New Generation of Voting Machines in Germany
The Hamburg Way to Verify Correctness

Melanie Volkamer, Roland Vogt

German Research Center for Artificial Intelligence (DFKI GmbH)
Stuhlsatzenhausweg 3, 66123 Saarbrücken, Germany

Abstract. The state government of the Free and Hanseatic City of Hamburg, Germany, is planning to introduce a new type of voting device for its Bürgerschaft (state parliament) election in 2008. They came up with this idea because of a change in their election law which causes the use of ballot booklets instead of one side ballot sheets and thereby results in a time and capacity intensive task for counting. Therefore, the persons in charge are planning to use a new voting device, the so-called digital electoral pen system. The digital pen has the advantage that its handling does not make a big difference for the voters. Additionally, the pen has the nice feature that paper ballots still exist as back-up and fall-back. This new voting device has still to be developed, certified and approved. In this extended abstract we give a short overview of the project, the technology and the way to certify and approve the digital electoral pen system.

1 Introduction

Mechanical election devices are allowed in Germany since 1975 for Bundestag elections and European parliament elections. Since 1999 also electronic and software based devices are allowed. The law specifies how to evaluate and approve the devices. In addition, it defines how to deliver the devices on the election day and how to preserve the integrity of the devices between different elections: The evaluation is performed by the national metrology institute (Physikalisch-Technische Bundesanstalt) and the approval is signed by the Federal Ministry of the Interior. The local voting commission takes care of the devices in the period between elections and the election officers in the polling station can check if the voting device they use is the one that has been evaluated and approved[1]. Only the electronic devices from the Dutch company NEDAP (cf. Figure 1) ever got an approval and are in use[2]. By the way, here we face the same problem as in many other countries: Only view information about the machines and the verification process are available. In the past, several companies tried to introduce

[1] They can verify whether the official seal is intact and whether the hash value of the software inside is correct. But, of course, if the developer wants to cheat he could do so undetected.

[2] In 1999, the devices where only used in the City of Cologne but in 2005 in 65 cities, thus at all 5% of the voters had to use the machines.

new and more modern forms of voting machines (e. g. touch screens) but the requests were rejected because their ideas do not match with the verification method: checking the whole system, including hardware and operating system[3].

Fig. 1. NEDAP machinen (http://www.wahlsysteme.de/Homepage.htm)

The City of Hamburg recently has changed the state election law for the Bürgerschaft (state parliament) elections. At the moment, voters are allowed to choose up to 10 of around 1.000 candidates. Thus, not a simple ballot sheet rather than a ballot booklet (approx. 25 pages) will be used. Counting will become very complicated and time intensive. The persons in charge are expecting around 1.6 million ballot sheets with 8 million votes and they estimate that it would need a whole week to compute the result instead of having it on Sunday evening like within the past elections (in Germany we are used to have results on the same evening). In order to compensate the expected time delay four times as many election officers would be needed – with estimated costs of around 6.8 million Euro.

Therefore, the City of Hamburg is planning to use electronic support by counting the votes. They came up with the idea of a digital electoral pen because of several reasons: First, there are no big differences for the voters in comparison to the traditional system; with the digital electoral pen the voters can still use paper ballots and mark them with crosses as before. For example, a touch screen system has the disadvantage that a completely unfamiliar technique would be introduced to the voters, Second, other voting devices can not handle the new ballot booklet properly. For example, the existing NEDAP machines would have to show the whole ballot at once; thus, it would be, if any, a rather huge machine which is not practical at all. Third, as an additional advantage the paper ballots serve as a back-up or fall-back, e.g. in case of technical problems. While the digital electoral pen is not yet approved in Germany so far, the City of Hamburg is anyhow allowed to introduce it for its Bürgerschaft elections by defining the particular way to evaluate, certify and approve the voting device.

In this extended abstract we will shortly explain how the digital pen works (chapter 2), report about the test election in 2005 in Hamburg (chapter 3), and

[3] The NEDAP machines are based on a small self-implemented operating system, specialised hardware and the voting application.

describe the planned voting procedure in the polling booth (chapter 4), which is rather important to ensure that all authorized votes and only those are counted. Finally, we illustrate (chapter 5) the new way to evaluate and certify the digital electoral pen for the state elections in Hamburg.

