Institution:
University of Cambridge
Unit of Assessment:
UoA11
Title of case study:
Real VNC

1. Summary of the impact (indicative maximum 100 words)

RealVNC is a spin out company launched by the University of Cambridge researchers who developed Virtual Network Computing (VNC) remote access technology. VNC allows connection and control of devices from anywhere in the world, irrespective of operating system. VNC is now the default mechanism for remote sharing of graphical desktops across the internet. RealVNC has sold over 300 million licences across 175 countries. The company has won three Queen's Awards for Enterprise and the Royal Academy of Engineering's MacRobert Award, the UK's premier engineering prize.

2. Underpinning research (indicative maximum 500 words)

The research was undertaken by Professor Andy Hopper [1–6], who joined the University of Cambridge in 1977, became Reader in 1992 and Professor in 1997 (see note below). He was appointed Head of the Computer Laboratory and Professor of Computer Technology in 2004. The research was undertaken collaboratively with Olivetti Research Labs in Cambridge (which became Oracle Research in 1987 and then AT&T Research from 1999). Professor Hopper led the research project throughout. Other key members of Hopper's University research groups were Quentin Stafford-Fraser [1,5], Research Assistant at the Computer Laboratory,1991–1992, who joined Olivetti some years later; Mark Spiteri [6], Research Associate in Hopper's Laboratory for Communications Engineering 1999-2001; John Bates [6], Lecturer in Hopper's Laboratory for Communications Engineering 1998-2000; and Glenford Mapp [2], who was a Visiting Fellow in the Computer Laboratory.

The research project began with [text removed for publication] funding from Oracle to develop network computing software. The software was open sourced during its development in the 1990s. During the key research period (1991–98), there was a free exchange of ideas between the Cambridge University research groups and the staff at Olivetti Research. Hopper operated an "open door" policy in both directions so that members of each lab were free to meet, work, and discuss ideas with one another.

The underpinning research addressed the problem of remote user interaction with emphasis on the range of remote device capability, the mobility of users, and disrupted communication. The approach was empirical. By considering the diversity of available devices in formulating device abstractions, rather than by starting with an idealised device model, a simpler client model than, say, that of the X windows system, was developed. This model was stateless in the client (device) end, leading to toleration of disruption and more significantly of a change in association between user and device, the latter being informed by the location awareness research being carried out by Hopper's group.

Reference 1 is the key publication that describes the VNC technology used to break down the screen image produced by a particular software application into a representation of the pixels, which can then be reproduced on another remote screen. The keyboard strokes and mouse actions made remotely can then be transmitted back to affect the original application. This means that a very simple screen and keyboard can be used to remotely complete tasks that require a large amount of computing power, provided that the less powerful receiver has the prerogative of requesting updates.

Reference 2 describes earlier collaborative work between Olivetti and the Cambridge Computer Laboratory on which the later VNC work built.

Reference 3, Section 3, summarises the work and puts it in the context of "sentient computing", Hopper's major strategic research goal at the time.

The other three references document some of the subsequent projects undertaken in the Cambridge Computer Laboratory, which investigated the potential of VNC in various application

domains.

References 4 and 5 discuss how VNC can be extended to support co-operative work, including asynchronous co-operation, student-teacher interaction, and distance learning.

Reference 6 discusses how VNC permits the capture and indexing of computer-based activities, enabling the review of work and work flow.

Note: For most of his career at the University of Cambridge (1977–1997, 2004–present), Hopper was affiliated with the Computer Laboratory. For the period 1997–2004, he was head of the Laboratory for Communications Engineering at the Department of Engineering. That Laboratory was transferred in its entirety to the Computer Laboratory in 2004, being renamed the Digital Technology Group. Hopper, his research group, and any research produced by them are therefore considered part of UoA 11 for this REF exercise.

3. References to the research (indicative maximum of six references)

*[1]. Tristan Richardson, Quentin Stafford-Fraser, Ken R. Wood, Andy Hopper, "Virtual Network Computing," *IEEE Internet Computing*, pp. 33-38, 1998
DOI: http://dx.doi.org/10.1109/4236.656066

[2]. Tristan Richardson, Frazer Bennett, Glenford Mapp, Andy Hopper "Teleporting in an X Window System Environment", IEEE Personal Communications Magazine 1.3:6-13 (1994)
Web: http://citeseerx.ist.psu.edu/viewdoc/summary?doi=10.1.1.17.3112

*[3]. Andy Hopper, "The Royal Society Clifford Paterson Lecture, 1999 — Sentient Computing", *Phil. Trans. R. Soc. Lond. A (2000)*, vol. 358, pp. 2349-2358, Royal Society, Aug 2000
Hopper gave the lecture in September 1999. This is one of the Royal Society's prize lectures, which comes with the award of a medal.
DOI: http://dx.doi.org/10.1098/rsta.2000.0652

[4]. Sheng Feng Li, Andy Hopper, "What You See Is What I Saw: Applications of Stateless Client Systems in Asynchronous CSCW," *Proceedings of the Fourth International Conference on Computer Science and Informatics(CS&I'98), The Fourth Joint Conference of Information Sciences(JCIS'98)*, Research Triangle Park, North Carolina, vol. 3, pp. 10-15, Oct 1998
Web: http://citeseerx.ist.psu.edu/viewdoc/summary?doi=10.1.1.17.7507

[5]. Sheng Feng Li, Quentin Stafford-Fraser, Andy Hopper, "Frame-buffer on Demand: Applications of Stateless Client Systems in Web-based Learning," *Proceedings of the 5th International Conference on Information Systems Analysis and Synthesis (ISAS'99), Orlando, Florida*, Jul 1999
Web: http://citeseerx.ist.psu.edu/viewdoc/summary?doi=10.1.1.45.9089

*[6]. Sheng Feng Li, Mark Spiteri, John Bates, Andy Hopper, "Capturing and Indexing Computer-based Activities with Virtual Network Computing", SAC'00 *Proceedings of the 2000 ACM Symposium on Applied Computing, Como, Italy*, vol. 2, pp. 601-603, Mar 2000
DOI: http://dx.doi.org/10.1145/338407.338514

*Indicates those references most representative of the overall quality of the research.

