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An electronic voting service to support decision-making in local government

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Abstract

This paper presents details of a web-based, database-oriented "electronic voting service". Rapid world-wide growth in Internet and Web use has stimulated many initiatives aimed at applying information and communication innovations to create what has been called a "digital" or "electronic democracy". Internet voting is already widespread in a variety of forms, some serious, most not. A new set of opportunities is offered to facilitate closer links among citizens, between citizens and politicians and direct democratic participation through online voting and interactive polling. Local government decision-making procedures can be enhanced by the application of a electronic voting service to evaluate citizens' responses to certain issues and to canvass the possible solutions they have in mind.

The main characteristics of this electronic voting service were developed on the basis of strong lengthy experience of and a good deal of consultation with local authorities. This interaction revealed a demand for an easy to use (for novice users) and administer tool, low cost with a minimum set of security mechanisms, but still able to provide valid results. The systems services were planned and implemented to be easily expandable. The application is based on state-of-the-art software platform, integrating WWW and database. The system aims to become a pilot for implementing efforts to support on line voting procedures. The service provides the capability to create a questionnaire/poll, view the subject and participate in the voting procedure. Only authorised users can use the system to vote or create a questionnaire. All users can view results from previous voting procedures.
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1. Introduction

The explosion in popularity of Internet and the existence of tools such as the World Wide Web (WWW), and various Internet applications, like web browsers, make the Internet readily accessible even to novice computer users. Moreover, the WWW has proven itself to be a cost effective means of providing information sharing and exchange.

The introduction of information technology has been set as a major goal for the Governments of Europe under the eEurope initiative and action plan (eEurope Initiative "An information society for all", 2002). The application of digital technologies has become a vital factor for growth and employment in the 'new economy', mainly driven by the Internet. In spite of Europe's lead in certain digital technologies, e.g. mobile communications and digital TV, the uptake of the Internet in Europe remains comparatively low. The success of the new economy will also depend on the ability of consumers and citizens to take full advantage of the opportunities on offer. A more effective use of the Internet can give a better and easier access to public sector information for European citizens and businesses. Better public information online would make the Internet more relevant to daily lives and so boost the number of Internet users and encourage wider participation in the Information Society. A lot of work has been done both by the member States and European Institutions to set up Web Sites and provide citizens with online access to government information. More will be done to make these sites easy tools to access information and to interact with government services, while respecting the EU standards on data privacy. The eEurope initiative aims to make public information more accessible by extending and simplifying Internet access. This action has the potential to bring government services closer to the citizen, reduce government expenditures by limiting bureaucracy, create new jobs and so on.

Every new information and communication technology seems to generate proposals for applications in politics and governance. Rapid world-wide growth in Internet and Web use has stimulated many initiatives aimed at applying information and communication innovations to create what has been called a "digital" or "electronic democracy".

A democracy based on citizen participation in decision-making procedures will always be an articulated goal for social units, like localities, whole states or even communities of nations, but the promise is not always matched by the practice. Nowadays the reality of the "Information Society" and of the globalisation of which it is a part, potentially affects conventional ways of taking decisions, with new modes of citizen interaction permitting the public to take part in decision-making procedures (Berhel, 2000; Dutton et al., 1999). The inclusiveness of decision-making processes are central to the quality of democracy because they should perform expressive functions, not just produce decisions through an instrumental, if efficient, process.

Proponents of electronic democracy, suggest that democratic governments and organisations can exploit the wide range of technological capabilities provided by Information and Communication technologies to facilitate closer links among citi-

zens, as well as between citizens and local authorities. Traditionally, elections have served as the official mechanisms for people as citizens to express their views to government, while surveys have augmented elections as unofficial—but in often valuable—measures of public opinion (Cranor, 2000).

In recent years there has been growing interest in the impact of Information and Communication technologies on the conduct of governance and the quality of democratic life (Key, 1996). Local governments, rely increasingly on the monitoring of public opinion as part of the management of their own visibility and as a way of providing tailored information about aspects of policy and the policy process. Most applications linked to establishing electronic democracy over the internet start life, at least, as efforts to support existing systems of representative democracy. What we have learned from trying to build real life applications is that the technology involved must be easy enough for anyone to use it, while maintaining both the perception and reality of privacy for any users.

Democratic governments and organisations have available a variety of mechanisms for canvassing the opinions of their members. The application of information technology has augmented these techniques as unofficial but nevertheless valuable measures of public opinion. Public opinion canvassed in these ways can be used as a basis for planning and development. On the other hand, traditionally, elections have served as the official means for people to express their views to government, most obviously by effecting the ultimate democratic sanction of endorsing or rejecting candidates for office. Election procedures need strong authentication and verification mechanisms and this becomes even more critical when elections are conducted online.

