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| <b>Institution:</b> University of Surrey  |  |   |
| <b>Unit of Assessment:</b> 11 Computer Science and Informatics  |  |   |
| <b>Title of case study:</b> Verifying the integrity of the democratic process whilst using electronic voting  |  |   |
| <b>Period when the underpinning research was undertaken:</b> 2005-2020  |  |   |
| <b>Details of staff conducting the underpinning research from the submitting unit:</b>  |  |   |
| <b>Name(s):</b>   | <b>Role(s) (e.g. job title):</b>                       | <b>Period(s) employed by submitting HEI:</b>                                      |
| Steven Schneider<br>Helen Treharne<br>James Heather   | Professor in Computing<br>Professor<br>Senior Lecturer | September 2004 - present<br>September 2004 – present<br>October 2001 – March 2014 |
| <b>Period when the claimed impact occurred:</b> 2014-2020   |  |   |
| <b>Is this case study continued from a case study submitted in 2014?</b> N  |  |   |
| <b>1. Summary of the impact</b> (indicative maximum 100 words) <p>The impact concerns the introduction of verifiability into electronic voting. Areas of impact are society, commerce, public policy and services. Beneficiaries are voters, public and private sector election services, and policy makers.</p> <p>Deployment in the State of Victoria, Australia, enabled accessibility for voters with accessibility needs. We have provided verifiability for electronic voting in real elections run by UK market leader <i>Civica Election Services</i>.</p> <p>The research has also impacted on policy proposals on electronic voting for organisations (e.g., the Knight review on industrial action balloting for UK Government) as well as for those formulating national and international government policy.</p>   |  |   |
| <b>2. Underpinning research</b> (indicative maximum 500 words) <p>Electronic voting can engage a much greater proportion of an electorate than traditional voting, and provide greater accessibility to potentially marginalised groups, but voters must be sure that their vote remains both secret and unchanged. Our research has focussed since 2004 on technical proposals for the introduction of '<b>verifiability</b>' into electronic voting systems while preserving the secret ballot: verifiability provides mechanisms and processes to enable voters to verify that their vote has been recorded as intended, and independent parties (including voters) to verify the result.</p> <p>Schneider has led Surrey's research contribution in this area since 2004. The Prêt-à-Voter electronic voting system, for use at polling stations, was first proposed in 2005 and enhanced in 2006 <b>[R1]</b> by Schneider and collaborators. This system used cryptography in a novel way to provide each voter with a paper receipt which captures how their vote was cast but in a way that does not expose the vote. This uses a ballot form with the candidate names in a random order on one half, and the boxes to mark the vote on the other half. When the list of candidate names is separated from the voter's selection (and destroyed), the remaining half constitutes a receipt while maintaining secrecy of the ballot. Proposals to enable verifiability in practice on top of this system were brought together in <b>[R2]</b> by Schneider, Heather and others.</p> <p>An early proof-of-concept prototype was developed at Surrey (with support from collaborators at the University of Newcastle) for the VoComp University Voting System Competition in 2007. This won Best System Design <b>[S1]</b>.</p> |  |   |

Another research contribution was the first practical implementation of a 'Web Bulletin Board' [R3]: a trusted, tamper-proof mechanism for collecting and providing election verifiability data. This was a key 'idealised' component in the literature on verifiable electronic voting. However, no one had previously produced a practical design and implementation for deployment in real elections. Our research demonstrated the realisation of verifiability in practice.

The first steps to a practical system was the design of the vVote system used in the November 2014 Victorian State Election, Australia [R3, R4, R5], which included the Web Bulletin Board as a key element. This was a collaborative effort over the period 2011-2014 involving the Surrey team led by Schneider and Heather, with partners in Australia including the Victorian Electoral Commission, and academic partners in Luxembourg. This system again used novel cryptographic protocols for the generation of ballots such as used by Prêt-à-Voter, and, crucially for the geographically remote voters, the real-time printing of ballot forms.

Schneider and Treharne's more recent research over the period 2017-2019 [P6, P7, R6] has developed a way to extend verifiability mechanisms to the more challenging arena of voting over the internet. Here the research focused on designing a way to augment existing internet voting systems with a verifiability layer, so that it is easily deployable with any preferred voting platform, while maintaining integrity and privacy requirements, the first time this has been done, with positive feedback from voter trials [R6].