4. Details of the impact (indicative maximum 750 words)

The research into VNC created the remote access market. RealVNC was founded in 2002 by Professor Hopper and Dr Andy Harter to promote, enhance and commercialize VNC. Today, Hopper is Chairman and Harter is CEO.

RealVNC is the only organization offering commercial licenses to embed remote control and access capability into third-party products and services.

VNC is an extremely widely ported piece of cross-platform software:

"Over 300 million licenses have been sold across over 175 countries, and given that our software is also available in free and open source versions, this makes VNC the most widely ported piece of cross-platform software." (CEO RealVNC) [7]

VNC is the default mechanism for remote sharing of graphical desktops across the internet.

One of the major benefits that RealVNC offers to customers is the ability to resolve IT issues remotely, minimizing downtime and leading to associated savings in cost and efficiency.

In 2010 Intel embedded RealVNC software into their vPro and i5 & i7 processor chipsets.[7] This allows remote maintenance irrespective of the main processor state. One hundred million VNC-enabled chips have been manufactured to date. This initiative enables IT technicians to boot machines from a remote location, meaning that machines no longer need to be left on overnight to allow time-critical software patches to be deployed. This in turn has led to energy efficiencies and cost savings from reduced power consumption. For example, an ROI Analysis conducted in 2009 for Intel at the California University of Pennsylvania, which has 2,170 desktop PCs across its campus, found that the ability to remotely boot up machines in this way was likely to save around [text removed for publication] per year in reduced energy costs.[11]

In January 2011, Google purchased a [text removed for publication] license to embed remote access capability in Chrome products [6]. An Engineering Director at Google, said 'We are thrilled to tap into RealVNC's proven technology and expertise.'[10]

The company won two Queen's Awards for Enterprise in 2011, for Innovation and for International Trade [8]. In the same year, the company was Cambridge Ring Company of the Year and Business Weekly Private Company of the Year. In 2013 it won a third Queen's award, again for International Trade, and the Royal Academy of Engineering's MacRobert Award, the premier award for UK innovation in engineering.[9]

The following examples demonstrate the wide deployment of RealVNC systems and the commercial advantages of using RealVNC software [7,12]:

Example A. Since 2009, Alexandria Police Department Tactical Computer Section, Virginia, USA, have used RealVNC with an Enterprise License to support its fleet of mobile computers. The ability to fix problems in real time has allowed officers to remain in the field serving the community rather than returning to headquarters to fix their PC.

Example B. Telesat Canada operates 25 orbital satellites. It requires 24/7 access to multiple remote sites plus cross-platform support for UNIX and Windows systems. Since 2010, RealVNC's cross-platform remote support has enabled Telesat's satellite controllers and antenna engineers to remotely access all the networks required at any time of day or night, which is critical to success when the time taken to drive into work could be enough to lose a satellite.

Example C. The W. M. Keck Observatory adopted VNC in 2009 to remotely display screens from their telescope systems, based near the 4200 meter summit of Mauna Kea, and to manage and administer its systems whether Windows, Mac or UNIX. The performance of RealVNC has enabled the Observatory to reduce its operating costs.

Example D. The ability to fix problems without the need for inconvenient travel has also been of benefit for Boston Valley Terra Cotta, who have used RealVNC since April 2010 to minimize the risk of expensive product damage in their kilns and dryers. They have also made use of RealVNCs iPhone application 'VNC Viewer' to effectively manage the production process when access to a PC is not possible.

Example E. Burwin Leighton Paisner LLP have used RealVNC since 2008. They use VNC with an Enterprise license so that their IT helpdesk, based in London, can remotely support their offices in Abu Dhabi, Brussels, Paris and Singapore, resolving 95% of IT issues in this way. VNC is also used to provide internal training to new starters, providing an efficient and cost effective alternative to travel for such purposes. Dartford Borough Council have similarly found that deploying VNC enables their technical support time to resolve 90%of issues remotely, saving on off-site travel costs and making the best use of Council resources.

5. Sources to corroborate the impact (indicative maximum of 10 references)

[7]. Letter from CEO, RealVNC

[8]. Queen's Awards for Enterprise:
http://www.queensawardsmagazine.com/

[9]. Royal Academy of Engineering MacRobert Award 2013: http://www.raeng.org.uk/prizes/macrobert

[10]. Information on Google collaboration: http://www.realvnc.com/company/press/news/realvnc-collaborates-with-google.html

[11]. Intel vPro ROI Analysis: Document on file

[12]. Details of VNC's case studies: www.realvnc.com/products/vnc/case-studies/

[13]. Information on Intel collaboration: http://www.realvnc.com/company/press/news/vnc-viewer-plus-intel-developer-forum.html