Networks Disrupt Universities?

Alex Reid
Advisor, eResearch & Middleware, AARNet
&
Honorary Professorial Fellow, University of Western Australia
Networking is a key piece of data centre, enterprise, national and international e-infrastructure, and has been for many years.

Indeed, it is perhaps so taken for granted nowadays that it has largely become invisible to end users.

Enterprise e-infrastructure architects need to ensure that they don't also overlook its critical role not just in supporting the enterprise mission, but also in shaping it.

Universities are essentially information enterprises, and ICT therefore plays a vital role - both in teaching/learning and in research, as well as in supporting corporate functions.

In this context, networking has the potential to be a highly disruptive technology, which could dramatically change the nature of both learning and research, as well as the very shape of the enterprise itself.
Contents

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  – National/International R&E
  – Community
  – Enterprise
  – Data Centre
• Disruptive Technologies
• Impact on Higher Education
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  – Corporate Systems
• Conclusions
Maintain World-Class Standing

- Upgrade backbone to 100Gbps
- Customer connections: 1-> 10-> 40Gbps
- Extend to unreached locations (eg Darwin, Hobart)
- Dedicated wavelengths, circuits
- 24x7 NOC
- VERY high availability, reliability
- Resilient international links (eg 10Gbps from Perth)
- etc
AARNet’s Strategic Roadmap for 10+ Years

- **AARNet3**
  - Customer Access: 1G Access
  - Internet Backbone: 10G
  - DWDM Backbone: 32x 10G
  - Year: 2006

- **AARNet4**
  - Customer Access: 10G Access
  - Internet Backbone: 100G
  - DWDM Backbone: 40 x 100G
  - Year: 2010/11

- **AARNet20**
  - Customer Access: 100G Access
  - Internet Backbone: 1.5P
  - DWDM Backbone: 320 x 1P
  - Year: 2020?

Source: AARNet
Demands of the SKA

Source: http://www.skatelescope.org
SKA will require solving Petabit networking

Source: AARNet
Broadband Penetration

Figure 1 Fixed broadband subscriptions per 100 inhabitants, 2000-2010*

Data Communications Developments


Source: Sood & Tellis, 2011
Part of animated video promoting the NBN.

Institute for a Broadband-Enabled Society (IBES):
http://broadband.unimelb.edu.au/

Education & Learning:

Ubiquitous high-speed broadband provides a way to improve the educational capabilities of students, teachers and the wider community. IBES is fostering innovative research to enrich learning and demonstrate how connecting Australians via broadband opens up new opportunities.
Health & Wellbeing:

IBES is fostering multidisciplinary research that investigates the use of next generation broadband technologies in health care. New broadband technologies can improve the quality and safety of care, access to services, and innovations in clinical care and health maintenance.
Services & Business Transformation:

High-speed broadband has the power to dramatically impact the quality, innovativeness and reliability of services delivered to businesses, governments and the not-for-profit sector. This research will assist the development and implementation of new tools and technologies.
Social Infrastructure & Communities:

Broadband availability drives changes in patterns of social interaction across a wide spectrum of activities. This theme is fostering innovative interdisciplinary research that will investigate the emerging opportunities and challenges of a broadband-enabled society.
Network Deployment & Economics:

The technology base for advanced broadband network infrastructure is well developed. Research in this theme is focusing on advanced technologies for future enhancement of fibre and wireless networks and how to measure and model the benefits from broadband.
Networking: Direct Consequences for EA

• Match campus capabilities with national/ international
• Ubiquitous connectivity
• Accommodate high-end users’ needs (eg wavelengths)
• Prevent Firewall congestion
• High availability, quick response
• Upgrade paths/ strategy/ flexibility
• Data Centre networking (eg QFabric/ BrocadeOne, Cisco Universal Computing System for simplicity, flexibility, efficiency, …)
• Network virtualisation
• …
Disruptive Technology: Innovator’s Dilemma

• Incremental improvements (sustaining technological innovation) vs Disruptive technological innovation.

• Start by creating large growth opportunities away from the core of the established market.

• Disruptive Innovation is a dynamic form of industry change that unlocks tremendous gains in economic & social welfare:
  – Eliminates inefficiency by *creative destruction*
  – Drives improvements via *creative construction*
  – Allows broader group of people to do things only an expert or wealthy group could do
  – Convenience increases, consumption rises, prices slump

• Established providers usually cannot respond (eg out of loyalty to existing customer base), or do not see this as a threat.

• They listen to their customers and make gradual improvements or enhancements, but this outstrips the needs of the core market.
Disruptive Technologies

Chart of Definitions of Sustaining and Disruptive Innovations: Performance vs Time.