An *Internet or Electronic Voting System* is defined as an election system that uses electronic ballots that allow voters to transmit their vote to election officials over the Internet. The provision of electronic voting via the Internet may still be some way off, but the various pieces of the technology puzzle needed to make it a reality are now close to being in place. In fact, Internet voting is already widespread in a variety of forms, some serious, most not. It is technologically possible to utilise the Internet to develop a novel method of voting that would be at least as secure as the current ballot systems in use. A new set of opportunities is available to facilitate closer links among citizens, between citizens and politicians and to facilitate direct democratic participation through online voting and interactive polling.

Actual advancements in developing democracy—and e-democracy in particular—are based on the efforts of national, regional and local governments and also non-governmental organisations (NGOs) and civil movements operating at different levels of governance. The UK is a good example of this trend, and has influenced all of the Europe by its Modernising Government Agenda (Modernising Government, 1999). In 1998, the British Government set up the People's panel where 5000 citizens were randomly selected for regular polling and focus groups. The panel is designed as a representative cross-section of the population of the UK. Members of the public are consulted about how public services are delivered and how that delivery can be improved from a user-centered point of view. Citizen panels and citizen juries had been in use for years in local government, but this was the first scheme of its kind

operating at national level. Because of the local authorities' widespread responsibilities in service provision, a considerable part of the development activities are directed to improving service delivery systems through the participation of citizens. A good example of NGOs is the UK-based Institute for Public Policy Research (Becker and Slaton, 2000), which is furthering the development of new ways of involving the public in decision-making through the practical development of new models for citizens juries, deliberative polls, consensus conferences, citizens panels and electronic meetings.

Despite the increasing complexity of local politics the application of digital technologies to organisational problems and communications strategies has been patchy. Communication is a central activity of politics and of the role of government, playing a vital part in the quality of decision-making (Artenton, 1987). The quality of decision-making itself depends on the evaluation and acceptance of new ideas and the utilisation of new tools with which to tackle perennial and new problems of resource delivery. Arguably, the involvement of citizens in this process of identification–evaluation–decision and delivery should be a routine part of how local authorities behave as democratic organisations. In reality the prescribed and appropriate intensity of citizen participation and the means whereby their views can be elicited, remain sensitive areas of debate. Often, local governments (and national governments too) opt for low-key and low cost mechanisms aimed at utilising public opinion as an input to the policy process, or as a legitimation of decisions already taken. Sometimes, they will adopt deliberative procedures as a part of this process and as a means of raising political awareness about an issue. Interactive acommunication is central to all these aims and functions. Whether as a policy resource or as a means to raise the stocks of political competence, politicians need awareness mechanisms that provide information about what different stakeholders in the policy arena are thinking, discussing and doing.

Of course, a range of conventional mechanisms and procedures are at hand. Political and administrative matters are discussed extensively over the telephone, at occasional public meetings, in non-political forums or when politicians and citizens meet in the course of daily life. The result is a loosely defined network of interaction operating alongside the formal consultative procedures and alongside elections. Politicians discuss forthcoming issues within and across their political parties, within the local administration, to various interest groups and with fellow citizens. In much of this discourse, the ordinary citizen remains, at best, an interested outsider.

Although observed variably, it is often held that todays' democratic process suffers from the low participation of citizens. Although the percentage of people participating in local or national elections is quite high in Greece, the participation of citizens' in the day to day process of governance is very low. The application of voting schemas for collecting citizens' opinions through surveys at any time, from any place and without limitations, may well stimulate the awareness of people and increase their involvement in decision-making. These are contested issues, but certainly one of the powerful claims about raising voter and citizen participation is the argument that people would be more engaged with politics if politics were more accessible to them. In other words that voter participation and civic engagement will

increase if people could easily cast votes from computers in their homes, offices, schools, libraries and kiosks, and interact with government on a routine basis using the same means.

Our argument is that local government decision-making procedures can be improved and democracy better served by the application of an online voting tool to evaluate citizens response to issues. Through such a voting service the decision makers can highlight the most important problems for citizens perhaps in a hierarchy, they can also evaluate the possible the acceptability of any solutions they have in mind.

Electronic surveys improve everyday contact between citizens and local authorities and amplify active citizens' participation in the routine conduct of governance. As a "top–down" device, the scope and intensity of interventions by the public remains a potentially vexed question, as does the matter of which actor or group of actors is able to initiate the process. That said, the need for such applications has grown because of the increased requirements to encourage even more citizens' participation in the reception of decisions. An appreciation of public opinion in certain policy areas (environment, culture, etc.) is important for every local government for use in designing and planning actions which will impact on people. Public opinion should be taken account in every action planned by local authorities and especially the ones that affect a major part of the community. The ability to collect and evaluate opinions can save the administration from acting precipitately.

Such systems can be used to collect citizens' opinion on all manner of issues. Accredited citizens can participate in the procedure by adding their ballot on a specified voting subject. After the ballot the validity system extracts the final results and the local authorities can determine their stance, pronouncement or policy through reference to public trends. To reiterate, the system must be easy enough to be used by non-experienced users and capable of being used across any geographically dispersed area.

