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Experiments with e-voting technology experiences and lessons

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Abstract: A secure PKI based system for e-voting was developed. We tested the application, several organizational aspects, and usability in fourteen field trials. In this paper we describe the method and findings. What do we learn about turnout, about the logistics of organizing e-voting, and about usability and reliability of the system in practice?

1. Introduction

Most e-voting systems and e-voting R&D projects focus on the technological aspects [1], and the chosen technical solutions seem rather similar [1] [2]. In this paper we emphasize different aspects of e-voting technologies. Firstly, as is well known but hardly practiced, the organizational context of implementation and use of ICT-based systems is essential to success and failure [3] [4]. Therefore, we included in our e-voting project a phase of studying users' opinions and needs [5] [6], and a set of extensive field experiments to study e-voting and e-polling technology in its organizational, political [7] and practical context. Secondly, we consider e-voting technology as potential useful for all kinds of settings, and not only for political voting. This is reflected in the field experiments, which include two municipalities, but also a trade union, and two community networks. In this paper we will briefly describe the field experiments with the e-voting system, as well as the methodology used to study the experiments (section 2). Section 3 focuses on the main findings. Finally, we will draw some conclusions with respect to the design and use of e-voting and e-polling systems (section 4). In this paper we cannot discuss the technological aspects of the e-voting application. Figure 1 gives a brief overview of the developed application.

2. The field experiments: set-up and methodology

The field experiments were organized in five different environments, namely:

Orsay, a town of 16.500 inhabitants, 25 km south-west of Paris;

Carpenters Estate (Newham Council, London), a residential area with about 600 apartments and a very heterogeneous and multicultural population;

CGIL, the largest Italian trade union;

RCM (Rete Civica di Milano), an urban community network in Milan;

OYK (Learning Upper North Karelia), a rural community network in the eastern periphery of Finland, covering three neighboring municipalities with a total area of 4500 km^2 km and a population of about 20,000 inhabitants.

2.1 The voting sessions

Between December 2002 and March 2003, each of the five sites organized two or three ballots, which resulted in a total of 14 experiments. The first and second voting sessions were on local issues, selected by the organizing institution. This was quite critical, as the selected topics had to be relevant enough for voters to encourage their participation in the ballot. The third voting session took place in parallel in the five experimental sites. Organizing a multiple site voting was important from a technical as well as from an organizational perspective. Technically, we used it to test the voting application in terms of concurrent access, and to check the interoperability of the French and Italian certification authorities. From an organizational point of view multiple site voting increased the organizational and logistical complexity.

