by people experiencing homelessness in partnership with mobile service providers, libraries, local councils and service users.

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Notes

[i] The relatively high representation of participants living in private rental is explained by the intake of clients to specialist homelessness services, some of whom may have been living in dwellings so severely crowded that they counted as homeless, or were facing a threat of eviction or violence.

[ii] This figure is the cost of a mobile phone as a proportion to a monthly Youth Allowance payment if on a mobile plan. The proportions ranged from 4.7 to 8.7% depending on the type of government benefit.

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Internet connectivity among people experiencing poverty and deprivation

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Summary

Access to the digital world can have a positive impact on people's standard of living, life capabilities, sense of inclusion and wellbeing, and is fast becoming an 'essential of life' in developed countries. While the majority of Australians enjoy the benefits that access to the Internet can provide, millions are still missing out on important online services and opportunities. In-depth research is starting to uncover a range of factors that can influence digital inclusion among non-users of the Internet generally. Results from a *2013 Hardship Survey* show the disparity in Internet connectivity between people experiencing poverty and deprivation and Australians generally. The paper presents detailed findings from the survey on Internet connectivity. It concludes with suggestions to enhance smartphone usage that might help bridge the 'digital divide' for this population subgroup.

Introduction

Easy access to the Internet is fast becoming a basic component of civil life in developed countries. The most recent Australian Bureau of Statistics (ABS) *Household Use of Information Technology Survey* revealed that 83.0 per cent of Australian households had access to the Internet (ABS 2014). Broadband Internet has also increased markedly in Australia. Of all people with home Internet in 2012-13, 93.0 per cent had broadband access (ABS 2014). Further, the Australian Communications and Media Authority (ACMA) estimated that at May 2013, 64.0 per cent of adults over the age of 18 (11.19 million people) were using a smartphone (mobile phone built on a mobile operating system with more advanced computing capability and connectivity than a feature phone) (a 29.0% increase from May 2012) (ACMA 2014: 25).

The way in which new telecommunications technology has been woven into the fabric of Australian society is captured in surveys carried out by Saunders in 2006 and 2010 to identify the 'essentials of life' (Saunders et al 2008). Items are defined as 'essential' if a majority of respondents to the survey thought that they were essential. Between 2006 and 2010 community support increased from 19.7 to 32.1 per cent for access to the Internet at home being a basic need that no-one in Australia should be without (Saunders & Wong 2012: 34).

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The Internet transfers information and knowledge relevant to many spheres of life (Dane et al 2013). Many services are increasingly available online, especially through the health, education and government sectors because of the improvements in service delivery and cost-efficiencies that can be achieved. Government agencies such as Medicare and Centrelink, for example, are moving to online and "app" based servicing (SACOSS 2013). E-learning is also becoming an increasingly utilised and important educational tool. Children under school age can also benefit from educational games, activities and books available online. Options for social and political participation also open up to people who have access to computers and the Internet through communication with friends and participation in online discussion groups. Access to the Internet also provides a means for employment, creative expression and for people to stay in touch with current affairs, pay bills and shop (Eardley et al 2009).

The 2013 *Connecting your Community* survey provides clear evidence of positive benefits for Australian users of the Internet. While frequency and type of Internet use varied, users of the Internet reported improvement in their knowledge and skills, aspects of their social life and engagement in society. Benefits were also reported in terms of access to health treatment and information, and access to knowledge and skills-building activities (Dane et al 2013).

Despite the essential nature of Internet connectivity in modern Australia, official statistics suggest millions of Australians are missing out on important online services and opportunities. Several commenters have suggested that digital exclusion has the potential to reinforce and deepen existing social inequalities (Baum et al 2012; Dane et al 2013) and is one of the most urgent social justice issues facing Australian society today. Notwithstanding the loss of opportunity for individuals, if population subgroups are unable to engage online, then several prospects for social development, innovation and economic growth also may not be realised (Campbell et al 2013: 10).

There is a range of enablers and inhibitors of digital engagement such as skills, education, disability, literacy, language skills, support, perceived benefits and interest/motivation. In the latest *Household Use of Information Technology Survey* (ABS 2014), age and geographic location were two demographic factors that appeared to account for some the uneven uptake of Internet in Australia. Internet access was higher for people living in cities, in households with children under the age of 15 years and for young people generally. The proportion of households with Internet access in cities and with children under the age of 15 was 85.0 per cent and 96.0 per cent respectively. An ACMA-commissioned survey found that smartphone adoption at May 2013 was highest for people aged 18–24 at 89.0 per cent (ACMA 2013a). The low rate of Internet access in Indigenous communities in Central Australia and other remote areas is well documented elsewhere (Rennie et al 2011: 9). Further, the 2013

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Connecting your Community survey showed that lack of skills and confidence in using the Internet was a significant factor among people who choose not to engage with the Internet (Dane et al 2013).

