Chapter 5

A Synthesis of Vote Verification Methods in Electronic Voting Systems

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ABSTRACT

A large amount of research has been conducted to improve public verifiability of e-voting systems. One of the challenges is ensuring that different and apparently contradicting requirements are met: anonymity and representation, vote secrecy and verifiability. System robustness from attacks adds further complexity. This chapter summarizes some of the known vote verification techniques and highlights the pros and cons of each technique. Also, it reviews how different verification technologies cover different phases of the voting process and evaluates how these techniques satisfy the e-voting requirements.

INTRODUCTION

The way people vote has evolved from paper based systems, where voters use paper to write down their votes, to the use of special mechanical or electronic machines to cast votes electronically. The technologies available are rather diverse and include: punched card systems, optical scan systems, Direct Recording Electronic (DRE), and online (Internet) voting systems. The e-voting systems have many potential advantages: it can facilitate vote casting, it may reduce voter’s mistakes (e.g., under-voting and over-voting), it can speed up the election processes, and it allow underserved (e.g., illiterate and impaired) voters to vote in independence. In spite of the advantages of e-voting, concerns about security and various accidents occurred during elections have slowed its adoption. The research in the area has thus focused on methodologies and technologies to support security properties of e-voting systems. Another area of investigation has focused on the usability advantages, promoting new ways of casting preferences and votes. A large research area is allocated to solve the verifiability problem, which is how to allow voters and other partici-
pants (e.g., public observers and electoral staff) to verify election outcome, (i.e., votes are correctly captured, stored and counted), without breaking the privacy requirement?

Research in the areas mentioned above has produced a number of results. For instance, most of the DRE machines that are currently deployed in the polling places are equipped with a verification devices that provide a redundant physical evidence of the votes cast, such as a paper audit trail (Mercuri, 2001) or audio messages (Selker & Cohen, 2005). Other vote verification methods are based on cryptography to craft an encrypted receipts that the voters can use to challenge the credibility of the process; see, e.g., Votegrity (Chaum, 2004), Prêt à Voter (Ryan, Bismark, Heather, Schneider, & Xia, 2009) and Scantegrity (Chaum et al., 2008). Lately, a technique based on electronic encrypted trails has been proposed for Internet voting, e.g., in (Clarkson, Chong, & Myers, 2008), in order to allow the voter to cast in a non-controlled environment, while, at the same time, avoiding the risk of voter coercion.

In this chapter we have two main goals. The first goal is to overview some of current vote verification techniques, and in particular, the physical audit trail, the electronic audit trail, the physical encrypted receipt, and the electronic encrypted receipt. The second goal is to evaluate the techniques mentioned above. For this purpose we introduce an evaluation framework that highlights the different verification techniques advantages and disadvantages, and also evaluates to what extent those techniques are implement voting requirements.

The chapter is structured as follows: the next section discusses the e-voting requirements. Successively, we give a general description about the different e-voting technologies. We then continue describing the different vote verification techniques and a number of e-voting systems, which have been selected to illustrate the techniques. The goal is not that of giving an in-depth presentation of the selected e-voting systems, but, rather, to highlight how the different verification technique covers the e-voting requirements. We then continue by illustrating all the results using and comparing the different technologies. Finally, we conclude with some consideration about the future work and research directions.

**VOTING REQUIREMENTS**

Several countries (e.g., the U.S. Federal Election Commission (FEC) Voting Systems Standard (VSS) (Federal Election Commission, 2002, 2005), Council of Europe (Council of Europe, 2004) and various researchers, e.g., (Volkamer, 2009; Antonyan et al., 2009), have defined requirements for voting systems and machines. These works contain a set of principles to ensure compliance with the principles of voting and, in many cases, with the local laws. These documents can also be classified according to the context in which the requirements are to be developed (e.g., paper-based voting or e-voting), the type of e-voting system addressed (e.g., DRE-based versus optical scan-based), the categories in which the requirements are classified, and the level of detail for the requirements. Some of the requirements, like: verifiability, integrity, privacy usability and accessibility, are related to the vote verification process. In the following, a brief description about these requirements is provided.

- **Verifiability:**
  - **Individual (Voter) Verifiability:** The ability of the voting system to make a voter sure that his/her vote has been cast and tallied as intended by him/her (Demirel, Henning, Ryan, Schneider, & Volkamer, 2011; Warren, 2005).
  - **Eligibility Verifiability:** The ability to convince people that tallied votes belong to eligible voters and there is at most one vote per single eligible voter (Kremer, Ryan, & Smith, 2010).
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