Success Factors of Geneva's e-Voting System

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Abstract: In eight official votes between January 2003 and April 2005 authorities in Geneva invited up to 90'000 citizens to test a remote e-Voting system as a complement to traditional voting methods.
Multidisciplinary teams composed of specialists in law, political rights, public relations, government, security, and computer science, together with strong support from the Government itself were necessary to build the system which will be evaluated by Parliament en 2006.
The paper reports on the project, its results in terms of numbers and socio-political profile of e-Voters, and its success factors. All three authors were directly or indirectly involved in the project from the beginning and are currently working on the deployment of Geneva's e-Government platform (Sandoz 2005).

Keywords: remote e-Voting, direct democracy, project success factors.

1. Introduction

Switzerland is a federal State composed of 26 cantons and some 2800 communal constituencies. The political system is a three-level stack where a legislative body (i.e. parliament) and an executive body (i.e. government) operate at each level. With respect to political rights, cantons enjoy a large autonomy. Rights defined in the federal Constitution must be implemented in all cantons, but each canton defines political rights and procedures on its own as far as the two lower levels of authority are concerned. Over the past years, political rights at these levels have been extended to Swiss citizens living abroad and to foreign residents, but not everywhere alike nor within the same scope.

If enough citizens sign up in support, authorities can be challenged anytime by the call of a referendum on any legislative or constitutional object. The number of signatures needed varies from a few hundred at the local level in small communities up to 100'000 to call for an amendment to the federal Constitution. Because Swiss politics is pretty active, citizens vote every three to four months.

This is an ideal situation to develop a remote e-Voting system and reach out to the voter all the way home, because there is a real need to entice over-solicited citizens to vote. Moreover, the granularity, locality and frequency of voting enable to deploy a new system incrementally (Auer 2001).

The Republic and Canton of Geneva has a long tradition of innovation and dynamism in the practice of democracy. In 1982 the government and the parliament passed a new Law on the exercise of political rights, whose article 188 allows the testing of new voting methods in cantonal or communal matters "to adapt the exercise of these rights to the possibilities offered by technology".

That article delegates a limited legislative authority to the government, letting it define and implement new ways of voting if worthy. Taking advantage of this provision and the particularities of Switzerland's political system, Geneva has introduced voting through the Internet in a controlled manner.

The paper reports on Geneva's e-Voting project. Starting in the year 2001 the system went through a number of test trials and then through eight official votes between January 2003 and April 2005. In 2006 voting through the Internet will be examined by Parliament to determine if it can be permanently adopted in the canton as a complement to traditional voting methods.

Remote e-Voting is not a technical problem and cannot be solved using only standard technical procedures. It has more to do with a leap of faith into the unknown because it opens perspectives that do not connect to our experience. Like for most complex socio-technical systems, success owes more to a tightly controlled development process than to technology (Reira 2002).

In response to the question “How can e-Voting be made to work?” the paper examines project constraints (§2); project strategy, development and success factors (§3); how the system works, systems infrastructure and procedures and sensitive issues like security and scalability (§4); and finally marketing issues, test and voting results, and the socio-political profiles of e-Voters as measured after a vote on complex and hot issues in September 2004 (§5). The paper shows that the concept of e-Voting can indeed be made to work and that it reaches out to an important and stable body of voters as a comfortable and secure alternative to traditional ways of voting.

2. Project and system constraints

Building a complex socio-technical system is usually not a technical problem. Complexity can always become a project killer, but rarely stems from the technical side as long as standard procedures and quality insurance are respected. Even if 200’000 potential users share a dozen or more web browser technologies, it’s only a matter of linear complexity to comply with 80% of client platforms. The difficulty lies within the “socio” part, because one cannot build such a system without reaching out to users in the sensitive field of the exercise of political rights.

Thus the project must be kept under tight control: organization, strategy, momentum, maturity of the public, and public relations are key project constraints. They are dynamic and must be monitored; and project development must be adapted in response to changes in the environment. Strategy means to target benefits and identify project risks, to define approaches and to allocate or shift resources accordingly, and to stimulate the right sensors so the project moves on. Communication means to maintain a tight grip on quality, to be able to answer questions and to accept criticism, to publish and to correct errors, and to stay on course in the face of adversity. Any error with political consequences, not the least the failure of an official vote, could have delayed the introduction of e-Voting in Geneva for years.