The rest of the paper is organised as follows: in Section 2 we present the main characteristics of electronic voting systems. In Section 3 there is a short description of the specific characteristics of our service. Section 4 contains a system analysis, where the specifications of the system are presented, and where we reflect on system design, system architecture and specific implementation issues. Finally we describe in detail the main functionalities offered by the system. The last section presents inferences from our work and future work to be undertaken.

2. Electronic voting systems

While there has been a lot of research on electronic voting systems, there is not much software available that can be purchased or downloaded for use in running an election immediately. A number of systems have been developed and are used run an elections for NGOs. FREE (Free Referenda & Elections Electronically (The FREE e-democracy project, 2003)) is designed to make an easy and secure job to run an election or referendum and it is an open source system for conducting electronic

votes. VoteBot (Coding VoteBot, 2002) is a system that offers decision-support for dispersed communities. It offers starting a poll, a survey or an election for free. The basic service is free, the technology is easy to use and the service is flexible, trustworthy and secure enough to be useful.

EVote (Chelma et al., 1997) is a system that allows members of an email list to poll themselves. Any list member can initiate a poll, vote and receive a receipt for his/her vote and change or remove the vote while the poll remains open. At the same time he can find the polls in progress and the statistics in a separate list, find out how someone voted and carry on a discussion with other list members as usual.

True Ballot, Democratic Governance Systems (Automated Election Administration, 2002) does not offer online access, but supports an electronic voting booth, vote-by-mail, and vote-by-phone for use in non-governmental elections. The Italian Academic Community (Bonetti et al., 2000) voting system is a simple voting system to support voting in common matters for the Academic Community. There are also many Services Vendors that offer voting equipment, which is designed for special purposes and has very small capabilities.

Some attempts to introduce voting technology have been reported by local governments trying to replace their old voting systems. Kai R.T. Larsen presents some lessons from the application of voting technology in local government (Larsen, 1999). Voters in a voting system which does not perform ideally still get accustomed to a certain level of service and find it difficult to adjust to a different service leading to errors and a reluctance to participate. User populations must be taken into account in any voting system to be designed since the voter population usually includes people with little or no computer experience. Privacy is considered an important issue and any technological solution is expected to maintain the same level of privacy of traditional election systems, or else any real or perceived threat to a voter's privacy will lead to extensive negative publicity. Failures receive much attention and must be avoided. In any case we must keep in mind that any change to voting procedures tends to raise resistance from those who benefit most from the status quo. These are salutary warnings for the designers of online voting systems.

A number of experimental voting systems have been developed to support actual voting procedures. Vivarto Voting System (Vivarto NetConference Plus, 2000) is a system which aims to combine efficiency, democracy and expertise in governing large organisations with the help of modern information and communications technology. The primary innovations are the so-called Vivarto Representative System (a very advanced proxy voting system), and the Vivarto NetConference Modules (a new, powerful, easy to use, communication structure based upon the adoption of different rating scales, multi-level conferences, statistical analysis and intelligent display of results). Sensus 0 employs a three-stage protocol in order that the vote gets tallied and presumes the use of a public key system for all voters. The system was developed in C and Perl and makes use of CGI scripts. E-Vox is a secure electronic voting system developed by the MIT Laboratory for Computer Science and Cryptography and Information Security research group. This research is supported by DARPA contract DABT63-96-C-0018, "Security for Distributed Computer Systems" and by NTT and is based on the work done under that contract. A second version of the

EVote system (Project: eVote(R)/Clerk, 2003) has been created which uses multiple administrators for vote signing and aimed at improving security by preventing the administrator from forging votes. In Davenport et al. (1995) and Vivarto NetConference Plus (2000) secure web-based systems developed for undergraduate student elections are presented.

The characteristics of a good electronic voting service/system depend on the purpose for which the system will be used. When designing an electronic voting service, it is essential to consider ways in which the voting tasks can be performed electronically without sacrificing voter privacy or introducing opportunities for fraud. A system that will be used for effecting national or regional elections that is combined with the traditional voting process (where the identity of a voter is established though visual and documentary means), ensures democracy. Thus no extra authentication mechanisms are needed.

So the need is to develop a set of general system attributes that are desirable in most situations where online voting would be applied. The most common desirable attributes for an "ideal" electronic voting include Cranor and Cytron (1997) and Fujioka et al. (1992):

Accuracy. A system is accurate if (1) it is not possible for a vote to be altered, (2) it is not possible for a validated vote to be eliminated from the final tally, and (3) it is not possible for an invalid vote to be counted in the final tally.

Democracy. A system is democratic if (1) it permits only eligible voters to vote and, (2) it ensures that each eligible voter can vote only once.

Privacy. A system is private if (1) neither election authorities nor anyone else can link any ballot to the voter who cast it and (2) no voter can prove that he or she voted in a particular way.

Verifiability. A system is verifiable if anyone can independently verify that all votes have been counted correctly.

In addition an electronic polling system should possess the following properties aimed at ensuring a high voter turnout, something that is often desired but not always achieved.