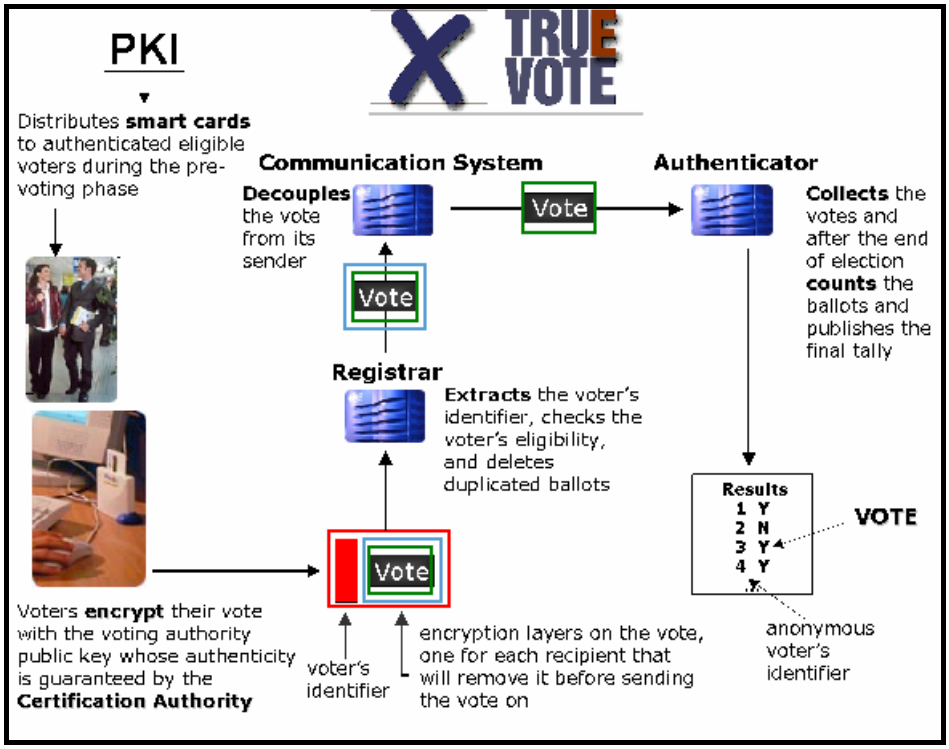

Figure 1: The TRUEVOTE system

The voting sessions included both single choice (yes/no) and multiple choice ballots. More precisely, the two local voting sessions in Newham asked residents about security issues at the estate, while for CGIL the ballot issues concerned the position the trade union should take on some political hot topics, such as the Italian laws about immigration, the relationships between CGIL and the European Social Forum, the war in Iraq. In Orsay the ballot was to find out the citizen's opinion about the extension of a regional administrative network with additional municipalities. The topic for the first ballot of RCM was defined in collaboration with the Milan City Council about priorities in organizing activities during Christmas time, whereas the Province of Milan defined the second ballot about public transportation in the Milan region. In the regional community network OYK, the first ballot was about welfare services and measures to be undertaken in case of a crisis in the municipal finances, while the second one was on the desirability of Finland entering the NATO. The third and at all sites identical ballot was about possible actions to decrease Europe's dependency on oil.

2.2 Recruiting and registering the voters

In Orsay eligible voters were all the citizens, and everyone got an official letter from the municipality inviting him/her to participate in the experiment. In Newham eligible voters were the residents of the Carpenter's Estate. CGIL involved several groups of members and local officials in the experiments. In the two community networks all the registered members were invited to participate, while others, interested in the voting experiment, registered to RCM and OYK to be able to participate. All partners did a further recruiting of voters between the first and the second ballot. No further recruiting has been done after the second ballot, so the number of registered voters in the second and third round is the same.

Eligible voters, who voluntarily accepted the invitation, received a smart card carrying their own digital signature. Votes could be expressed either from a kiosk or from a PC (at home or at work) equipped with a smart card reader provided by the project for free. The difference is that in the second case it is the voter who installs the smart card reader and the software (the smart card reader drivers and the voting application) whereas in the case of kiosks the project staff took care of this. Since the voting application was still a prototype not supporting all hardware and software architectures, some eligible voters could not participate because their PC did not satisfy the requirements.

Table 1: Overview of the field experiments

	Partner	Orsay	Newham	CGIL	RCM	OYK	Total
1st round Dec/Jan 03	Voting duration		2 days	2 days	7 days	22 days[4]	
	Registered voters[1]		83	326	190	310	909
	Voting attempts[2]		7	231	130	238	606
	Votes		6	221	125	215	577
	Turnout[3]		7%	68%	66%	69%	63%
2nd round Feb 03	Voting duration	4 days	2 days	3 days	11 days	10 days	
	Registered voters[1]	925	96	357	303	396	2077
	Voting attempts[2]	N.A.	N.A.	155	207	224	586
	Votes	628	10	145	188	210	1181
	Turnout[3]	68%	10%	41%	62%	53%	57%
3rd round March 03	Voting duration	4 days	2 days	12 days	12 days	12 days	
	Registered voters[1]	925	96	357	303	396	1859
	Voting attempts[2]	477	12	137	168	197	969
	Votes	462	12	135	158	187	954
	Turnout[3]	50%	13%	38%	52%	47%	51%

1. Number of people registering for the vote
2. Registered by the server
3. Votes as percentage of registered voters
4. Period was extended due to technical problems

2.3 Variation in the voting situation

Orsay, Newham and CGIL only used kiosks, while in the two community networks the large majority of voters used internet voting from home or the office. In the two latter cases, also some kiosks were installed to enable the participation of groups of people, such as senior high school students and people in neighborhood offices. During the second local ballot in OYK, the mayor of one of the municipalities, who strongly supported the experiment, asked to put a kiosk in his office. Apart from the e-voting technology, we also

used traditional paper ballots and CAWI technology, as this enabled us to compare the various media. In this paper we focus on the experiences with the TRUEVOTE technology.