The main system constraints on the other hand were easier to define and handle:

With the vote through the Internet, citizens are introduced to a third way of voting, complementary to ballotbox and postal voting (see §4 for a brief description). Each citizen is free to choose her preferred way of voting for each poll. The vote by Internet should not require any preliminary step or subscription. The democratic principle "one person - one vote" must be respected in spite of the diversity of channels. The first recorded vote is preserved. All possible later votes are discarded.

The process of voting must remain simple and easily explainable. The voter must also be able to verify that the system correctly understands his choice, whereas the vote must be kept secret with regards to third parties. The system must prevent the voter to make choices that can lead to the cancellation of a vote (for example choosing “YES AND NO”, or choosing more candidates than the number of seats available), while still leaving open the possibility to vote blank (Hensler 2000).

Globally, the system must be auditable and present a sufficient degree of transparency to satisfy controllers from all political parties. Systems execution must be logged in such a manner to reveal every tentative on fraud.

The system must be available 24h/24 and 7d/7 during the voting period of two to three weeks. Voting must not be possible before or after that interval of time.

From the technological point of view, the front end must be available on the largest possible number of home platforms covering at least 80% of the existing park.

Finally the system must remain the ownership of the Government : licensing fees per vote or per voter in any form are not to be considered.

3. The e-Voting project

3.1 Project strategy and systems development

Could remote e-Voting be established as a reliable and valuable way of voting on top of existing methods? Postal voting was generalized in 1995 and led to a consistent increase of 20% in participation. It showed that reaching out to voters responded not only to a need for comfort, but also

to a need for privacy in the act of voting. Based on this experience, the project sought to identify an untapped potential of voters and activate it in the democratic process (Trechsel 2005).

To take off, the project needed a solid legal basis, support, and partners. Once it was completed, the system was tested for functionality, reliability, security, and scalability in test trials with an increasing degree in complexity. This led to the first official vote in 2003 and seven more until April 2005 (see §5 for details). During this last phase of live trials, the votes were systematically measured and analysed, and reported to the public and political authorities (Geneva 2005). Now in its sixth year, the project is going through the legislative process.

Over the past 10 years, 95% of voters have come to chose postal voting rather than going to the ballotbox. So the project set out to realize the same procedure on the web, using the same techniques and evolution of standards as when banking orders migrated from the mail to e-banking and home purchasing migrated from catalogue orders to e-commerce.

At the start of the project, partnerships with specialized actors in the fields of cryptography, Internet transactions, technology, and sociology were established. Thus the project could progress based on external competencies and start transferring know-how inside the project organization in order to later be able to control the product and its evolution.

Finally, the Geneva project was one in three e-Voting pilot projects sponsored by federal authorities (solutions from Neuchâtel and Zürich first went live in votes in 2005 and remote e-Voting will be examined at the national level during 2006 and 2007). A delegate from the federal Chancellery took part in all developments. Specialists from the federal government and other cantons closely followed the project and submitted recommendations. Several audits and penetration tests were also ordered by cantonal and federal authorities (Geneva 2005).

During the trial votes, a crisis cell (composed of technicians, as well a political rights and a public relations specialist) stood by and could be called on 24h/24 if an operator set off an alarm. The cell reported directly to the State Chancellor who is Secretary of the government and constitutes a formal link between the government and the administration.

The first prototype was realized by two partners (Hewlet-Packard and Wisekey, who answered to an official call for tender (Hensler 2000). In parallel procedures were developed so as to integrate e-Voting to the two other official voting methods.

After the system had gone public (in the high school trial, see below) the project entered a cycle of incremental improvements: preparing a vote, certifying the system, running the trial, analysing results, establishing a priority list of points to treat, and starting over with the next operation.