Affordability of Internet access is another important factor influencing Internet uptake in Australia (Tsatsou 2011). Indeed, income is a consistent predictor of home Internet access (ABS 2014; Mossberger et al 2012). The *2012-13 Household Use of Information Technology Survey* found that 59.0 per cent of households in the lowest income quartile had access to Internet at home compared to 96.0 per cent in the highest income quartile (ABS 2014). In Saunders and Wong's 2010 survey, deprivation rates for home Internet was as high as 26.3 per cent for people receiving a Parenting Payment (Saunders & Wong 2012). Findings from the *World Internet Project Australian Survey* (2011) showed that 12.0 per cent of those who had home Internet regarded it 'unaffordable' or 'very unaffordable' (Morsillo 2012: 3). Additionally, studies conducted outside Australia in the USA and Canada, for example, show that between 5 and 17 per cent of 'Internet dropouts' (a class of non-users who were once online and have not gone back) drop offline because paying for the Internet is too expensive (Katz et al 2001; Lenhart et al. 2003; Crompton et al 2002).

The current research

This paper describes research on Internet access among a sample of adults experiencing poverty and deprivation. It presents findings from a 2013 survey involving 325 emergency relief and financial counselling service clients (welfare service clients) across 24 locations in the Australian state of Victoria. It outlines the proportion of welfare service clients who did not have home Internet, mobile Internet via tablet or laptop computer (using dongle, datacard or USB modem services) or a mobile phone because they could not afford it as well as the key demographic characteristics linked to deprivation of home Internet and smartphone. The type of home Internet (broadband versus dial-up) and mobile phone (smartphone versus feature phone) is examined, as is monthly expenditure on home Internet, subjective affordability of home Internet and the perceived role of home Internet on living standards among users and non-users. The paper concludes with a discussion of measures involving smartphones to reduce digital disparity.

Method

In partnership with the Australian Communications Consumer Action Network (ACCAN), items on Internet access were bolted onto Anglicare Victoria's *2013 Hardship Survey* (see Wise 2013). In the last two weeks of February 2013, people accessing emergency relief and financial counselling services were invited to take part in the survey. Emergency relief

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services distribute essential items such as food, vouchers, clothing and toiletries to people in need. Financial counselling is provided to low-income individuals and families struggling with debt.

Emergency relief and financial counselling services in scope for the survey were delivered from 14 metropolitan and 10 non-metropolitan sites. These sites were located in communities marked by high socioeconomic disadvantage with the exception of two emergency relief service sites located in one of Melbourne's inner-city suburbs (Fitzroy), which services a largely homeless population. Staff and volunteers were responsible for sample recruitment and survey administration using paper forms in all but 10 metropolitan emergency relief sites. Here, surveys were administered by trained interviewers engaged specifically for this purpose using Computer Assisted Personal Interviewing (CAPI) technology. This was due to the high volume of clients accessing metropolitan emergency relief services during relatively short operating hours. Clients completed the survey after receiving a regular service. Participants received a $10 grocery voucher in recognition of the time taken to participate in the survey.

Sample

The total sample achieved was N = 325. This includes 87 (29.0%) clients from the two emergency relief sites located in the inner-Melbourne suburb of Fitzroy. Another third of the sample (32.3%) was recruited from the other Melbourne metropolitan service sites and the final third (36.0%) of the sample was recruited from non-metropolitan service sites. The majority (86.3%) of survey respondents were recruited from emergency relief services.

Results from the *2013 Hardship Survey* show the survey respondents were missing out on basic items that the majority of Australians consider to be essential. These items included basic material needs such as a 'decent and secure home' (15.0%) and 'a substantial meal at least once a day' (12.7%) as well as items that would protect them from slipping to further difficulty, such as '$500 in savings' (86.1%). A number of factors linked to deprivation and social exclusion were common among survey participants, including a disability (62.8%), homelessness (7.7%), long-term (more than 10 years) unemployment (41.8%) and less than Year 12 education (51.0%). On other socio-economic indicators, more than half (55.0%) were living with dependent children under the age of 18 and just over one-quarter (26.3%) were born in a non-English speaking country. Just under half of the sample was male (46.6%). Approximately one in 10 (10.8%) were above the working age (65 years or more).