Source: Christensen, 2003, Figure 1
Chart of the 2 Types of Disruptive Innovation:
Low-end disruption & Non-consumers.

Source: Christensen, 2010, Figure 2
Disrupted Industries/Markets

- Model T Ford vs other cars
- Home power tools ($20) vs professional tools ($150)
- Canon countertop copiers vs Xerox business copiers
- Department stores vs Speciality shops
- Discount stores vs Department stores
- Catalogue companies vs Department stores
- Amazon vs high street book stores
- Mobile phones vs landlines
- Bell telephone vs telegraph
- Desktop publishing vs Offset Print shops
- Email vs Fax
- Email vs Postal services
- Minicomputers vs Mainframes
- Microcomputers vs Minicomputers & Mainframes
- Cheap airlines vs Standard carriers
- Online travel vs Travel agents
- Community colleges vs State universities
- Online universities vs Brick & Mortar universities
Disruptive Technologies

Chart of Centralization Followed by Decentralization in Computing.

Source: Christensen, 2003, Figure 1
Chart of Each Computing Wave Dwarfing & Disrupting its Predecessor.

Disruption in Learning

Chart of Characteristics of the Two Stages of Disruption in Learning Content Delivery.

Source: Christensen, 2008, Figure 5.2
Chart of The Pace of Substitution of Computer-Based Learning for Monolithic Learning.

Source: Christensen, 2008, Figure 4.2
Disruption in Learning

Chart of The Pace of Substitution of Computer-Based Learning for Monolithic Learning, when converted to S-Curve.

Source: Christensen, 2008, Figure 4.2
Disruption in Learning

Chart of Percentage of Undergraduates Enrolled in Distance Education Courses or Degree Programs (USA,) by year 1999/200, 2003/2004, 2007/2008.

Disruption in Learning

Chart showing growth in cost of conventional teaching (public schools, state colleges, private colleges) vs decline in cost of Plato on-line learning, 1972-1986.

Chart of Diana Laurillard’s Conversational Framework for Learning, showing interactions between teacher & student.

Source: Laurillard, 2002
Learning: Conversational Framework

For On-Line Learning:

Chart of Diana Laurillard’s Conversational Framework for Learning, showing interactions between teacher & student – for the case of on-line learning.

Source: Laurillard, 2002
Disruption in Learning

http://en.wikipedia.org/wiki/Medieval_university
Disruption in Learning

http://en.wikipedia.org/wiki/Lecture_hall
Disruption in Learning

http://en.wikipedia.org/wiki/Desiderius_Erasmus


Same picture of Erasmus doctored to show him instead using a Mac.
Disruption in Learning

Images from University of Phoenix:
http://www.phoenix.edu/

Images from Think Education Group:
http://www.think.edu.au/
Disruption in Research

Chart of the Four Science Paradigms:
- Empirical
- Theoretical
- Computational
- Data Exploration (eScience)

Source: Hey, 2009
Diagram of a High-level view of a research infrastructure that brings together knowledge bases and computational services. Savas Parastatidis, Figure 1.

Source: Hey, 2009
Christopher Southan, Figure 3.

Source: Hey, 2009
Chart of exponential decline in rate of dissemination of medical discoveries to clinical practice over the past 2,500 years, and over the past 150 years, projected to reach ~0 by 2025.
Michael Gillam, Figure 2.

Source: Hey, 2009
Disruption in Research

• Networked world impacts Research publications in 3 ways:
  – digital space allows authors to interact with their peers and readers, placing a new emphasis on the process of writing rather than the final product, with the potential of a text that is forever open to comments and rewriting;
  – digital texts are interlinked in a way that printed books are not;
  – internet offers new multimedia tools, including the use of videos and images, audios and blogs as a way of expressing thoughts instead of, or in conjunction with, words.

• Humanities as well as Science
  ⇒ dynamic, interconnected, multi-media publications
  ⇒ Open Access, Innovative Publishing models.
Research Cloud

Nectar's Research Cloud

Building a national Research Cloud for Australian researchers in partnership with Australian institutions and research organisations:

- Hosting research applications \textit{in the cloud};
- A computational resource which complements existing and new supercomputing facilities;
- Fostering innovation in eResearch services in the cloud.

Benefits:

- supports research collaboration by making it easier to share access to innovative research applications on a national scale.
- cost-effective computational infrastructure which complements existing and new supercomputing facilities.
- fosters innovation in eResearch and research software services by allowing innovative new services for researchers to be rapidly deployed at low cost.

Source: NeCTAR
Cloud Computing

• **Jeff Weiner**, LinkedIn CEO: Cloud makes it easier and cheaper than ever for anyone anywhere to be an entrepreneur and to have access to all the best infrastructure of innovation.