2.4 Methodology

We studied the experiments using a variety of methods. After every ballot the organizers completed a standardized report with 44 subjects. The questions concerned the set-up and the course of the voting session, and problems that emerged. Second, the researchers went to several ballots to observe the use of the e-voting application. Finally, three surveys were held among the voters. The first survey was completed when registering for the smart card. This questionnaire asked the voters to provide information about sex, age, occupation, computer literacy, way of using computers, previous voting behavior, their opinion about e-voting, and about the effects of ICTs on society. In the post-ballot surveys we asked specific questions about the usability of the system, about the quality of the system in terms of secrecy (privacy) and safety (against fraud), about their viewpoints related to voting, and some questions related to the voters' identity. Finally, we asked where the voting was done (at home, work, school, kiosk, etc.) and in some cases what they had voted. We used different questionnaires for the various voting situations (e-voting from home or work; e-voting from a kiosk; voting with CAWI; traditional paper-based voting) and the questionnaires were translated into various relevant languages. In this paper we only use the first post-ballot survey in RCM and OYK, as other data are not yet available.

3. First findings from the field experiments

3.1 Motivation for experimenting with e-voting technologies

The motivations for participating in the experiments were different for each organization. Both Orsay and Newham have been involved in previous e-voting pilots, and the focus was mainly on the use of e-voting in elections and other political ballots. Through participation in TRUEVOTE, Orsay and Newham wanted to test more e-voting technologies and hoped to learn more about the citizens' reactions. CGIL was interested in e-voting as a quick, simple and secure tool for internal elections and consultations. This was expected to increase the possibility of involving lower levels of the organization in crucial decisions, such as accepting the results of negotiations with employers, or a new labor act proposed by government. RCM used the voting experiments to enhance local governments awareness of the possibilities of using e-voting applications for citizen consultation, and to increase collaboration with the municipality. For the two virtual communities (RCM, OYK) experimenting with e-voting is part of their efforts to provide citizens with ICT based support for communication and participation. Both community networks already use software for polling and voting. OYK consults people on hot topics on a frequent basis, whereas RCM organizes an annual election of the members' representatives. As debates about e-voting issues (such as secrecy and accountability) already arose, both community networks were eager to test other systems.

3.2 Organizational issues

The self-evaluation by the organizers of the field experiments generated interesting information. The most important issue that came up is the logistics of organizing an e-ballot. The process of registering, distributing hardware and software, organizing helpdesks and other forms of support for voters, etc. proved to be a complex and difficult task. It requires planning of activities of various institutions, such as the institution organizing the ballot, the certification authority, and the 'supplier' (developer) of the e-voting service. We

think that this inter-organizational collaboration is the normal case in operating e-voting technologies, and that makes the experiences generally relevant. A main problem field is the organization of the users' support, especially for the e-voters from home. Another issue is the breakdown of the system. For example, on several occasions the voters were not able to cast the vote because of technical problems at the server site, and therefore not all voting attempts resulted in a counted vote. The number of missed votes was in average 6.3%, 7,4% and 1,6% in the three waves respectively. Although these are substantial percentages, the good thing is that the figures show a decline, suggesting a learning process in operating the technology. If we look at the failed votes in the experimental sites individually, we see a similar pattern. However, on top of this we have to count the technical breakdowns at the voters' site of the system, indicating that new users of the technology may need quite some support to have proper ballots.

These observations suggest that the delivery structure [8] of the technology is important, especially if the e-voting technology is to be used widely in local organizations, trade unions, and other contexts where it is more difficult to devote resources to voting and polling than in the traditional elections. This of course has implications for the business models of organizations that aim at bringing e-voting technologies to the market, but discussing this is beyond the scope of this paper.

3.3 E-voting and turnout

In most countries, decreasing political participation and turnout in elections is a general tendency. One of the claims of the proponents of e-voting technology is that the use of new technologies will make voting easier and therefore may increase the turnout in elections. This is also a major argument behind much of the efforts to develop and deploy e-voting technology. What did we learn in this respect from the experiments?