With this method the project reduced the number of new features to a minimum at each trial and lowered risks. On the other hand, the cost of certification before every trial was heavy. In the future it will not be possible to run more than one complete cycle per year and each stable version of the system will have to be used five to six times before a new one is released.

3.2 Success factors

Of all the aspects described in the paper, we consider that the three main success factors of Geneva's project are :

1) politics were implicated at the highest level. The project was initiated and sponsored by the highest official in matters of political rights in Geneva, the State Chancellor. A strong personality, very much opened to modern information technologies, Mr. Robert Hensler constantly kept the government informed on the project, prepared the main decisions and regularly briefed representatives and political parties, checking that the project correctly responded to what politics and the people wanted and helping gain acceptance.

2) the approach went step by step. The significance of trials was gradually increased along two dimensions : the number of potential voters concerned and the stakes of the votes. This method enabled the project to manage risks and harness the increasing pressure by systematically building on an accepted success before going the next step. Starting with no stake at all in a tiny

dummy electorate (a blank vote executed by a few hundred government employees) the size of the target electorate was increased until it reached 12'000 high school pupils. Only then were the stakes incremented to a unique political question (financing the facelift of a public building) concerning 1'200 voters in the small town of Anières. Maintaining the stakes to one question at the communal level, the electorate was then gradually increased to 9'000 (see Table 1), before the stakes were once again increased to cantonal and federal questions. The last test implied an electorate of almost 90'000, which represents half the voters in the canton (the other half being composed by of the city of Geneva which has to be managed as a whole). The next steps will be concerned with elections, again increasing the stakes, but starting again at the lowest levels of authority to gradually reach the level of federal elections.

3) teams were multidisciplinary. The questions relative to remote e-Voting were treated under many facets by experts in specific domains: legal basis and questions related to democracy and legitimacy, by the Law faculty of the University of Geneva; protection of personal information and of privacy, by an attorney specialized on these questions; security by experts from CERN and Geneva's university hospital; sociological aspects by the University's Center for study of direct democracy; systems reliability by an ethical-hacking company; organizational questions by the government's own specialists on political rights; technical problems by the administration's computer specialists and their partners; etc. These approaches being complementary in many respects, the pitfall of building a system solely out of technical considerations was avoided.

4. The e-Voting system

4.1 Voting through the Internet

The principle of postal voting is the following: a few weeks before a vote, each voter receives a voting card at home along with documentation on the vote and a number of ballots to fill in (or voting lists to choose from). Voting cards are used for only one vote. The voter either takes the card to the polling station on election day, hands it over to an official and votes at the ballotbox; or she sends the card back in a prepaid envelope along with a second, sealed anonymous envelope containing her ballot.

For the purpose of remote e-Voting, voting cards were adapted. The new card contains a unique 16-digit number allocated to the voter for this unique vote, a 4-digit control key, and a 6-digit secret code hidden under a scratch-away opaque layer. If the layer is scratched away, voting in any of the other two modes is no more possible, as the card is then visually controlled by a human operator.

The electronic vote proceeds in two steps: (1) establishing a valid ballot (NB: which is not guaranteed by traditional voting modes); and (2) casting the ballot. In step (1) the voter types the 16-bit number on a dedicated web-page. The server checks this frame and establishes that the general conditions on the vote are met (valid date, frame not forged, etc.). If this is the case, the server sends the 4-digit key back to the voter as a low-level immediate self-authentication and proceeds to construct the appropriate electronic ballot (for elections, ballots are different from one municipality to the other). A protected connection is established between the voter and the ballot. Once the ballot has been filled in, the voter proceeds to step (2). The server invokes the electronic ballotbox over a protected gate invisible from the Internet. This second server authenticates the voter using the secret hidden code (something the voter has) and some information specific to that person (something the voter knows) the voter has to type in. Once this is checked, the voter can deposit the ballot. If this step is successful, the transaction commits, with three effects: the voter is registered as having voted, the ballot is stored in the e-ballotbox (no link to the voter is kept there), and a confirmation (date and time of vote's registration) is sent to the voter online. Any time before the vote closes the voter can check this information online by typing in the 16-digit code back to the server.

