Electronic voting Best practices
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Abstract.
The problems with electronic voting machines used during the 2000 and 2004 USA elections have been widely publicised. In June 2004 a symposium on electronic voting was held at Harvard's Kennedy School of Government, which produced a report entitled *Electronic Voting Best Practices.* The report made a number of recommendations covering the practices which were considered essential for the acceptable and reliable use of electronic voting technology for future elections in the USA. This paper reviews that report and discusses the proposed best practices in the light of experiences of electronic voting in Australia, and in the broader context of the full election system and processes.

1 Introduction

1.1 Background
The problems with electronic voting machines used during the 2000 and 2004 USA elections have been widely publicised. As a result of these problems, several organisations of concerned US citizens were formed to raise public awareness of these problems; and a number of academics made contributions to the debate about possible solutions. A substantial contribution was made in June 2004 when a Voting, Vote Capture and Vote Counting Symposium was held at Harvard's Kennedy School of Government (KSG), which produced a report entitled *Electronic Voting Best Practices.* This report was co-ordinated by Professor Jean Camp, with a number of contributors, who are listed in the report. It is referenced in this paper as (Camp, 2004).

The report made a number of recommendations covering the practices which were considered essential for the acceptable and reliable use of electronic voting technology for future elections in the USA, including the, then, upcoming elections in November 2004.

This paper reviews that report and discusses the proposed best practices in the light of experiences in Australia, in terms of electronic voting and the broader context of the full election system and processes. It will argue that:
- it is possible to meet the recommended best practices;
- vote verification using a printed record of the ballot is not necessary; and
- it is essential to have reliable and transparent processes throughout an election system before the widespread use of electronic voting and voting counting technology should be implemented.

Note
In this paper there are several references to an Australian electronic voting system called eVACS®. The author was involved with the development of the first version of this system in 2001, but is no longer an employee of the company. The paper is not meant to be a promotion for eVACS®. However, its design features and successful usage in Australia makes it ideal for discussion of the practices proposed by the symposium.

1.2 Best practices
The term "best practice" came into common use in the 1980s, with the rise of interest in TQM, process improvement, benchmarking and so on. It is a poorly defined term, and

frequently misused, particularly in the management and motivation media. "Best" implies that the practices cannot be bettered, which is often a hollow and inaccurate claim. In many cases, where an organisation is performing well, "leading practices" would be a better term.

It should be noted that not every point in the report defines a "practice", that is, a description of a specific activity to contribute to successful electronic voting, in this case. Sometimes the point is a more general statement, and a particular practice has to be gleaned from the supporting discussion.

The document is assumed to define and qualify the practices as being the best for the USA. If the actions really are the best, or leading practices, they could be considered as providing a description of what should be done in any jurisdiction or election. This paper compares these USA election practices with what is done in Australia, both with electronic voting in the Australian Capital Territory (ACT) and other election systems across Australia.

2 Summary of the proposed Best Practices

The symposium held at the KSG identified six major themes deriving from issues related to voting and vote counting in the USA. The symposium was held in June 2004, the timing of which reflected the growing concern in the wider community of problems with the current state of voting processes, particularly with respect to electronic voting. The recommended practices cover:

- what needed to be done immediately (June 2004) to start to address the problems;
- aspects of electronic voting and allied technology;
- aspects of the human element in the election processes;
- technology design standards;
- a wide range of processes to be improved and made transparent; and
- aspects of auditing electronic voting systems.

The attendees at the symposium were diverse, and included technologists, election officials, political scientists, policy analysts, press experts, and activists. The report comments that there was not common agreement between the attendees on everything, and therefore not everyone agreed with every defined practice. However, the list of practices provides a good starting point for comparison between voting systems, and for further development of the practices.

3 The Australian Election Systems.

Before considering the details of the voting best practices, it will be useful to describe briefly the systems of elections in Australia.

Like the USA, Australia is a federation of states and territories which, with local councils, provide a three tier system of government. The Federal Parliament comprises two elected houses, the lower House of Representatives, and the upper house, the Senate. Five of the six states also have bicameral parliaments, while the sixth state and the two territories each have just one elected house. The third tier currently includes 722 local government councils, covering the day to day administration of a diverse range of metropolitan, regional, rural, and indigenous communities.

Since the middle of the 19th century, that is before federation, Australia has been a leader in the development of election systems, for example initiating: secret ballots; female suffrage;

payment of members; no requirement to own property to be a lower house representative; and compulsory registration of voters; amongst others.