2 Digital Electoral Pen

A digital pen is used in the same way as common pens. It is a little bit bigger, because of an integrated camera besides a usual lead. Using a digital pen for elections does not introduce essential changes to the voting procedures. The voter marks his choice on a paper ballot in the polling booth and the pen stores the corresponding positions. At the end of the individual voting process the voter drops the paper ballot into the ballot box as usual and additionally inserts the digital pen into a docking station. The voting data from the pen is copied to the electronic ballot box[4], erased from the pen and the pen is reinitialized for the next voter.

The scanning is done based on a thin pattern on the paper ballot. The distance between the pattern railing is 0.3 mm and each field is uniquely marked with very small dots (cf. Figure 2). The contact of the pen on the paper is noticed by a sensor in the top of the mine causing the integrated camera to start scanning. Using the pattern the pen deduces its current position and stores it. This technique was developed by the Swedish company Anoto Group AB and is therefore called *Anoto* technique.

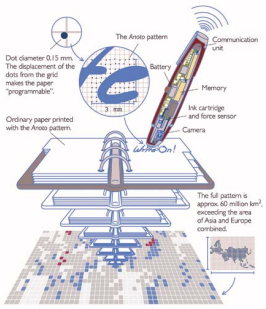

Fig. 2. Digital Pen (http://www.heise.de/ct/06/06/090/)

The election result calculation is based on a validation of each ballot. Rules for separating valid from invalid ballots have to be specified. Based on this the software distinguishes three case: valid ballots, invalid ballots and those ballots that have to be checked manually by the electoral officers because they are not clearly marked.

[4] The ballots are stored in such a way that it is impossible to reconstruct the order of their storage.

3 Test election for the Bundestagswahl 2005

Before introducing the digital pen to a legally binding election the City of Hamburg decided to arrange a test during the 2005 Bundestag election in two election districts located in Hamburg-Wandsbek[5]. The main reason to do so was to see whether the voters and the election officers accept the digital electoral pen. There was some kind of prototyped system developed by the IT service provider Lufthansa Systems. Besides the test election the Statistic Office of Hamburg and Schleswig-Holstein also organized an inquiry to find out how the people think about the new technology.

Fig. 3. Test Election (http://fhh.hamburg.de/stadt/Aktuell/nachrichten/2005/september/18-digitaler-stift.html)

Approximately 1.800 voters were assigned to the selected districts and 677 participated in the additional test election[6] (cf. Figure 3). 504 of these voters participated in the inquiry. The main result of the inquiry convinced the City of Hamburg to go ahead with the introduction of the digital electoral pen: 84 % of the voters would welcome the use of the digital electoral pen for the next Bürgerschaft election. The second result was that people are more afraid that their ballot gets lost than that someone opens it in order to break the election secrecy. The third and very important result was the wish of the voters to get much more informed about the techniques and security features before the election in 2008.

4 Voting Process on the Election Day

The whole voting device of the digital electoral pen system probably will consist of at least one digital electoral pen, three docking stations, one computer, one printer and at least one portable storage device (e. g. memory stick). The printer is used at the end of the election day to print out the result of the particular polling station and the portable storage device is used to transfer all the voting data (e. g. votes, decisions, protocols) to a central place for computing the total result there. The computer basically represents the electronic ballot box and

[5] For more information see http://fhh.hamburg.de/stadt/Aktuell/wahl/digitaler_20wahlstift/pilotstudie,property=source.pdf.

[6] After having voted regularly on paper with a normal pen, the voters had the possibility to get a digital electoral pen and a patterned ballot sheet for casting a test vote.

the three docking stations are needed to make the correct proceeding clear to everybody. Thus, there is one docking station that is only used to activate the digital electoral pen right before the voter gets it. The second docking station is used to register and store the vote on the computer and to erase it from the pen. The third docking station is needed either if a voter wants to correct or change his ballot again or the person who casted the vote is not allowed to vote at all. In both cases the vote on the pen has to be erased and must not be stored. For a more detailed illustration about the voting process please have a look at Figure. 4.