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Measures

After Australian poverty researchers Saunders, Naidoo and Griffiths (2008), and the Poverty and Social Exclusion (PSE) survey in the United Kingdom (Gordon et al 2013), deprivation was conceptualised as a not having a specific item due to an inability to afford it. Welfare service clients were asked if they had different forms of telecommunications and if they didn't have an item, whether this was because they couldn't afford it. Other relevant survey items (expenditure, perceived affordability and so on) were developed specifically for the *2013 Hardship Survey*.

Findings

Findings are presented in terms of deprivation of telecommunications, broadband and smartphone access, socio-demographic indicators of deprivation of home Internet and smartphone, affordability of home Internet and perceived impact of home Internet among users and non-users.

Deprivation of home Internet, mobile Internet and mobile phone

As outlined in the measures section above, a person is considered deprived of a certain item if they don't have it and cannot afford it. In the current study, approximately half of the study participants were deprived of home Internet (49.2%) and mobile Internet via tablet or laptop computer (using dongle, datacard or USB modem services) (56.1%). This was very high, especially when compared to deprivation of mobile phone among survey respondents. The proportion of welfare service clients who use a mobile phone was high at 85.7 per cent, just a little lower than the 92.0 per cent of Australians over the age of 18 who used a mobile phone at May 2012 (ACMA 2013b). Deprivation of mobile phone (those who didn't have one because they couldn't afford it) was relatively low compared to home Internet and mobile Internet at 11.1 per cent.

The number and proportion of participants who had these forms of telecommunications when the survey was conducted ('had it'), didn't have them because they didn't want them ('didn't have it and didn't want it') or couldn't afford them ('didn't have it and couldn't afford it') is shown in Table 1. Percentages exclude cases where response variables were not stated.

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Table 1. Number and proportion of participants deprived of home Internet, mobile Internet and mobile phone

	Had it *N* (%)	Didn't have it and didn't want it *N* (%)	Didn't have it and couldn't afford it *N* (%)
Home Internet	100 (33.4%)	52 (17.4%)	147 (49.2%)
Mobile Internet	55 (18.2%)	78 (25.7%)	170 (56.1%)
Mobile phone	263 (85.7%)	10 (3.3%)	34 (11.1%)

Type of home Internet and mobile phone

The type of home Internet and mobile phone service was examined. Among the 100 participants with home Internet, the proportion with a broadband service was roughly similar to Australians generally (88.0%).

By comparison, the level of mobile phone capability among study participants was much lower than for Australians generally. Specifically, of the 263 participants who had a mobile phone, less than half (112 (42.6%)) had a smartphone. When considered as a proportion of the total sample of 325, only 34.4 per cent of clients had smartphone technology. This is well below the 64.0 per cent estimated for Australia generally (ACMA 2014).

Difference in deprivation of Internet and smartphone according to key demographics

Independent *t*-tests were ran to determine whether or not there was a statistically significant difference between the mean age of survey respondents who had home Internet and those who were deprived of home Internet and between those who had smartphone and those who had a feature phone. Age distinguished those who had a smartphone and those who had a feature phone (mean age of clients with smartphone (M = 40.47) was significantly younger than mean age of clients without a smartphone (M=46.33) (t = 3.64, p = .00)). The difference in age between users of home Internet (M = 46.77) and those who were deprived of home Internet (M = 43.86) was approaching statistical significance (t = 1.79, p = .08).

Chi-square analyses were undertaken to examine differences between those with home Internet and those deprived of home Internet and between those with smartphone versus feature phone on categorical variables including income type, private versus public home rental, geographic location, non-English speaking background and presence of dependent children under the age of 18 in the household. These analyses showed that the presence of

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dependent children under the age of 18 was the only factor that significantly increased the likelihood of *having access* to home Internet ($x^2(1) = 12.78$, $p = .00$). There was no significant difference on type of mobile phone by pension type, location, CALD status or the presence of children under the age of 18 years in the household.

There is a number of ways of interpreting differential deprivation of home Internet. Younger respondents may be less likely to have home Internet than older respondents because they already have Internet access via smartphone, because their housing situation is unstable or because they are experiencing 'severe multiple deprivation'. It is also possible that older respondents are more likely than younger respondents to have dependent children and therefore perceive greater benefits of access to the Internet at home.