First of all, there is the issue of recruiting participants for the experimental ballots. If the appeal of new technology is as high as proponents expect, we would expect an easy process of recruiting. However, we experienced a large variation in the willingness of people to participate. In Orsay, the high number of registered voters may be explained because the City Hall organized the voting session, and all residents received an official letter of invitation. Many members of the two community networks were willing to participate and test the new voting system, but time and organizational constraints lowered the number of volunteers, such as problems with the distribution of the card readers among the participants. Another obstacle was the registration of voters. Although registered as community members, people had to register again as voter. Also hardware and software constraints caused a reduction of the number of participants. CGIL's recruiting was simple, as they could use membership lists to select groups of participants that were easily to contact for distributing the smart cards and readers.

Secondly, registering is one thing; voting is another one. We found turnout being very diverse between the various experimental sites, and this suggests that other factors than using the new technology are decisive. In Newham turnout was very low, despite the choice of topics for the ballot that were relevant for the residents of the Carpenters Estate, and despite the participation of the tenants organization in organizing the ballot. Political participation and computer illiteracy may be factors explaining this, apart from large problems with organizing the ballots. Also for CGIL it proved to be difficult to get the members to vote, especially in the later ballots. This declining participation was a general tendency over the experiments. So if an effect of the new technology on turnout exists, it seems that people quickly get used to the new technology, which then loses its special appeal. In case of RCM the participation remained relatively high and stable, probably because the strong identification of members with their community network [9].

Thirdly, turnout is related to the issue of getting the technology working. As the users survey will show (below, section 3.4), installing the hardware and software was not unproblematic. Both in RCM and in OYK we observed that the large majority of requests for help came from home voters in need for assistance with installing the hardware and software. This is confirmed by a comparison of turnout of TRUEVOTE users with turnout of voters registered for using the CAWI technology. The latter technology is much easier to use (most people have no problems to go to a WWW page, and to click a button to vote), requires hardly any registration or no registration at all, and no installing of hardware and software. Whereas the average turnout of voters using TRUEVOTE went back from 63% to 51%, the CAWI voters remained on a turnout level of 80%. The lesson seems obvious. Much more attention should be given to usability when designing and implementing applications for the general public. If we don't want technology to be a barrier, we have to design it as a tool, which can be used without being aware of it, such as a hammer [10]. In other words, ICT applications should become 'invisible' [11]. The implication is that even if the technology is not the most relevant factor in rising voting turnout, it obviously may be an important factor that can reduce turnout, if not well designed or not well embedded in the existing socio-technical infrastructure.

Finally, one of the arguments in favor of e-voting is that the ballots can continue over more days, without additional costs (as would be the case with traditional paper-based ballots). Extending the voting period is expected to increase turnout. However, this does not seem to be the case. Leaving out Newham because of the very deviating low turnout, the correlation between turnout and length of the voting period is negative.

3.4 The evaluation of the system by the voters

We used a questionnaire to get information about how the individual voters evaluate the system. The questionnaire consists of 60 items, and we used factor analysis (orthogonal rotation, varimax) to reduce the number of items into latent variables. We found some seventeen new variables, of which we use nine in the analysis presented in this paper (table 2). Two variables measure the digital divide, three variables measure levels of trust in e-voting systems, and the four are various dimensions of usability of the TRUEVOTE system.

Table 2: Some results of the users' survey

	Yes	Neutral	No	N
Use of computer every day from home	58%		42%	428
Use of computer every day from work/school	64%		36%	393
Trust in safety (against fraud and hackers)	43%	34%	23%	431
Trust in secrecy (privacy)	8%	32%	60%	433
Trust in accountability (verify the vote)	72%	21%	7%	279
TRUEVOTE is easy to use	92%	6%	2%	281
TRUEVOTE is fast	80%	16%	4%	279
TRUEVOTE is easy to install	65%	24%	11%	260
TRUEVOTE is vulnerable for losing cards or pin code	40%	33%	27%	280

First of all, the questionnaires showed that a large part (43%) of the users did trust the safety of e-voting systems against internal fraud and external hackers, whereas some 23% did not trust the security of the system. The remaining 34% were more or less neutral. The level of trust in the secrecy of the vote, that is trust in the privacy protection, was much lower. A large majority of 60% did not trust this, and only 8% were confident about the secrecy of the vote, and the other 32% were neutral. Many users think that they can easily verify their vote and correct mistakes. Although verification was included in the

specifications, it was not implemented in the prototype used in the experiments. So here we only measure the image respondents have of the application.