Major differences in election systems between Australia and the USA are:
- since 1924, Australia has had **compulsory voting** in federal, state and territory elections;
- all elections use **preferential voting** as opposed to "first past the post" voting, as used in the USA and most other nations;
- the Senate, one state and the territories also have **proportional representation**, where several members are chosen for each electorate from a list of candidates.

Several USA states are exploring these voting alternatives, which basically are designed to achieve a more democratic outcome from an election.

This is not the place to discuss the desirability of compulsory voting. However, it will be argued that such a system in Australia has been beneficial to the election processes, and provides a more democratic result.

The use of ICT is well established to support election administration and processing in Australia, but electronic voting is not as widespread. However, the Australian Capital Territory (ACT) has developed and implemented a fully electronic voting and vote counting system, known as eVACS®. It was used for just under 20% of the voting in the 2001 and 2004 ACT government elections, and to count all votes and allocate preferences for these elections. The system has a data entry and verification module to provide input of paper ballots to the electronic system for counting. The counting system was also run in 2003, to fill a casual vacancy.

Electronic votes are cast using a standard PC and keypad, connected to a secure local network. Only the election software is installed on the PC, operating in a Linux environment. The source code of the system is available for inspection by anyone, and is audited by an independent third party.

Voters navigate around the ballot paper using the keypad, and select their candidates in their order of preference. Changes can be made to this order at any time, and when the voter is finished they are required to confirm their selection before submitting the vote. Informal voting (ie not casting a vote) is possible.

Because of its size of population, the USA has been using mechanical and electronic means to support election processes for a long time. Australia's small population has not required that level of automation, and eVACS® is the first automated election system to be used.

Further information on the Australian approach will be provided in the following sections, discussing the list of best practices.

4 Details of the Electronic Voting Best Practices

Using the terminology of the report, the six themes are shown below. Each theme includes a number of points, describing the "best practices" identified by the symposium. In the report there is further discussion, clarification and justification of the points from the symposium debate. The details of these aspects are not reproduced, but reference is made to them as required.

4.1 Theme 1 - Certain immediate steps must be taken.

1. Election Assistance Commission and National Institute of Standards and Technology open standards must be developed and implemented.
2. Voting experts and technologists can aid in whatever voting process is used by designing guides, working in polls and gathering trustworthy data.

Discussion

The symposium was held in June 2004, and this theme identified the immediate steps to be taken for the elections to be held in November 2004, and for ongoing improvements.

Point 1 identifies the need for open standards for voting systems and voting processes, and for testing and certification processes. The report comments that there has been a slow start and a lack of funds for standards development, but by June 2005 progress has been made and a draft version 2 of the Voluntary Voting System Guidelines (NIST, 2005) is publicly available. This document builds on earlier publications by the Technical Guidelines Development Committee (TGDC), National Institute of Standards and Technology (NIST), and others.

Currently, no Australian standards exist, or are planned, for electronic voting systems. However, Australia is active in the standards field, and there are national and international standards which would apply to the development of systems; covering accessibility, software development processes, quality assurance, testing, documentation, and others.

It seems that part of the problem in the USA may be the proliferation of different types of equipment from different vendors, in the various states and sub-divisions. Standardisation to a limited number of products may help these practices to be achieved.

The symposium seems to have excluded discussion on an important aspect – the processes to develop and support the electronic voting systems. Voting systems are mission critical, to use defence parlance. If citizens are to have complete confidence in their democracy they must trust the voting systems, electronic or otherwise, used to elect their representatives. Voting systems need the reliability of aviation systems and the security of financial systems to ensure this trust. Therefore the maturity of the companies that develop these systems, and the capability of their processes, should be measured and tested against standards.

In general it is desirable to involve citizens to strengthen democracy, and the research work of the symposium is a good example. The reference to volunteers "working in polls and gathering trustworthy data" is assumed to include the TechWatch programme, organised by the Verified Voting Foundation. This was a scheme to enlist technology professionals to volunteer to observe and document problems which arose with the election process and voting technology, during the November elections. This documentation would be used to provide evidence to support litigation and policy making with respect to electronic voting.

This is an on-going activity and by June 2005 42,696 election incidents had been reported (Verified Voting Foundation, 2004). Incidents have been reported from every state, and cover a range of issues, not all related to voting technology. In fact the majority of incidents reported were about voter registration problems and difficulties in being able to vote, often because of insufficient polling places and ballot papers to meet the voter turnout.