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

The quality of the underpinning research is evidenced through the publication of scientific papers in peer reviewed journals and conferences and competitively won, peer-reviewed grants.

[R1] David Chaum, Peter Ryan and **Steve Schneider**, A Practical Voter-Verifiable Election Scheme, European Symposium on Research in Computer Security (ESORICS), pp118-139, Springer LNCS 3679, (2005).

[R2] Peter Ryan, David Bismark, **James Heather**, **Steve Schneider** and Zhe Xia, The Prêt à Voter Verifiable Election System, IEEE Transactions in Information Security and Forensics, 4(4): 662-673 (2009). DOI: [10.1109/TIFS.2009.2033233](https://doi.org/10.1109/TIFS.2009.2033233)

[R3] Chris Culnane, **Steve Schneider**, A peer-reviewed bulletin board for robust use in verifiable voting systems, IEEE 27th Computer Security Foundations Symposium, (2014). DOI: [10.1109/CSF.2014.20](https://doi.org/10.1109/CSF.2014.20)

[R4] Craig Burton, Chris Culnane, **James Heather**, Thea Peacock, Peter Y. A. Ryan, **Steve Schneider**, Sriramkrishnan Srinivasan, Vanessa Teague, Roland Wen, Zhe Xia, A Supervised Verifiable Voting Protocol for the Victorian Electoral Commission, 5th International Conference on Electronic Voting (EVOTE), Lecture Notes in Informatics 205, (2012).

[R5] Chris Culnane, Peter YA Ryan, **Steve Schneider**, Vanessa Teague, vVote: a verifiable voting system, ACM Transactions on Information and System Security (TISSEC) 18(1), (2015). DOI: [10.1145/2746338](https://doi.org/10.1145/2746338)

[R6] Mohammed Alsadi and **Steve Schneider**, Verify My Vote: Voter Experience, 5<sup>th</sup> International Joint Conference on Electronic Voting (E-Vote-ID), TalTech Press (2020).

### Projects

[P1] Heather, J., Schneider, S., (Surrey) Ryan, M. (Birmingham): **Trustworthy Voting Systems**, EPSRC, April 2009 — October 2014, £1.5M.

**[P2]** Heather, J.: **Real World Secure Elections**, Leverhulme Trust, September 2010 – August 2011, £40,660

**[P3]** Schneider, S., Heather, J.: **Software for the Verifiable Election System Demonstrator**, Victorian Electoral Commission, March 2012-July 2012, £13,000

**[P4]** Schneider, S., Heather, J.: **Design Specification for the Verifiable Election System**, Victorian Electoral Commission, August 2012 — December 2012, £5,770

**[P5]** Schneider, S., Heather, J.: **vVote voting system implementation**, Victorian Electoral Commission, July 2013 — December 2014, £103K

**[P6]** Schneider, S., Treharne, H., Dupressoir, F., (Surrey) McBurney, P., Dhillon, A., Mahmoodi, T. (KCL), **Trusted and Transparent Voting Systems**, EPSRC September 2017 – October 2020, £615k

**[P7]** Schneider, S., Treharne, H., Dupressoir, F. **Adding Voter-Verifiability to Online Elections and Real-World Trials**, Impact Acceleration Account University of Surrey 2017: £39,972

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

The impact is concerned with the introduction of verifiability into electronic voting: its use in real elections in Australia and the UK; and influence on policy in the UK.

**Australia:** For the Victorian State Parliamentary Election in November 2014, the Victorian Electoral Commission (VEC) desired to ensure accessibility to a secret ballot for voters who might otherwise be disenfranchised, but security was a key consideration. VEC chose the University of Surrey's verifiable vVote system **[R3, R4, R5]** as they felt it offered the most trustworthy solution **[S4]**. Voters in the State of Victoria who were visually impaired, mobility impaired, or had a language other than English, were able to cast binding ballots electronically using the Surrey vVote system across the State of Victoria. The system was also made available to all voters resident in the UK who voted at Victoria House, London. The team from Surrey led by Schneider worked with VEC to adapt the vVote system to their specific requirements, providing particular expertise on the back end which managed all the cryptography and the capture and handling of the votes. A feedback survey established that voter satisfaction was high.