Affordability of home Internet

A number of home Internet affordability measures were included in the survey. These included bundling services, monthly expenditure, perceived affordability and the relation between having home Internet and deprivation of other basic items.

On monthly expenditure, more than half (57.6%) of clients with home Internet 'bundled' this service with another form of telecommunications as a way of keeping costs down. Of the remaining clients who did not bundle their home Internet service, all but one were spending less than $100 per month on home Internet with the majority (68.0%) spending less than $50 per month. While it should be remembered that 49.2 per cent of the total sample did not have home Internet because they couldn't afford it, interestingly, the majority of clients with home Internet who did not bundle this service (63.4%) felt the cost of home Internet was either 'very affordable' or 'somewhat affordable'. Similar to Morsillo's (2012) research, only 12.2 per cent felt home Internet was 'very unaffordable'. Consistent with these findings, clients with home Internet were no more deprived of other basic items than those without home Internet. Specifically, those with home Internet were deprived of an average 5.6 of 24 basic items, whereas those without home Internet were deprived of an average of 7.7 of 24 basic items ($t = -4.62$, $p = .00$); that is those without home Internet were significantly more deprived than those with home Internet.

Impact of home Internet on standard of living

Respondents in the survey who had home Internet were asked whether it had made an 'extreme', 'moderate' or 'no' improvement on their standard of living. The majority (83.4%) reported it had made an extreme (36.7%) or moderate (46.7%) improvement on their standard of living. Among those clients who did not have home Internet because they couldn't afford it, 33.7 per cent felt that having it would make an 'extreme' improvement to

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their standard of living and 30.2 per cent felt it would improve their standard of living 'moderately'. These results show the actual and potential improvement in standard of living that the Internet can make in the lives of people experiencing poverty and deprivation, especially when set against results from the 2013 *Connecting your Community* survey, which showed that approximately one-third of respondents reported that Internet access had improved their standard of living.

Conclusions

This study very clearly shows the disparity in Internet connectivity between people experiencing poverty and deprivation and Australians generally. Only 33.4 per cent of welfare service clients had home Internet compared to 83.0 per cent of Australians. Just over one-third (34.4%) of welfare service clients had smartphone technology compared to 64.0 per cent of Australians. Deprivation of mobile Internet was very high (56.1%).

Deprivation of a greater number of basic items and the presence of dependent children under the age of 18 years were the only factors that differentiated users and non-users of home Internet among the survey sample (those experiencing 'multiple severe deprivation' were less likely to have access to home Internet while households with dependent children were more likely to have access to home Internet). Although not reaching conventional levels of statistical significance, older respondents were also more likely to have home Internet access than younger respondents. Age was the only factor that differentiated mobile phone users who had smartphone technology or not. Further, only a small proportion of clients who didn't have home Internet didn't want it (17.4%), presumably for a complex mixture of social, psychological and pragmatic reasons (see Livingstone & Helsper 2007; Tsatsou 2011). Further, among the high proportion (47.9%) of clients who were deprived of home Internet, the large majority felt that access to home Internet would improve their standard of living 'extremely' or 'moderately' (63.9%).

These findings show that while younger welfare service clients may be more able to take advantage of smartphone technology, the vast majority of non-users of home Internet wanted it and felt it would improve their standard of living. In short, deprivation and poverty are real drivers of digital exclusion.

Widespread use of mobile phone (85.7%) among the survey respondents underscores the fact that this form of telecommunication is not only affordable, it is more easily accessed by welfare service clients who may struggle with insecure housing and poor credit records (SACOSS 2013; Eardley et al 2009). While survey respondents weren't asked directly about deprivation of smartphone, it is likely that cost is the main reason why survey respondents

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who owned a feature phone did not upgrade to a smartphone. This is rationalised by the fact that the majority of non-users of home Internet want to be connected and see the benefits of Internet access, coupled with findings from other studies that show smartphone ownership is closely linked to income (Roy Morgan 2011).

Together, the dominance of mobile communications among welfare service clients, the relative affordability of mobile phone compared to home Internet and better access to the Internet through the continued rollout of mobile networks, such as 4G, and the increased use of Wi-Fi hotspots suggests the need for cost effective programs and special schemes for smartphone usage as a strategy to increase Internet access for disadvantaged groups, especially transient and homeless population subgroups. While the range of products and services would need to be determined through industry consultation and informed by previous attempts to bring smartphones to low-income markets, both no-contract phone plans as well as low-cost phones are needed to keep smartphone technology affordable to welfare service clients. In the current study the vast majority of mobile phone users (82.3%) spent $50 or less per month on mobile phone and more than half (61.7%) of all mobile phone users reported that their mobile phone expenditure was 'very' or 'moderately' affordable.