Producing the vote's results requires the presence of controllers delegated by the political parties. Each controller has a private key that must be typed into the counting server so that the ballots can be deciphered. The server then produces two results: a file containing the detailed results of the vote per circumscription; a file containing anonym information on the voters (gender, age, way of voting, date and time of the vote) which is then sent to the bureau of statistics for a detailed analysis. After legal validation, information concerning the vote is stored for 50 days and then destroyed.

4.2 Infrastructure

The basic infrastructure is composed of three parts : network infrastructure, server infrastructure and monitoring system. The network infrastructure was designed to protect the database servers that manage the electronic ballotbox. The servers are protected by several layers of firewalls and cannot be accessed directly from the Internet.

Database servers are redundant and automatically replicated, thus guarantying that relevant information is always stored twice in database tables and twice in database logs. Using database processing technology guarantees that transactions either run to commit or abort without updating any information on the vote or the voters' registry.

Application servers conduct the dialogue with the voter and manage the voting process. They are replicated with load balancing and automatic failover. The operating system is designed to run protected applications on the Internet. It manages two separate compartments, one containing an Apache web server and the other containing a Tomcat application server. It controls communication between the two services. This schema protects the database servers running in the background better.

The monitoring system controls the functional infrastructure and is itself redundant. It controls the front page of the voting system against any attempt to modify its looks or contents. Monitoring system operators are connected to a crisis cell that can be activated if any alarm is set off.

4.3 Security

The system's security specification was defined by 11 criteria (COE 2003): votes must not be intercepted, modified or diverted; the contents of a vote must not be knowledgeable to any third party before the counting procedure; only persons enjoying the right to vote can participate; each voter has only one vote and can vote only once; it must never be possible to connect a voter and his/her vote, even during the counting procedure; the system must be able to resist denial of service attacks attempting to saturate the voting server; voters must be protected against identity theft; the number of votes emitted must be equal to the number of votes received, any difference must be clarified and corrected; it must be possible to prove that a voter has voted; the system accepts votes only within the interval of time during which e-Voting is open; and finally, assigned authorities must be able to verify that the system works correctly.

However, a secure e-Voting system must achieve an optimal trade-off between security of the procedure and user comfort. So Geneva's concept takes a layered approach to security, introducing different techniques and technologies to guarantee both secure and simple usage.

- e-ballots are encrypted by randomly mixing alphanumerical characters to their content. Anyone who would get hold of the ballot (a very improbable occurrence) would see only a meaningless series of numbers.
- When the ballot is returned to the voter for confirmation, a picture is woven in to make it still more difficult to read. This image is generated using the unique voting card number and is printed on the card so the voter can compare and check that he isn't connected to a counterfeit site.
- The voting card also reproduces the voting server's digital certificate's finger print.
- Voters' identity and ballots are kept in two distinct files.
- Voters' identity is anonymous (no names in the system).
- Before opening, the content of the electronic ballotbox is "shaken" by applying an algorithm to change the order in which the e-ballots will come out. This impedes any matching of the entries in the voters' register with the e-ballotbox, which could allow a cross reading (who voted for what).
- All hardware elements are configured to only react to the queries consistent with a normal voting procedure.
- Servers are connected to the network only during the votes.
- Infrastructure is redundant and data is stored twice.
- The servers are located in a safe room, only a few operators (having undergone a security inquiry) can access them, never alone.
- Representatives of political parties cast a number of "test votes" in a "test e-ballotbox" and record them aside so they can check that the system yields the expected outcome.

4.4 Scalability

Specific peak and load tests were conducted. Several hundred front ends were used to simulate a peak load of more than 50 times the estimated mean load for a vote in the whole canton (calculated on the basis of 220'000 voters, 15% using remote e-Voting over an interval of 10 days). After the first test run showed that the infrastructure's capacity was just sufficient to support these peaks a new infrastructure with tenfold capacity was deployed. The new test established the ability of the system to support peak loads during the evening or the weekend.

Finally a vote was organized for the European council, concerning 30'000 pupils in all of Europe's countries during two weeks. With more than 50% participation, this trial showed that the system could support heavy loads in real circumstances and that it was able to register votes coming from places faraway from the canton' territory. This is important in view of extending e-Voting to Swiss expatriates.