We also asked the respondents how often they used computers, email and internet, at home, and at work or school, in order to relate the evaluation of the technology with the level of computer literacy.

The opinions about the usability of the TRUEVOTE system are relatively positive, given that we are testing a prototype. The system is easy to use, and fast. Less positive is the opinion about installing the system, although 65% of the respondents found it easy to install the application. Within this context it is important to remember that the data analyzed here are from two community networks, with probably a higher computer literacy than can be expected in average. Finally, losing the smart card or pin code is generally perceived as a (big) problem by 40 % of the respondents.

As a next step, we investigate whether the answers are systematically related to characteristics of voters. If that is the case, e-voting technology may be more accessible for some social groups than for others. This may effect the demography of the turnout, and as a consequence the outcome of the vote. To study the possible demographical effect, we investigated the relation between several personal characteristics (sex, computer literacy, and the opinion about the safety and secrecy of e-voting systems), and the evaluation of the various dimensions of the TRUEVOTE system.

The opinions of the voters are related to characteristics of voters. Firstly, women tend to be more positive about the usability (navigation, number of screens, readability of screens) of TRUEVOTE than men. Secondly, Finnish voters are more positive about TRUEVOTE than Italian voters, and whereas Finish voters tend to become more positive over time, the opposite is the case for Italian voters. Thirdly, the more frequent respondents use a PC and the Internet, the fewer problems they have with installing the application. This implies that the digital divide remains important, but not in terms of access but in terms of experience and skills. Development work to make installation easier is probably needed, but also a good support system to help voters with installing. Finally, the trust in the security of the system influences the voters' opinions about the TRUEVOTE system considerably. Voters that trust the security of the system have a higher trust in the accountability of the system, a more positive assessment of its speed, find it easier to use, and find the application less vulnerable. In our view, this shows that the trust in the system – and in its institutional and legal aspects – may be more important for success than the nature of technical characteristics of the e-voting system. Trust in the secrecy (privacy) of the system is not related to the users' evaluation of the quality of the system.

Further work on the data is needed for a better understanding of the factors underlying the users' opinions. This may teach us to what extent the voting technology is equally accessible for different social groups. We address the possible effects of the choice of voting media and voting places on the outcome of ballots more in depth elsewhere [7].

4. Conclusions

This paper has shown that when designing and introducing e-voting technologies, more issues have to be considered than only technical. We identified some of the important technical and non-technical problems of the e-voting application. Firstly, the experiments show that the discussion about e-voting should be extended from only elections to the larger field of consultation and participation of citizens in a variety of organizational contexts.

Secondly, the expectation that e-voting will increase participation is not supported by our experiments, and we find indications for the opposite effect, when the technology is not well designed and properly embedded. If the usability of the new technology is insufficient, it may result in lowering participation. On the other hand, trust in the system seems to be

more important than the technical characteristics themselves. In other words, the legal and institutional context of the deployment of e-voting technology is rather decisive.

Thirdly, the usability of the technology relates also to the issue of the digital divide. Although in terms of access to ICT the digital divide seems to be closing [12], we found considerable differences in frequency of use of ICT. And, the frequency of using ICT is related with the amount of difficulties with installing the system. We therefore cannot assume that every citizen has similar access to e-voting possibilities. Technical and organizational solutions should be investigated, in order to overcome these barriers.

Finally, various actors play a role (such as the organizer of the ballot, the certification authority and the e-voting service provider), and the resulting complexity of organizing e-voting is a issue that needs further attention. Additionally, many potential users of e-voting technology will have to use it with relatively little resources. Together with the need for supporting the voter, this asks for rethinking business strategies for bringing this type of technologies to the market.

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