Such an activity is unnecessary in Australia. State and federal elections are well planned and run by trained electoral officials and temporary support staff at the polling places. The

election management processes include the requirement to record incidents that occur at the poll, but there are very few of these.

4.2 Theme 2 - A hybrid of paper and electronic systems provides an effective voting system.

1. Electronic interfaces enable customizable ballots by precinct, party or disability.
2. Electronic Systems can meet the widest range of accessibility needs.
3. Voter verification of a paper ballot allows the greatest degree of confidence that the ballot was cast as intended.
4. A paper ballot, when handled properly, allows a robust audit trail for a recount to ensure that the ballot was count as cast.
5. Hybrid systems can be designed to accommodate provisional arrangements and contingencies for equipment failure.

Discussion

The symposium uses the term "electronic interfaces" in points 1 and 2 to indicate how election officials and voters could communicate with the electronic voting systems, and ICT can provide the required level of customisation to met the functional needs of these two groups. The report cites examples of customising ballots for specific voters, by providing ballots in a required language, or a special print size.

The design of eVACS® provides a number of useability and accessibility features within the software. Visually impaired voters, or those with poor reading skills, can vote in private through the use of an audio function. On-screen voting instructions are provided in English and eleven other languages. The audio function is available on all versions of the software, not just a special version for blind people. Later versions of the product could expand this function to provide audio instructions in a range of foreign languages.

The Report mentions the Massachusetts approach as an example of a hybrid system, in which paper ballots are optically scanned to provide an electronic record of the votes, which are then counted by computer. This is one of the many methods of automating the voting process used in the USA, and this plethora of approaches is one of the problems that the electronic voting best practices are trying to address. The other methods range from various methods of producing punched cards through to all electronic devices, usually referred to as direct recording equipment or DRE. Typically, paper does not have a function in these DRE systems.

This is the reason for including points 3 and 4 in the list of best practices. Because of the many equipment malfunctions reported in the 2000 elections, the symposium was rightly concerned that a reliable method of vote verification should be available to the voter, before the ballot was finally committed to the system. It is argued that a paper ballot can be read by the voter, to verify the voter's choice, before it is put in the ballot box, and therefore a human-readable ballot should be included as part of all of these hybrid systems. An added advantage of a human-readable ballot, mooted by the symposium, is that a reliable audit trail is available, if a recount is needed for any reason, say equipment failure or a contested result. There are a number of problems with these suggestions.

A properly designed module for electronic voting, eg. a DRE, should not need to use a paper ballot. If voters have so little trust in the DRE, that they require a paper record of their electronic vote, then surely the electronic option should not be available in the first place.

There is no paper validation of the vote cast using the eVACS® voting module. Voters can change their vote, or restart voting, at any time until they are satisfied. When finished, their choice of candidates is then shown to them, for confirmation, or they can start again. Blind voters follow the same process using the audio function. Confirming the vote sends it to the database for subsequent counting.

The suggestion in the report under point 4, that paper ballots can be counted by hand, as part of a "robust audit trail", ignores the fact that manual counting is inaccurate and hence unreliable.

In Australia, eVACS® contains a data entry module to key in the voter preferences on ballot papers. Batches of 50 papers are independently entered by two different operators, with candidate scrutineers in attendance. The software produces exception reports of any differences between the data entered by the two operators. Batches cannot be committed to the database for vote counting until the differences have been resolved and corrected. The counting module can then be run, to distribute preferences and declare the successful candidates. Further information on the accuracy and reliability of this approach to electronic voting and counting can be found in Green (2002).

Point 5 identifies the need for a hybrid system of electronic and paper systems, and states that it is important to have the ability to vote using a paper ballot as a backup in the event of equipment failure. This is a valuable point, and some form of paper ballot will also be needed for postal voting, and mobile voting, eg. for hospital patients, as is done now.

To summarise, the symposium's approach is that both components of a hybrid voting system, paper ballots and electronic devices, are used by each voter. The Australian approach to a hybrid system is to provide both paper ballots and electronic means of voting, but each voter chooses the single method they prefer.