Convenience. A system is convenient if it allows voters to cast their votes quickly, in one session, and with minimal equipment or special skills.

Flexibility. A system is flexible if it allows a variety of ballot question formats including open-ended questions.

Mobility. A system is mobile if there are no restrictions on the location from which a voter can cast a vote. One of the reasons people are interested in electronic voting systems is that they can be mobile. The mobility property on the other hand is a major contributor to some of the problems associated with designing a secure and private electronic voting system.

All systems try to address most of the properties above with their main emphasis on providing a secure and private electronic voting system. In both surveys and elections, privacy and security are usually desired, but not always simultaneously achievable at a reasonable cost. Mechanisms that ensure the security and privacy of an election can be time-consuming and expensive for election administrators and inconvenient for voters. Conducting secure and private elections can become even

more difficult when voters are geographically dispersed. Electronic voting over the Internet is convenient for voters even if they are geographically dispersed, through a simple computer.

In their attempt to ensure all four "core properties", the systems noted above apply complicated mechanisms requiring extra software for the client and the adoption of a complicated user interface. The systems are still complicated to administer and difficult to use even when some properties are relaxed (allowing only the detection of errors on counting votes as no automatic cross-checking can be done).

At the same time electronic surveys—in order to constitute a useful tool—must be inexpensive to administer, ensure privacy and security to an acceptable level, be easy to be use by novice users, and be without any extra HW or SW requirements. They should also provide mechanisms for interpretation of the results.

Some exigencies are easier to meet than others. For example, a common process can be used to determine who is eligible to vote. This may involve a formal registration period or an announcement that anyone who is a member of a certain group at a certain time may vote. Once the voting procedure begins administrators may validate the credentials of those attempting to vote by asking voters for identification cards or passwords. After validating each voter, the administrators collect the completed ballots and these are tallied to determine the election result.

3. Specifications of the system

Local authorities often lack the possibility to consult public opinion efficiently and quickly on matters that are of interest to the whole community. The traditional way to measure public opinion is to conduct surveys. A survey is a systematic, scientific and unprejudiced way to collect data. You can survey a group or a sample of people about their feelings, plans, opinions, beliefs and personal, educational of financial background. Surveys are used by many different kinds of organisations and the data collected by surveys can be used to enhance communication, report on attitudes, increase involvement, and determine and social and other needs (Welcome to Infopoll, 2002).

Electronic polls are now commonplace all over the WWW. With a few clicks anyone can express their opinion on a variety of important and not-so important issues, vote for his favourite Web sites or add ratings to the running average for one of several thousand movies. Very few of these polls are designed to maintain the levels of security and privacy that we come to expect from governmental elections, surveys or even polls. The use of such simple polling systems to gauge public opinion for local administration and planning is prohibited, since they do not offer enough security mechanisms. While for instance some these Internet polls take precautions to prevent people from tampering with the ballot box, they generally do so at the expense of voter privacy. On the other hand they can not ensure that someone votes only once, because the identity of the voters remains anonymous.

At the same time setting up a strict electronic voting system to support the voting process is problematic due to the following:

- The assignment of credentials is difficult due to the fact that the list of eligible voters in national elections includes a large number of people who vote at a specific municipality but are not resident there. The application of other identification mechanisms is considered too expensive (for example, the use of smartcards). In order to conduct a survey we do not need all citizens to vote but just a sufficient and properly constructed sample of the eligible voters.
- Most of the citizens are not familiar with information technology applications thus any system has to be easy to use.
- A general authorisation procedure will be applied to all applications developed. E-voting is part of a Municipal Information System developed and available through the Web. The system offers a number of applications where an authentication procedure is needed and different interfaces would be confusing.
- The main aim of the system is to provide both the administration and the public with a policy tool for government, which will facilitate the canvass of public opinion.

The electronic voting service we have developed had to meet the following objectives:

- Public participation in the political process will be enhanced through encouraging citizens to exercise their right to vote on common matters and public concerns through an efficient, easy to use and up to date Internet based mechanism.
- Decision-making will be enhanced though the application of a Web-based tool to survey public opinion.
- The voting procedure will ensure valid and accurate results while adhering to minimum privacy and verifiability properties.
- The system will be capable of providing minimum statistical processing capabilities using a representative percentage of people within the bounds of a local authority area.
- Participation in the voting process will enhance the familiarisation of citizens with modern technology.
- Citizens will be able to maximise their political intervention by posting surveys for specific subjects and argue with the decisions of local authorities.

The specifications of the service were reviewed by local administration officials keeping in mind the above objectives (Bouras et al., 1998, 2000). As a result of this procedure the following characteristics of the system were derived:

- The user must fill in a form supplying all identification information. This information could be used to ensure the identity of the physical person behind the username and password.
- No authority would be able to link a vote to a specific voter. A simple mechanism would be developed in order to ensure anonymity.
- Low cost and accessibility from a wide range of media (infokiosks, Home PC etc.). No extra client software would be needed.