- Although limited to mobile phone (and not Internet) The *Safelink Wireless Program* implemented by TracPhone in the United States is a potential model to consider. Here, participants are offered a free phone, without contracts or monthly fees and customers receive a pre-paid card to pay for their calls and receive free calling time (see Eardley et al 2009: 28).

The *2013 Hardship Survey* adds to a body of research which shows that affordability is a real barrier for disadvantaged people accessing the Internet. However, a simple binary calculation of disadvantaged people who are "offline" and "online" does not do justice to the variety of relationships that people have to online technology. More in-depth research is therefore needed to understand how disadvantaged subgroups engage with online technology and what other skills and knowledge they may need to use it in a way that benefits them. Nevertheless, special schemes for smartphone usage should help disadvantaged Australians use technology to take up service delivery and education opportunities, stay connected, be informed and stay safe and generally improve their life circumstances.

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Telegraphy and the downfall of the Kelly Gang – and other vignettes from the Telegraph Society of Victoria

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Summary: Four historical vignettes are provided from the period 1875 to 1880 from the Proceedings of the Telegraph Electrical Society of Victoria – the lineal antecedent of today's TelSoc (Australian Telecommunications Society). The extracts cover Alexander Graham Bell's invention of the telephone, Telegraphy at the downfall of the Kelly Gang, the speed of the Morse system, and the curious phenomenon of 'Fighting by Telegraph'.

Introduction to the historical extracts

Peter Gerrand's article in the June issue of the *Australian Journal of Telecommunications and the Digital Economy* (Gerrand 2014) traced the opening of the first telegraph office in the Southern Hemisphere back to Melbourne, Australia on 3rd March 1854.

Twenty years later in 1874 (and two years before Alexander Graham Bell patented the telephone), several like-minded telegraph workers and country postmasters formed the Telegraph Electrical Society of Victoria. The purpose was for mutual discussion of day to day telegraph problems and the advancement of their technical and practical knowledge (Credlin 1938).

The Proceedings of the Society were published on a quarterly basis and lecture pamphlets were reproduced in newspapers of the day such as *The Argus*. This paper features four extracts from those Proceedings, which resonate into the modern era.

The first extract, entitled 'Novel Telegraphy in Canada', was published in 1876. It perspicaciously described Dr Bell's invention of the telephone as 'very satisfactory' and '[it] will certainly be the greatest mechanical discovery since the telegraph'.

The second extract, entitled 'Extermination of the Kelly Gang', was published in 1880. It described two Posts and Telegraph personnel who attended the siege at Glenrowan.

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One bravely climbed a pole while bullets were flying to establish a telegraph connection to Melbourne, and the other relayed continuous updates on the situation.

The third extract, entitled 'Speed of Working the Morse Instrument', was published in 1875. It discussed the top speed of Morse messages on the busiest telegraph lines in New York, USA. Not to be outdone, the Victorian operators covering the Melbourne Cup demonstrated they could send messages at double that speed.

The fourth and final extract, entitled 'Fighting by Telegraph', was published in 1880. It is a curious article describing the fighting by operators over telegraph lines, before reliable duplex systems were introduced.

These extracts were all published later in a Society paper entitled 'Centenary of Telecommunication Societies in Australia', written by J.E. Sander for the *Telecommunication Journal of Australia*, the predecessor of this Journal, in 1974 (Sander 1974).

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The historical extracts

NOVEL TELEGRAPHY IN CANADA.