4.3 Theme 3 - The process is as important as the underlying technology.
1. Poll workers should be well trained to fully understand the interface and contingency plans in case of failure.
2. The educational process for given technologies must follow a "chain of trust" where the election workers trust their trainers and are trusted by the public.
3. Poll workers should be well-chosen from a motivated pool with appropriate incentives.
4. Poll workers should not have to rely solely on the vendors to address observed errors.
5. There should be adequate time for determining the official tally.
6. Speed and accuracy in the process are both achievable, but not simultaneously possible.
7. There should be provisional voting mechanisms, and adequate time to evaluate provisional votes for the final tally.
8. There is an inevitable trade-off between authentication of voters and access.

Discussion
This theme is perhaps the most important of the six identified. Since the early days of computer systems development it has been well known that the automation of poorly designed and understood manual processes will usually not be successful. Perhaps some of these points should have been included in theme 1, as matters of immediate action.

Points 1 to 4 cover the choice and training of election officials and poll workers, and their involvement with the representatives of the vendors of the voting technology.

Three months after the symposium, a report in the Washington Post, (Carter, 2004), emphasised the need for "A non-partisan electoral commission or a trusted and non-partisan official who will be responsible for organizing and conducting the electoral process before, during and after the actual voting takes place."   This was a reference to Florida, and the report describes the how the top election officials in the 2000 and up-coming 2004 elections had proved to be highly partisan, through their high profile involvement with the Republican party. It is possible that there are examples of this type of partisanship in other states.

Perhaps ensuring a competitive market is part of the problem facing the USA legislatures. Miller (2004) cites examples of conflicts of interest where senior executives of the four main companies manufacturing electronic voting equipment are major donors to the two main political parties, and some are fund raisers for the Republican Party. There have also been some very close links between senior electoral and other state officials and these companies, described by Miller as "This revolving door between elected officials and the voting machine companies,..."

The election incident reporting system, mentioned previously in theme 1, includes a large number of incidents related to the operation of polling places, including late opening and early closing of these centres.   The symposium's emphasis on the need for well trained and motivated people to administer elections is well founded.

By way of contrast, since 1902 Australia has had its federal elections run by public officials. It now has independent electoral commissions covering federal, state and territory elections, staffed by public servants, and supported by temporary polling officials and support staff, who are employed and trained to support each election. Those people running the polling places with electronic voting systems received additional training in the setup and operation of eVACS®.   In Australia, the election processes preclude the voting system vendors from accessing the system during the poll.

Points 5 to 8 cover issues related to the determination of the final result as speedily as possible. Delays are caused by the need to evaluate provisional ballots, and to conduct audits of the election. Other issues addressed in these points cover aspects of voter registration, voter verification, provisional voting and the time it takes to provide a final accurate result of the poll. Point 8 discusses the gatekeeper function that poll workers have, in allowing a person to vote, or not. One condition is that the person should not be a felon, and an example is given of people being denied the vote for having outstanding parking tickets. Other parts of the report propose ways to remove this gatekeeper function from the poll worker.

In Australia, since 1924, it has been compulsory for every citizen of voting age to vote at an election. To support this requirement there is an electoral roll for each jurisdiction, and it is compulsory for citizens to enrol to vote when they reach 18 years. Therefore, maintaining a roll of registered voters is an ongoing process, and compulsory registration minimises the occurrence of provisional voting on polling day. There are very few reasons why a person is exempt from voting, the main reasons include; being of unsound mind, serving a prison sentence of three years or more, and having been convicted of treason or treachery.

Because of the compulsion to vote, Australian election systems must have the capacity to enable every eligible person to vote, usually on a polling day, but also via postal voting, or pre-polling. Therefore there are always enough polling places, supplied with enough ballot papers, and the places are always open for the stipulated time.

4.4 Theme 4 - Good voting systems require good design standards.
1. There is no single voting interface that can meet everyone's needs.
2. An untrained voter should be able to know when voting equipment fails.
3. Access is critical: not to a specific, single technology, but to the ability to vote in a fashion that provides full civil rights.
4. Even with full auditing of each vote, rigorous testing for security, usability and reliability remains critical.

Discussion
This theme makes the point that technology is rarely value neutral and biases can be included in voting systems, even unintentionally. The report does not include much specifically about good design standards, although failure detection and fail-safe processes are included, and the benefits of electronic voting systems to people with disabilities are also stressed. The use of Value Sensitive Design (eg. Friedman et all, 2003) or a similar technique would be a desirable additional practice for inclusion in this theme.