- An easy to handle voting procedure. For this reason closed questions to be used. Closed questions include yes–no questions or questions that ask respondents to choose from a range of answers. This choice was based on the advantages offered by the use of closed questions, that is: easier and quicker for respondents to answer, answers can clarify meaning of the question for respondent, easier to compare the answers of different respondents, produce in fewer confused or inappropriate answers to questions.

In order to confront the above issues as the whole a web-based database-oriented, information system has been designed and implemented offering a set of interesting features. It includes:

- User administration for poll creation. The system is provided with a poll generation mechanism which guides the administrator through the whole poll set up process. The (authorised) user can create any number of close-ended questions per poll using already existing templates, thus avoiding form designing or programming. Any number of polls can be created and the last poll created will be enabled automatically. The polling period is user defined and the system is set up to maintain the poll and gather the results.
- Results of preview polls are also available for further examination. After a poll expires the data are stored and can be used for review purposes. All statistical data gathered are also available for review.
- Data Source Name connection to the database.
- The system satisfies most the properties for election systems. The system is verifiable, allowing users to verify their own vote without sacrificing privacy. No one can link any ballot to the voter who casts it and no voter can prove that he or she voted in a particular way.
- The system is designed and implemented assuming no predefined set of voters. The system dynamically corroborates and updates the information on eligible voters through a registration process. Each time a user uses the system his personal data are compared against the registered users. The system is designed to allow the use of predefined set of voters (voters database).
- Voters are provided with a simple mechanism to communicate with the administrator in order to send comments or questions about a specific poll or to inform him about his intention to set-up a specific poll. The administrator replies answering the citizens' request.

4. Architecture of the application

4.1. System analysis

The system specifications where derived from an extensive process of discussions with the responsible people of different kind of local authorities in Greece. The main objective was to obtain the basic requirements of such a system (Bonetti et al., 2000).

The specific service can be accessed only from authorised users and the system administrator. A user must follow a registration procedure in order to become an authorised user of the system. The user fills an electronic registration form where he gives his personal data (name, surname, address, telephone number, id-number, e-mail address) and a username and password. The personal data allow the voting authority to contact the specific person and verify his participation or not in a specific voting procedure. The system checks the uniqueness of the data provided and in case the whole set of data is already registered the end user and the administrator is notified. The mechanism always informs the user (citizen) of a successful or unsuccessful attempt when he/she tries to use the provided services.

Registered users have the following privileges (capabilities):

- They are offered information about the voting procedure and its mechanisms.
- Presentation of a set of available polls, selection of the desired polls and participation to the specific procedure.
- View the results of older polls. Results are available also in formatted text files allowing the possibility of processing the results.
- Communication with the administrator using a specific form for the creation of a new poll.

The system administrator has complete control of the application. Administrators have access to the privileges of registered uses and are responsible for

- Reading and answering any messages sent by citizens.
- The administration of each voting procedure (creation, maintenance and deletion).
- User administration (registration, privileges, deletion).
- Organisation and presentation of the results.

Poll owners are registered users who are given (from the administrator), privileges to create their own poll. The administration is responsible for giving the specific privilege to a specific user based on a set of rules (which organisation is represented, the theme of the poll etc.).

The use of the application must be available to all citizens who have access to the Internet through a personal computer (home, work etc.) or an infokiosk, without (necessarily) having an email account.

The presentation of the results of electronic poll will be available after the last day of the voting period and not during the procedure itself.

The system supports user–vote anonymity. A vote cannot be assigned to a specific user. This is done using a Secure Hash Standard. This standard specifies a Secure Hash Algorithm for computing a condensed representation of a message or a data file. When a message of variable-size m bits is input, the Hash Algorithm produces an output called a message digest. The message digest can then be input to the Digital Signature Algorithm (SA) which generates or verifies the signature for the message. Signing the message digest rather than the message often improves the efficiency of

the process because the message digest is usually much smaller in size than the message. The same hash algorithm must be used by the verifier of a digital signature as was used by the creator of the digital signature. The Hash Algorithm is called secure because it is computationally infeasible to find a message which corresponds to a given message digest, or to find two different messages which produce the same message digest.

After the publication of the results of a vote, each user that has participated in that specific vote has the ability to verify his own ballot. This way the voter can check if his ballot has been fraudulent or has been miscounted and can thus certify the integrity of the voting. During the voting procedure the voter submits the ballot decryption key. The system uses the key to decrypt the ballot which is then stored in the database. After the election, the system publishes a list of encrypted ballots, decryption keys, and decrypted ballots, allowing for independent verification of election results.

Additionally the system meets some non-functional specifications. The system is available 24 h a day. When system data change, the updated data are immediately available to the users. The system can collect statistical data and allow the study of citizen's correspondence with the administrator and local officials. No information is lost if the system fails and a backup mechanism ensures data integrity. The system is protected against inappropriate users' behaviour and unauthorised access. It is also designed to be open to the smooth integration of new projects or new services and to enhancement of the existing application (for example, smartcards).