A NUMBER of gentlemen interested in scientific matters recently assembled at the office of the Dominion Telegraph Company, to witness some very wonderful experiments on an apparatus which has been invented by Mr. A. Graham Bell, son of Professor A. M. Bell, of Tutelan Heights. This gentleman claims to be able to transmit musical sounds over a telegraph wire. A person singing or speaking, for example, at one end of the wire, every note or word will be distinctly heard at the other end—not only the words would be heard, but the tones of the voice also would be readily recognised by any one who had heard them before. Another very important improvement, which Mr. Bell claims to be able to put into use, may be described as follows :—A man wishing to send a message to Hamilton, for instance, writes it on shellac paper. It is received by a boy, who puts into a machine made for the purpose. The message is received in Hamilton by another boy, who brings it forth from a similar machine copied upon a piece of shellac paper in telegraphic impressions or written like copper-plate. Pictures drawn in shellac can also be sent and received in the same way. If this system can be put into use and worked effectually it will do away with telegraph operators altogether. But the most important feature which Mr. Bell claims is that he can transmit 30 or more messages over a single telegraphic wire at one and the same time. The way he proposes to do this is as follows :—On a wire running from, say, Brantford to Toronto, Mr. Bell would place 30 or more instruments at Brantford office. All these instruments will be tuned to different pitches. A corresponding number of instruments to be placed in Toronto office, each of the instruments tuned in unison with the corresponding instruments in Brantford. An operator can then transmit a sound on any one of these instruments, and none but that at the other end of the line which is in unison will correspond. Therefore, 30 or more operators can work together on the same wire without in any way affecting the others. This seems very wonderful, but Mr. Bell claims to be able to put it into practical use, and if he succeeds it will certainly be the greatest mechanical discovery since the invention of the telegraph itself.

Mr. Bell's explanation and practical experiments were very satisfactory, and every person present seemed convinced that he had got hold of a good thing, and one which only required time to bring it into general use. Strange to say, two other gentlemen, one an electrician named Gray, of Chicago, and the other a scientist in Copenhagen, have hit upon the same ideas, but it appears Mr. Bell was ahead of them both, and got his discoveries entered in the patent office at Washington ere they appeared upon the scene. He is backed by Boston and New York capitalists. The way in which Mr. Bell first got his idea was in blowing on a single chord inside a piano. He noticed that all the other chords which were in unison were affected thereby. A gentleman present when Mr. Bell was explaining said that when the whole thing was put into working shape a concert given in San Francisco could be easily heard in New York.—*Brantford Expositor.*

Figure 1 – Novel Telegraphy in Canada

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THE EXTERMINATION OF THE KELLY GANG.

THE Telegraph Service was not unrepresented at this terrible affair. Mr. H. E. Cheshire, who was acting as Post and Telegraph Master at Beechworth, volunteered, with Line-Repairer Osborne, to accompany the train which left that town on the morning of the 20th June for Glenrowan. They arrived there during the thick of the fray, and Mr. Osborne having, in a most plucky manner, climbed a pole while bullets were flying about him, communication was established with Melbourne, and Mr. Cheshire was enabled to keep the colony—indeed the neighbouring colonies also, for the excitement extended equally to them—informed of the progress of events until all was over. The Postmaster-General has expressed a high sense of the conduct of Messrs. Cheshire and Osborne in this affair. Messrs. D. Mickle and P. Cregan, operators from the Melbourne office, were also despatched to the scene of combat, but did not arrive there until the hotel had been burnt, and the dead and charred remains of the bloodthirsty Kelly gang had been taken from the smoking ruins of the hotel.

We are also glad to observe that Superientendent Hare, in his report on this affair, alludes to Mr. Saxe, of the Benalla Telegraph office, in the following complimentary terms :—" I would also bring under your notice the great services rendered by Mr. Saxe, Telegraph Master at Benalla. The police in the district found him always ready to assist them at any moment, day or night (Sundays inclusive), and he complied with everything he was asked to do most readily and cheerfully. I would therefore urge upon you the desirability of bringing his conduct under the notice of the hon. the Postmaster-General, with a view to his promotion in the service, as you are well aware, from your own personal knowledge, of the many services rendered to us by him."

Figure 2 – Extermination of the Kelly Gang

SPEED OF WORKING THE MORSE INSTRUMENT.

SOME interesting details of the speed of working the Morse system are given by Mr. F. L. Pope in *The Telegrapher*. Six days' work on five of the busiest lines in the New York office resulted in the transmission of 5,753 messages, containing 234,546 words. This gives an average of 191 messages of 40.8 words (7,800 words), as the work of one line for one day. The average number of words per message seems high, but it is evidently caused by the occurrence of long press messages. Two instances of fast transmission of ordinary messages are given, viz. :—

330 messages in 6 hours 30 minutes, 50.7 per hour
136 „ „ 2 hours, 68 per hour.

As it may be interesting to some of our readers to know what has been done in Victoria, we may mention that, on the occasion of the last Melbourne Cup race, 216 messages were sent from the Racecourse to Melbourne, on one of the wires, in 1 hour and 58 minutes, being at the rate of 109.8 per hour. At the Cup of the previous year, 135 messages were sent in 1 hour 5 minutes, being at the rate of 124.5 per hour. It must, however, be borne in mind that the average number of words in these race messages did not perhaps exceed 20 (address, signature, &c., included), and, on account of the frequent occurrence of the same names, abbreviations could be used to a great extent. As a matter of swift penmanship on the part of the receiving operator (he having written everything in full), these performances could not easily be surpassed.