• **Bill St Arnaud**: It is not only the private sector that is creating new opportunities in this field, but funding councils and R&E networks are also playing a critical role in the transformation of the future computing. The recent announcements by Internet2, SURFnet, JISC/JANET, etc to broker commercial cloud services for researchers are great examples of this trend.

• **Juniper**: QFabric enables exponential improvements in data centre speed, scale and efficiency, by removing legacy barriers and improving business agility.

• **Sinclair Schuller**, CIO Apporenda: As the sea-change that is cloud computing washes over the industry, certain aspects of cloud that make their way into the enterprise as private cloud will move enterprise architecture from fairy-tale to reality. The most important of the cloud form factors for enterprise IT will be Platform as a Service (PaaS).

• **St Arnaud**: cloud computing is fueling the next startup boom.

• **St Arnaud**: NRENs are transforming the global Internet through disruptive innovation.
Cloud Computing

• **Michael Hugos**: telecom providers around the world need to actively promote awareness of cloud computing and explain the benefits of cloud computing so as to create demand for products that they are potentially well suited to make and deliver over their networks – eg PaaS and SaaS.

• **Scott Jamieson**, a2b Fiber Inc: With its high bandwidth capability and low latency, local access fibre will be a catalyst in the growth of cloud services.

• **Juniper**: Enabling a virtualized, cloud-ready data center means re-thinking the very fundamentals of networks.

• **St Arnaud**: Researchers are voting with their feet (and wallets) to use commercial cloud applications because of their ease of use, simplicity, ability to scale quickly, no need for upfront capital costs for computing, and no bureaucratic hassles to access university computing resources. A good example is Galaxy (http://wiki.g2.bx.psu.edu/Admin/Cloud), which is taking the genomics and bioinformatics research community by storm.

• **St Arnaud**: Locate data centers in locations where there is cheap/green power, and connect with high-capacity fibre links (eg Google & Amazon @ Oregon; Pawsey).
Cloud Computing

• Cloud turns so many things on their heads:
  – Locate the data centre where there is cheap, clean power:
    • Google, Amazon, Microsoft, Yahoo at Columbia River, Oregon (14 hydroelectric dams)
  – Low cost of entry to expensive infrastructure, eg HPC
  – Scalable
  – Locate services where they are best provided
  – Does this apply to universities too?

Bonneville Dam: http://en.wikipedia.org/wiki/Columbia_River
Gartner Hype Cycle for Education, 2010, showing a plethora of relevant technologies “in the pipeline”.

Source: Gartner, 2010
Gartner Hype Cycle for Higher Education, 2004, showing Course Management Systems, etc already on the “plateau of productivity”.

Source: Gartner, 2004
Conclusions

1. **How is IT changing the global education ecosystem and impacting the future workforce in society?**
   
   There are blurring boundaries and increased interdependencies. It's no longer possible to treat a higher education institution like an ivory tower. [Chistensen]

2. **How should higher education institutions strategize and govern to make the most out of IT?**
   
   This gains importance with increasing turmoil. The simple fact that IT now touches virtually all stakeholders in the education ecosystem puts special pressure on the CIO not only to choose well, but also to communicate well. [Chistensen]

3. **How should higher education institutions invest in applications, systems and infrastructure?**
   
   The higher education CIO has a key role as both inspirer and supplier of IT services. In the role of inspirer, CIOs must identify disruptive and enabling technologies that can transform the institution and inject it early into the strategic planning process. In the role of supplier, CIOs must be diligent in choosing the right solutions and vendors to meet often varied demands for cost-effectiveness, security and availability, for example. [Chistensen]
Conclusions

4. **Management of IT**: (of the design, architecture, operation of IT infrastructure) this is essentially a “complex” process, not amenable to formulaic solutions; therefore management should be pragmatic, not idealised; agility is the key to success, not SOEs. Complexity thinking vs Systems thinking. [Snowden]

5. **Relish Hardship**: it is in times of recession and financial deprivation that innovation and new ideas thrive – look out for low-cost disruptive technological innovations. [Snowden]

6. **Measurement Obsession**: beware of the sort of measurement obsession that leads to neglect of the primary goal; this has beset parts of the NHS in UK to the point where Staffordshire nursing staff spent so much time monitoring that they ignored their patients & army medics had to be drafted in to keep the hospital running. [Snowden]
Principal References

- St Arnaud, Bill: Future Internet, R&E Networks, Green Internet, Green IT
Questions???

Alex Reid
AARNet Advisor, eResearch & Middleware
UWA Honorary Professorial Fellow
alex.reid@uwa.edu.au