4.2. System implementation

The application is based on the services provided by and the functionality of the WWW. The services have been developed on a WWW Server that provides the central node of communication, processing and reference. In Fig. 2 three layers of the system are shown.

The implementation of the system is based on the following concepts:

- A client–server model. We propose a model that consists of one server and multiple participant clients.
- An open platform architecture in order to support different operating platforms.
- International accepted standards.
- Access through Web pages.
- Object oriented design and implementation.
- Modular for scalability.

The architecture is based on the 3-tiered architecture model (Fig. 1). The browser is placed at the first layer. Citizens use this browser to access the system (e.g., MS Internet Explorer or Netscape Communicator). "Electronic Polling" is an interactive application where citizens send some kind of information (a ballot, user profile) and expect to view a set of results. For the exchange of this information the HyperText Transfer Protocol (HTTP) is used.

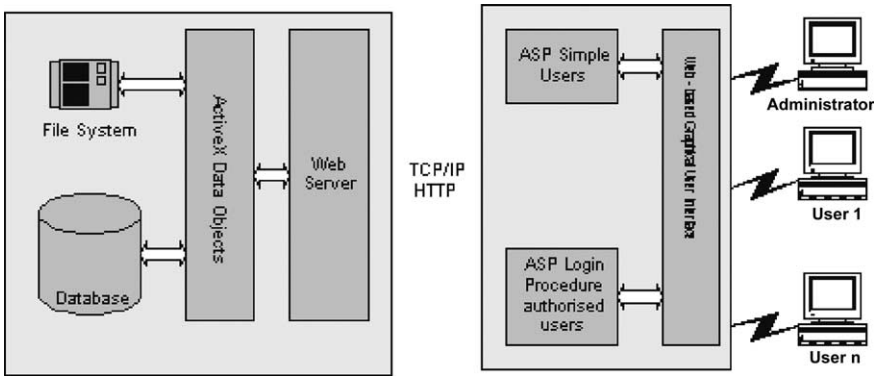

Fig. 1. The three tiered architecture.

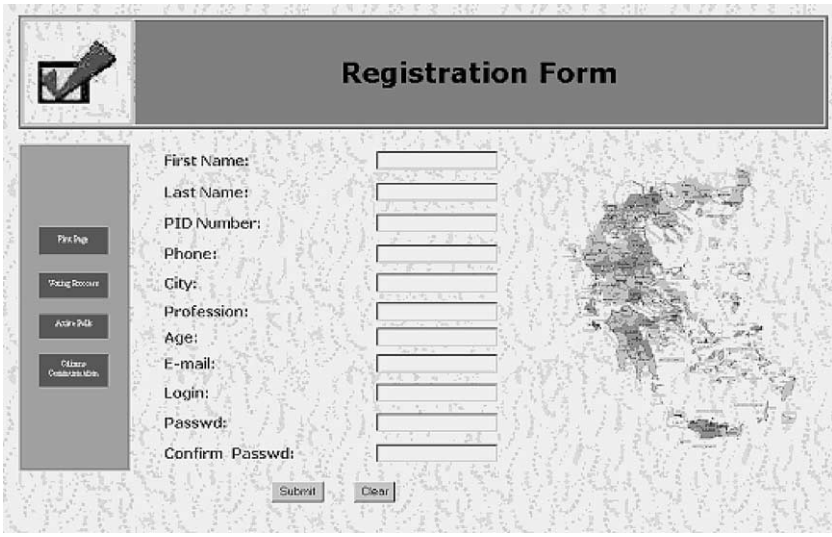

Fig. 2. Registration form.

In order to secure protection of the communication between the user and the system we applied the Secure Sockets Layer (SSL) protocol which has been universally accepted on the WWW for authenticated and encrypted communication between clients and servers. SSL protocol runs above TCP/IP and below higher-level protocols such as HTTP or IMAP. It uses TCP/IP on behalf of the higher-level protocols, and in the process allows an SSL-enabled server to authenticate itself to an SSL-enabled client, allows the client to authenticate itself to the server, and allows both machines to establish an encrypted connection.

SSL was used due to its capability to support the use of a variety of different cryptographic algorithms, or ciphers, for use in operations such as authenticating the server and client to each other, transmitting certificates, and establishing session

keys. Clients and servers may support different cipher suites, or sets of ciphers, depending on factors such as the version of SSL they support, company policies regarding acceptable encryption strength, and government restrictions on export of SSL-enabled software. Among its other functions, the SSL handshake protocol determines how the server and client negotiate which cipher suites they will use to authenticate each other, to transmit certificates, and to establish session keys.

The majority of the HyperText Markup Language (HTML) document responses are produced "on the fly". HTML is a markup language, which consists of tags embedded in the text of the document. The browser reading the document interprets these markup tags to help format the document for subsequent display to a reader (user). We tried to limit the cases where many of the decisions about layout are made by the browser.

The communication takes place over a TCP/IP connection. The transaction consists of the establishment of a connection by the client to the server, the request that corresponds to the sending by the client of a request message to the server, and the response that is the sending, by the server, of a response to the client. Finally the closing of the connection by either both parties commences.