As stated previously, not every point in the report defines a "practice", that is, a description of a specific activity. For example, point 1 above, " There is no single voting interface that can meet everyone's needs" is not a practice. The discussion covering this point identifies the need for a diverse range of requirements for voting interfaces, to ensure voters of their basic rights of access to the voting system, thus precluding a standardised interface. The symposium's conclusion makes a strong democratic statement, that "a community should seek to ensure that everyone could cast his or her ballot comfortably, conveniently and with confidence". This would indeed be a best practice.

This theme pushes the need for a diversity of interfaces. The Australian experience has shown that with good design, a single electronic voting system, coupled with the option of using a paper ballot, can be successful. A design criterion of the original eVACS$^®$ was that communication with the voting system by the voter should be no more complicated than using an ATM, since the vast majority of the people in the ACT accept this technology. Therefore the interface included a basic keypad and a barcode reader. Even blind voters use a barcode to initiate the vote, and the keypad. The keypad has an instruction option to enable the user to learn the function and placement of each key, by hearing this information from the audio module.

A requirement of the original system also precluded the use of touch screens as the interface, because the advice from blind people is that they find these difficult to use. It is understood that later version of the system could include a touch screen alternative, to meet the requirements of other legislatures.

4.5 Theme 5 - Transparency builds public trust and supports legitimate elections.
1. If underlying mechanics or software are not in the public domain, they must at least be available for inspection by the larger security community.
2. All security issues should be fully disclosed, although allowing vendors a limited, fixed time between notification and public disclosure could foster more public trust.

3. The voting technology acquisition process should be open for public scrutiny from constituents.
4. The voting technology acquisition process should be open to allow jurisdictions to learn from each other. Records of difficulties should be made available to all election officials.

Discussion
These four points are also very important and should be given priority for implementation. The comment concluding point 1-"Nondisclosure agreements have no role in the realm of voting" - is a powerful sentiment, which sums up this theme.

eVACS® was an open source project, and the ACT Electoral Commission web site contains the source code for the software used in the 2001 and 2004 elections, and the report of a minor error found in the original version. The web site also includes a description of the procurement process; an overview of the system; details of the testing and auditing activities; and a description of the consultation process.

Consultation was held in conjunction with a Reference Group, with representatives from the political parties; members of the Assembly; the ACT Blind Citizens Australia and the Proportional Representation Society. There were discussions with, and demonstrations for this group during development, and some members took copies of the software for inspection by their own technical advisors.

4.6 Theme 6 - Election systems must have built-in auditing capability.
1. The reconciliation process must be clear, precise, authoritative and binding.
2. The cast ballot must follow a "chain of custody" from the moment it is cast to the moment the vote is entered into the final official tally.
3. If some metric of voting irregularity is exceeded in a given jurisdiction, a court-supervised manual recount should be required.
4. Auditing should not be implemented by a vendor affiliated with the original system.
5. Equipment testing does not displace the need for outcome auditing.

Discussion
These five points cover a number of requirements to ensure the validity of the vote, through the use of audit processes, and security and reconciliation processes of the voting system. The independence of auditors is stressed.

In Australia, the rules for these activities are defined in the electoral legislation of each jurisdiction. When the ACT decided to implement its electronic voting system, the Electoral Act was amended to include additional clauses to cover the details and specific conditions of this system.

It could be assumed that any democratic society has similar legislation to cover the way it conducts its elections, and this should be the place to define many of the requirements and practices identified by the symposium.

With eVACS® there is a range of back up and security functions to ensure the reliability and integrity of the system, including keeping a record of every keystroke. The keystrokes and the back up of other data provide a complete audit trail and recovery mechanism in the event of failure. There is no way to link a voter to the vote they have cast.

5 Conclusion

The KSG Symposium produced a valuable document identifying a number of practices to be adopted to provide reliable and trustworthy electronic voting systems. These practices go beyond the technology and identify other aspects related to the underlying systems, for example of voter registration and election administration. While the practices are largely USA-centric they provide a starting point for any society wishing to consider ways to improve its democratic processes.

The practices do not present an excessively high standard, and they are what would generally be expected in any democratic society. They are achievable, as the Australian examples have shown. Part of the success in Australia can be identified with the country's long history of electoral innovation and reform, especially in the area of independent election management and administration, and transparent and open processes.

An important aspect of any voting system is vote verification by the citizen. The developers of the KSG practices believe that some form of paper trail is essential for vote verification and audit purposes. The experience in the ACT has shown that this is not necessary

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