The VEC reported *"This was comparable to, or better than the findings in 2010, and pleasing considering the new steps introduced with the verification processes in 2014. Of the open-ended questions asked of the London electors, almost all answers were positive about the system. Overall, this is an important finding that shows independent verification is not an impost on electors when voting electronically"* **[S2]**.

The then Director of Electronic Voting at VEC, Craig Burton, reported that *"the success of the deployment swung the discussion [see S3] and approach to e-voting across the various Australian election commissions, by demonstrating that verifiable voting was technically feasible"* and that *"the system has embedded the notion of verifiability [...] it is now understood across the industry as a key security feature."* Indeed, many current competitor systems now claim to incorporate forms of verifiability. With respect to improving inclusion of potentially marginalised groups, Burton reported that he *"trialled the system with profoundly physically disabled people", and that "access to this system for them, were it legislated, would represent the first time in many disabled people's lives where they could participate privately and independently in an election. For the profoundly physically disabled this may be one of the very few acts they can perform on their own at all."* **[S4]**.

**UK:** In the UK statutory elections are paper-based. However, organisations (e.g., trades unions, building societies, professional organisations, political parties, student unions) also run ballots. Civica Election Services (CES; formerly Electoral Reform Services Ltd) are the UK market leader in this sector with over 90% market share. In recent years, remote electronic voting has become popular to provide convenience for those entitled to vote, as well as allowing for cost saving and

rapid elections. In the period October 2018-September 2019, we developed the approach [R6] to introduce verifiability into the CES existing internet voting system. This was used on binding ballots with clients, including an election for the Royal College of Nursing in July 2019 with an electorate of 40,000. Approximately 40% of votes cast used the verification system to check their vote. Another example is the ballot with the College of Podiatry in October 2019. Philip Wright, CES Technical Director, reported *“the experience of having run verifiable ballots has demonstrated to the business that this can be done in a way that is commercially viable and attractive to customers [...] it is clear that verifiability plays a key role.”* He further comments that it has *“enhanced our offering and market position without negatively impacting on the use of our core product.”* [S5]

**UK Policy – Industrial Actions Balloting:** Schneider co-authored the technical annex for Sir Ken Knight’s Independent Review on Electronic Balloting for Industrial Action [S6] commissioned by the Department for Business, Energy and Industrial Strategy (BEIS), and made a direct impact on its policy recommendations [S7]. The annex together with Schneider’s involvement in the round table discussions and a fact-finding trip with Sir Ken to *Cybernetica* in Estonia *“led directly to one of the key recommendations in [Sir Ken’s] report that verifiability should be included in electronic balloting systems when used for industrial action ballots”* [S7] for consideration by UK Government developing policy on remote, electronic voting. Schneider also chairs the Institution of Engineering and Technology (IET) Working Group on Electronic Voting which includes members from industry, academia, government from UK and internationally, whose report ‘Internet Voting for the UK’ (October 2020) [S8] includes verifiability as a key recommendation.

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

##### Australia:

[S1] VoComp.org (archive

site): <https://web.archive.org/web/20160317221515im/http://vocomp.org/results.php.html>

[S2] Inquiry into electronic voting, Parliament of Victoria Electoral Matters Committee, May 2017 (Victorian Government Report on the electronic voting element of the 2014 Election).

<https://www.parliament.vic.gov.au/419-emc/inquiry-into-electronic-voting> (Also PDF)

[S3] Building an open source eVoting system: The vVote experience, Peter Scheffer, ComputerWorld 15 July 2016

<https://www2.computerworld.com.au/article/603488/building-an-open-source-evoting-system-vvote-experience/> (Also PDF)

[S4] Testimonial from Craig Burton, Manager Special Projects, Victorian Electoral Commission (PDF)

##### UK Civica trials:

[S5] Testimonial from Mr Phil Wright, Technical Director of Civica UK’s Democracy and Engagement Division, Civica Election Services (PDF)

##### UK Policy:

[S6] Independent review of electronic balloting for industrial action, Sir Ken Knight, Annex A <https://www.gov.uk/government/publications/electronic-balloting-for-industrial-action-knight-review> (Also PDF)

[S7] Testimonial from Sir Ken Knight (PDF)

[S8] Internet Voting in the UK report from IET Working Group on e-voting, October 2020, <https://www.theiet.org/media/7025/internet-voting-in-the-uk.pdf> (Also PDF)