At the second layer there is the Web Server, which operates as an interface between the two other layers. In particular, the Web Server using ASP scripts provides the interface with the user, defining the data that will de presented each time to the browser as well as the connection with the real data stored in database and file system.

So, each time a web client sends citizens' requests and receives answers via HTTP. Since the contents of various information changes, the HTML page has to be generated from the second layer—as shown in the above figure—every time the user makes the request. Thus web server scripting is essential in building systems such as ours. The second layer, namely Web Server, is responsible for the execution of the scripts. It is really easy to create web-based applications and dynamic content. For the development of our information system the Microsoft Internet Information Server 5.0 (IIS 5.0) for Windows 2000 was used.

But why is web server scripting so essential? First of all web server-scripting enables the "backend" for the web application. HTML and HTTP do not by themselves provide a way to access databases or carry information about users from page to page. Server-side scripting accesses programs on the server that provides this necessary functionality behind the scenes to deliver web applications and customised HTML for each user. Second web server scripting separates the content from the presentation for easier design and data management. Server scripting allows the user of templates for creating HTML documents "on the fly". The contents of a page can come from anywhere—databases, plain text files, searches, calculations and be dynamically inserted before it is sent to the user. Information can be managed in the most appropriate manner, and does not have to be stored in HTML pages that must be changed by hand whenever the data changes.

Active Server Pages (ASP) is a powerful server-based technology from Microsoft, designed to create dynamic and interactive HTML pages for WWW sites, or cooperative intranets. The technology of Active Sever Pages (ASP 3.0) allows the use of

programs, which are executed in the environment of MS-IIS 5.0. ASP pages are files that contain HTML headers, text and script commands. Moreover, ASP pages call ActiveX components for the execution of functions, like connection with a database or computations.

The power of ASP lies in two facts: first, the HTML is not created until the user wants to see the web page, and second, it does not care what web browser is being used. While ASP must be executed on a computer that supports it, we can view ASP-driven web pages from any computer, and with any modern browser. ASP pages are responsible for the administration of information stored in the system database and of setting up the connection with the database is achieved by ActiveX Data Objects (ADO), through OLE DB and ODBC.

Finally, at the third layer there is the file system of the server, where all the available electronic material is stored (messages, responses, several snapshots of the voting process, results etc.) and the database Server which stores all the relative information for the material.

The Data Base Management System (DBMS) works behind the Web Server and provides the whole system with an efficient means of manipulation. The database contains all the necessary information about the users (personal and identification information), messages (questions, remarks, comments and the respective answers) and the polling material (subject, potential answers). Also intermediate results (ballots in each category), final results (of the current and past snapshots of voting procedures) and useful statistical data for future study and processing are stored there. For the implementation the Microsoft SQL Server 7 is used.

4.3. System functionality

A set of functionalities where defined during the requirement analysis leading to a minimum set of parameters should be satisfied in order to have an efficient polling system (http://deimos/E-Voting/). These parameters may ensure the quality of the application (Berhel, 2000) and ensure the validation process. In Fig. 3 the interface from which the user accesses all functionalities is presented.

4.3.1. Registration procedure

The citizen first fills and submits a registration form. The registration form includes the personal data (first name, last name, personal ID number, address etc.) as well as the coded access data (login, password) that he/she wishes to use each time, in order to make use of the application.

The above data must be unique for every user. In a different case the authentication system will reject the request. The form in Fig. 2 presents the registration form and the relevant fields.

Citizens data used for this application are stored in the database of the system and are always available to the system administrator. In addition, administrator can delete a user in the case inappropriate or unreasonable use is notified.

Two kinds of users are envisaged: a simple user, which has access to the polling procedure and can vote and review the results and the advanced user, which has

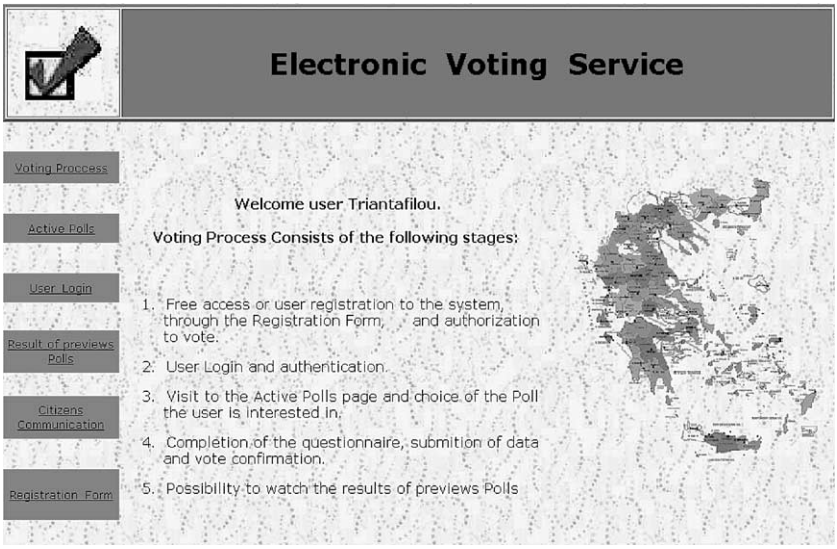

Fig. 3. The main user interface.

moreover the ability to setup a poll and to be responsible for the whole procedure. Any user interested to setup a poll sends a message to the administrator which send back a username and password to be used by the specific user.