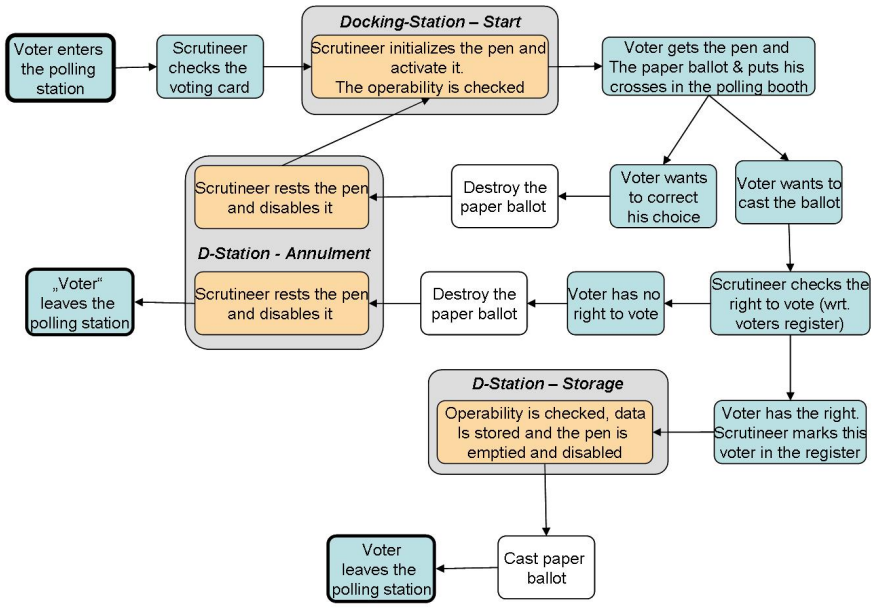

Fig. 4. Voting Process

At the end of the election day the election officers initiate the end of the election. Now, no additional votes can be stored any more. The voting software starts validating and presents the unclear ballots to the election officers who now decide (as they do it in current elections as well) how to interpret the corresponding ballots[7]. After finishing the validation phase, the result is calculated, printed and the corresponding data are stored on the external storage device.

[7] Note that the digital electoral pen system is equipped with a security feature that comes for free: It is impossible to manipulate, e. g. invalidate a ballot during validation.

5 Verification and Certification

The persons in charge for the Bürgerschaft election propose a new way to evaluate and certify the digital electoral pen system: Probably, it will be done in a cooperation of four institutions. Hamburg's Department of Interior (instead of the Federal Ministry of the Interior) approves the evaluation performed by the Physikalisch-Technische Bundesanstalt (PTB). Additionally, the Federal Office for Security in Information Technology (Bundesamt für Sicherheit in der Informationstechnik – BSI) certifies an evaluation of the security requirements performed by a Common Criteria accredited laboratory. The reason for this approach is the largely software based solution of the digital electoral pen system. The evaluation of such security critical products by accredited laboratories and the certification by the BSI is nowadays a widely accepted procedure.

While the PTB will mainly concentrate on the evaluation of functional requirements like e. g. the correctness of the counting algorithm, the accredited laboratory will evaluate the security functionality like e. g. the unlinkability of the stored ballots. Therefore, it is planned that a Common Criteria Protection Profile is going to be developed to define the security requirements based on the intended usage, assumptions, threats and objectives for the system.

Assumptions are those requirements the PTB is going to evaluate as well as assumptions on the availability of the system components and the correct progression in the polling station (e. g. the voter has to drop his paper ballot in the ballot box before leaving the polling station because otherwise he can prove his voting decision). The Potection Profile specifies several threats, e. g. the order of the stored ballots may be discovered, that have to be countered by appropriate security mechanisms of the system. The countermeasures are summarized as security objectives, e. g. every voter can check whether the pen is manipulated and whether his ballot is counted[8].

Deduced from the objectives, Common Criteria specific security requirements are defined. The evaluator of the system has to examine whether the security functions of the system cover all these requirements. It is planned to evaluate the digital electoral pen system according to the EAL 3 evaluation assurance level, in addition to the independent evaluation done by the PTB.

[8] Remark: Here it is enough that the computer displays that the vote was successfully stored in the electronic ballot box (of course without any information about the content).