Figure 3 – Speed of Working the Morse Instrument

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FIGHTING BY TELEGRAPH.

THE proceedings before the coroner at Huntingdon, on the 2nd February, in the Abbots-Ripton collision case (says the *Times*) recal the existence of a curious pastime in working the telegraph. When two stations want to send a message at the same time, and neither will give way, they are said to "fight." Each operator grasps the handles of his instrument tightly, and moves them rapidly and irregularly from side to side; the result being that the needles are violently agitated, even to "clicking" loudly, and the "face" of the instrument assumes quite an excited aspect. Such, or something like this, may be assumed to have been the case when the Abbots-Ripton signalman wanted to send his message to Huntingdon for "doctors and help," and somebody else on the circuit would not let him. "Fighting" on the wires was a common practice in the early days of the telegraph, when nothing but the double-needle instrument was used—so common, indeed, that a fine used to be imposed on clerks who broke the handles of their instruments in this warlike occupation. Battles of this kind were not always confined to two persons; for when there were more than two stations "in circuit" others would join in for the mere fun of the thing, and a "free fight" would often ensue. The improved forms of telegraphic apparatus have reduced "fighting" very much, although they have not altogether done away with it. The simpler forms of recording instruments still admit of telegraph clerks giving rein to their angry passions on the wire, the rapid up-and-down motion of the keys taking the place of the violent swaying to and fro of the handles. But the arts of peace as well as that of war are studied by the telegraphist in his spare moments, and the gentler passions often find vent through the wire. It has been stated that long courtships have been maintained between persons hundreds of miles apart, who never saw each other, and that there is now a telegraphic sign for "love's first snowdrop, virgin kiss." One of the latest inventions in telegraphy, known as the "duplex" system, is a great peacemaker, for it enables the operators at either end to charge at each other as much as they please without disturbing the continuity of transmission, thus removing all inducement to "fight." What an American humorist has said of a railway collision—viz., that it is an effort on the part of two trains travelling in opposite directions to pass each other on the same track—is true of the attempt to send two messages on the same wire at the same time by the needle telegraph, but not of the "duplex" system, by means of which this feat is now very generally accomplished throughout the world.

Figure 4 – Fighting by Telegraph

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Book review of 'Network Services: QoS, Signalling, Processes' by Harry Perros

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- Summary: This article reviews *Networking Services: QoS, Signalling, Processes* [Amazon Digital Services: ASIN B00IJFZTWC], by Harry Perros, Computer Science Department, North Carolina State University, USA; 2014, 516 pp.

Introduction

Rushing out of your office for your next meeting, you grab your smartphone and phone a colleague. Still talking on the phone, you hop into a taxi. You expect your mobile call to be of a certain quality: you should get a connection within a short delay; you and your colleague should be able to hear each other clearly – even recognise each other's voices; and the call should not drop out despite the taxi going through a tunnel. Many technologies are brought to bear to make the phone call possible, and to deliver the quality that you are paying for.

The book *Networking Services: QoS, Signalling, Processes* by Harry Perros deals with the very important topic of delivering networking services over the Internet, such as Voice over IP, video conferencing, and IPTV. The impressive breadth of coverage is obvious from a listing of the topics covered. After the Introduction, Part 1 (Processes) covers definitions, characteristics, and frameworks, plus process modelling. Part 2 deals with Quality of Service & Quality of Experience. Part 3 is about signalling to establish a service (mainly SIP and IMS). Part 4 deals with QoS in the Transport Network: MPLS, and congestion control. The final Part gives an introduction to capacity planning, including queueing and simulation.

The topics covered are sometimes the subject of separate text books. However, all those topics (and perhaps more) have a direct bearing on the quality of networking services. Therefore, with the aim of giving some guidance as to whether the reader should buy the book, this review dips into selected parts of this very broad range of topics.

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Quality of Experience and Quality of Service

The book begins by introducing the topic of Quality of Experience and Quality of Service. The former term relates to customer perceptions and opinions, while the latter term refers to Network Performance. The author emphasises end-to-end delay, jitter, and packet loss rate (though not throughput and availability). The author also emphasises the value of connection-oriented networks (using MPLS as an example) for guaranteeing end-to-end QoS, and also foreshadows that IntServ and DiffServ are covered in later Chapters. Also introduced is the concept of Next Generation Networks. The Introduction finishes with a survey of the important standards organisations. I consider it very useful to include this material in engineering education. Standards work is fundamental to telecommunications, but understanding the processes behind competing proposals is often elusive for student engineers, and indeed practitioners.