5. Results

5.1 Marketing strategy

Before each trial voters received an explaining notice and could call a dedicated helpline. Operators would only answer questions on the voting procedure (not the vote's object). Incidentally, many questions concerned the general voting procedure and not only the e-Voting procedure.

Before each of the first seven trials, a public conference was organized with the participation of the State Chancellor who answered questions. The participants could also simulate a vote on personal computers located in the conference room.

For the same purpose, PC's were installed in the town hall and main commercial malls of each commune concerned by a vote. Trained personnel answered the public's questions. During the voting period, advertisements were posted and every voter received a recall. The government's web site indicated the number of received postal and electronic votes daily. For the eighth vote, only the recall and the helpline were maintained: e-Voting had been well publicized and many people in communes not concerned called to complain and ask why they were being kept out.

The physical presence of officials and personnel was much appreciated, especially from women and from people over 50. The information campaign was adapted accordingly. We proved that eGovernment could be an integration factor and did not contribute to the digital divide: tens of people used the Internet for the first time to try e-Voting and benefited from the support provided.

5.2 Trials

Table 1 shows the participation results of the eight official votes. It seems that the number of e-Voters diminished over time. In reality, large communes have a larger proportion of older citizens who vote more in general but vote less using the Internet. The first result (44%), due to the hype in the news media, was exceptional. The more realistic and stable ratio of 20% to 25% of e-Voters was in itself a success, since only 10% were awaited initially. A majority of e-Voters always voted like the majority in the global vote, thus strengthening the vote's results. A more detailed analysis of statistical results is given in the following paragraph.

5.3 Voters' socio-political profile

For the September 2004 ballot, the objects of the vote were four federal referendums on politically sensitive questions and two cantonal referendums on technical questions. After the vote, Geneva University (EDC 2005) conducted a survey on a sample of 1014 citizens living in the municipalities where e-Voting took place. In all four towns, online voting had already been used at least once before.

The sample was established using the quota method, respecting the voters/abstainers ratio (abstainers were included in the sample). The raw results are consistent with previous studies realised using online questionnaires at the end of the voting procedure. For the first time, however, the study conducted on the September 2004 vote offered a comparison of socio-political data between abstainers, polling station voters, postal voters and internet voters.

Table 1: Results of the 8 official votes where the e-Voting system was used

Date	Place	Questions	Number of voters	Participation	Of which of e-Voters
7-18.01.03	Anières	1 communal	1'162	64%	44%
17-29.11.03	Cologny	1 communal	2'521	59%	29%
2-17.04.04	Carouge	1 communal	9'049	44%	26%
28.05-12.06.04	Meyrin	3 communal	9'180	39%	22%
3-25.09.04	Anières, Carouge Cologny, Meyrin	4 federal 2 cantonal	22'000	57%	22%
8-23.10.04	Vandoeuvres	1 communal	1'382	60%	32%
5-27.11.04	Total of 8 communes	3 federal 2 cantonal	41'200	41%	22%
9-23.04.05	Total of 14 communes	8 cantonal	88'000	44%	20%

Turnout: the study reveals that nine out of ten voters who had already voted online did so in this vote. Online voters come massively from postal voting: 17% of the regular postal voters chose to vote by internet. The first effect of internet voting was thus to decrease the share of postal votes.

Given the issues at stake, the overall turnout was very high for this ballot. A majority (55.5%) of persons who describe themselves as regular or quasi-regular abstainers and who voted this time chose the Internet (the average of online votes is 21.7%). The online turnout of citizens who declare voting only occasionally was also higher (30.8%). These results are however not significant because comparable data (communal ballots in the same municipality with and without internet, or a series of cantonal and/or federal ballots in the canton) is lacking.

Socio-demographic variables: when trying to match socio-demographic variables and the choice of voting online, only the variables for age and income pass the significance threshold and contribute to explain why e-Voters prefer the Internet to other ways of voting. Results: (1) the younger one is, the more one will use Internet voting; (2) the higher the income, the more one is inclined to vote online.