The book moves on to consider basic economic and marketing aspects of services (such as co-production of value), and covers the modelling of business processes. Including these topics in a treatment of service quality is very welcome, since many problems arise not from the network itself but from the processes by which services are delivered. Perhaps the classic problem is the perceived unreliability of the promise "our technician will be there to install your service between 2PM and 5PM tomorrow".

Both 'objective' and 'subjective' quality are dealt with in Chapter 4. Models for predicting the user experience of voice and video services are discussed. This is fundamental to making some estimate of what the customers will think of a service, based on measurements of network performance parameters. The coverage in the book provides very useful material that has great value but is often overlooked. Apparently engineers, mistakenly, tend to consider that the opinions of customers are not 'objective' enough.

The Session Initiation Protocol (SIP)

The signalling protocol SIP and its use in the IP multimedia system (IMS) are well covered. The SIP section contains a very informative description of the SIP protocol, its procedures and its message/method contents. The descriptions of the important header fields in SIP are excellent. The brief explanations about why things are done one way and not another are helpful to the reader's understanding of the protocol. The diagrams are clear and complement the text well. The omission of a statement of the purpose of the SIP signalling at the network level (that is, to find the destination terminal and exchange IP addresses) could leave the reader confused at times. The emphasis on the two SIP 'add-on' features of Presence and Instant Messaging before explaining the basic SIP procedure was confusing.

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The examples of use of SIP in the IP Multimedia Sub-system (IMS) used by large networks were useful but there is little information about other uses of SIP such as in most VoIP Service Provider networks. A few out-of-date References and minor editorial mistakes detracted slightly from the good protocol descriptions.

Other topics

IntServ, DiffServ, and MPLS (multiprotocol label switching), including Label Distribution Protocols, are all covered in Part 4. Chapter 11 of Part 4 surveys some congestion control technology, though does not cover TPC Flow Control or Congestion Avoidance and Control.

Capacity planning, queueing, and simulation are the final topics. The treatment of planning is high-level and descriptive. Of course, as a small chapter in the book, this material serves as a brief introduction to a large body of knowledge. As such it will be very valuable educational material for newcomers, and a useful reference for practitioners. Some minor glitches appear in the Queueing and Simulation parts. In Section 15.2 the definition of the Percentile of the Waiting Time is given as "The percent of the waiting that a customer has to wait more than a given amount of time" which is not likely to clarify the concept for a newcomer. Towards the bottom of the second paragraph of 15.3.1 the expression for the Poisson probability mass function uses the term $e\text{-}\lambda$ as an exponent instead of including the factor e to the power of $-\lambda$. The intention is clear, but again a newcomer may be confused by this simple error in superscripting. Readers with familiarity with the basic principles will not be too concerned by small problems of this sort.

Conclusions

Given the topics already covered, it would seem churlish to ask for more. However there are some aspects of quality in the telecommunications industry that still remain to be considered. Application performance measurement and management is a trend in Network Management which comes the closest yet to measuring quality as it is actually delivered to customers. Carrier Ethernet technology is notable for its emphasis on standardised management interfaces, and end-to-end quality management. Quite plausibly this may overshadow the treatment of quality in Layer 3, though it will not provide guaranteed quality through the TCP/IP global Internet. Arguably, Net Neutrality is not entirely a technical issue, and so may not be expected in a technical textbook. However the Net Neutrality debate is shaping the way quality is delivered over the Internet, particularly in the USA, and therefore deserves discussion.

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The great strength of the book "*Networking Services: QoS, Signalling, Processes*" lies in the range of technical topics included. Many practicing engineers, as well as students, would benefit from considering all the material in the book. The experience as well as the breadth and depth of the author's knowledge all contribute to a stimulating and valuable learning experience for both students and practitioners. Balancing that considerable strength, a small weakness arises from many small inconsistencies and typographic errors, which would be fixed by thorough proofreading. Are those small items merely quibbles, or are they significant issues? As is the case with networking services, the answer will depend on the perception of the end user. This particular end user will be very happy to use the book as a valuable guide to the broad areas of signalling and quality in networking, with the reservation that some details require critical evaluation rather than passive acceptance.

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