Voters' gender and level of education do not play a significant role, when matched with age and income. The model doesn't however cover all responses to the question "Why does one use internet voting?" The socio-demographic model doesn't yield the key to why one votes online and its global explanatory value is weak.

Political identification: political identification doesn't provide a better explanation for the choice of e-Voting: it is used by citizens of all political horizons without exception. Two small bias appeared: voters from the ecologist party used e-Voting the most; inversely voters from the right-wing populist parties used it the least but without ignoring it. The proportion of online voters among sympathisers of the other political parties is practically constant.

e-Voting and IT factors: a better clue came from the IT related questions. There's a strong and statistically significant relation between internet voting and the subjective level of IT skills of the sample's members. Internet voting is the preferred voting method used by those who judge their IT skills to be excellent. The more voters consider themselves to be IT competent, the more they trust e-Voting. IT skills affected the postal vote and e-Voting, but neither the outcome nor the abstention rate.

The use of e-Voting was also proportional to the frequency of Internet usage. Those who go online on a daily basis have an equal probability of using either Internet voting or postal voting.

Conclusion. When the socio-demographic, the political and the IT models are combined in a multivariate analysis, the significant effects shown in the socio-economic and demographic models disappear. Neither age nor income had any influence. However, the effect of income was almost statistically meaningful. The political variables appear equally irrelevant in the voters' choice.

6. Conclusion

Technically, the introduction of remote e-Voting is serious project work. Many issues must be carefully examined. Multidisciplinary teams composed of specialists in law, political rights, public relations, government, security, and computer science are necessary. A strong support from the government and political authorities is necessary to make e-Voting a success.

The drivers of Internet voting seem to be neither age, nor gender, income, level of education, political affiliation, but variables which were called "data processing": confidence in working with the Internet and in one's own computer skills. Once a voter tries e-Voting, that person tends to stick to it.

The three voting channels, polling station voting, postal voting and Internet voting, are politically neutral. In other words, it is impossible to guess a voter's political choices on the basis of the voting channel he or she chooses.

Remote e-Voting does not appear to be a marker pen, which would differentiate users and non-users on the basis of social status. It is a personal choice and an indicator of a way of life in which information technologies are, or are not, a central theme.

Reference

Auer, A. and Trechsel, A. H. (Eds) (1999) *Voter par Internet ? Le projet de e-voting dans le canton de Genève dans une perspective socio-politique et juridique* Helbing&Lichtenhahn, Genève-Bâle-Munich.

COE (2003) "Code of Good Practice in Electoral Matters, Recommendation 1595" [online] Council of Europe, http://assembly.coe.int/Documents/WorkingDocs/DOC03/EDOC9978.htm

EDC (2005) "Analysis of the 26th September 2004 ballot as held in four Geneva municipalities" [onlibe] E-Democracy Center, http://www.geneve.ch/evoting/english/doc/rapports/rapport_26sept_english_final.pdf

Geneva, State of (2005) "Different views of e-Voting. The Geneva Internet voting system" [online], http://www.geneve.ch/evoting/english/presentation_projet.asp

Geneva, State of (2005) "e-Voting project reports" [online], http://www.geneve.ch/evoting/english/rapports.asp

Hensler, R. (2000), "Invitation to tender", [online], State of Geneva, http://www.geneve.ch/evoting/english/cahier_charges.asp

Riera, A., Sánchez, J. and Torras, L. (2002) *Internet Voting: Embracing Technology in Electoral Processes*, Electronic Government: Design, Application and Management (ed. Gröndlun A.), Idea Group Publishing, London, pp 78-98.

Sandoz, A., Haenni, N., Eudes J.-R. (2005) *Addressing and protecting distributed resources in e-Government architectures using multiple digital identities*, ECEG'05, Antwerp

Trechsel, A. H. (2005) "e-Voting and new forms of e-participation in Europe and Latin America" [online] European University Institute, Florence, Italy, http://www.coe.int/t/e/integrated_projects/democracy/Presentation_Trechsel_Tunis_2005.ppt