All users are allowed to see results of old polls and to send to the administrator questions and remarks about the whole procedure.

4.3.2. Polling procedure

After the registration process is completed the user is free to make use of the application and participate in a vote. The user visits the page with the active polls and picks a subject. By following the link the questionnaire is presented to him/her. The questionnaire includes ''closed ended'' questions. In such a questionnaire the citizen can answer by selecting an answer from a set of possible answers.

There are two ways to access the system: (1) from distance, using a computer that has access to the Internet. (2) From an infokiosk established in a central area.

The execution of the voting procedure is based on the following steps: The user selects the desired answers and then submits his answer to the system. A confirmation mechanism is engaged that presents to the user the specific choices that he voted for before sending them to be stored and tallied. The confirmation of his vote results into counting his vote and storing the results into the database.

The system also offers the possibility of a simple statistical representation of data. The statistical representation for a specific vote is activated after the expiration date of the vote is over. Users can make combinations from a fixed menu of representations, containing the sex (man–woman), the age and the profession of the voting body. This way we can have a number of different representations according to the interests of the individual user. The graphical presentation of the data is analytical

for each question and every possible answer connected to it, and is in the form of simple arithmetic's, percentages or bars.

Based on the registration data given by the user in order to be allowed to use the voting service the citizen can send a message (question, remark, and comment) to the administrator of the electronic voting service. The user gives the username and password, writes down a short subject (description) of the main message, at the appropriate field and fills in his/her message and sends it. The response of the message can be retrieved when the user gives again the username and password and there is a response available for the specific user.

4.3.3. System administration

The system administrator is responsible for the creation and deletion of a poll. The user can dynamically generate a poll without the need for form designing or programming. Any number of polls can be created and the last poll created will be enabled automatically. The system administrator can assign privileges to users for creating a poll after they have send an application requesting such privileges.

The administration application offers a menu where the administration can create a new poll. The administrator is prompted for a title of the poll, a description and the questions/answers. The question/answer mechanism supports the insertion of a text for each question and the corresponding answers (questions having multiple answer choices). The administrator also defines the polling period and the system is responsible for maintaining the poll and gathering the results. After a poll is over users can see the poll results in a graphical form. Results of preview polls are also available for further examination.

Fig. 4 presents the first page of the poll creation schema. The fields are filled with the following information: Title of the poll, description of the poll, how many

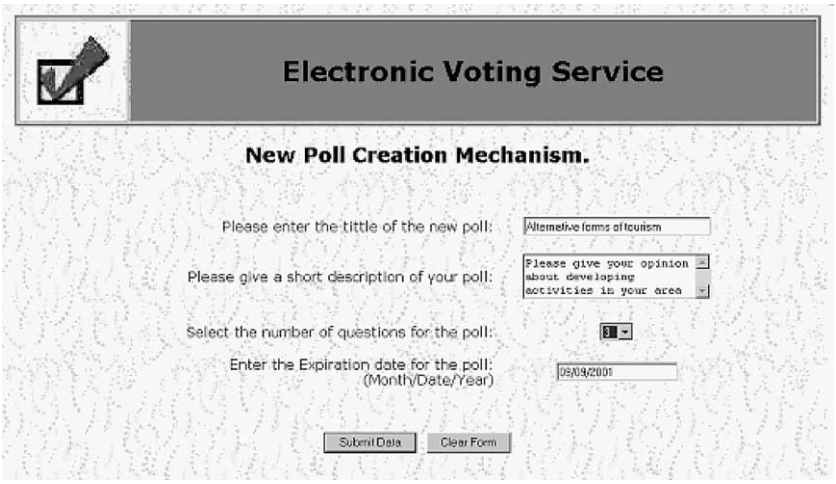

Fig. 4. New poll creation.

answers will the poll contains and when does the poll expires. When the above data are completed (the system checks if anything is missing) then the system produces a predefined form to be used for question structure.

The deletion mechanism presents to the administrator all polls (active or not) and he just selects the poll he wants to delete. There is no modification functionality for the administrator to perform because since a poll must be modified the assumption of quality between all voters has been violated thus leading to a false polling procedure.

The administrator is also responsible for the administration of the users. User administration is very important since it deals with personal data protection and user identification.

The system administrator is also offered a simple mechanism that allows simple statistical process of the results of each poll. This facility is provided to the administrator to organise and extract a set of conclusions based on samples of the personal data. Thus, the administrator can present answers per age, profession, and educational level thus enhancing the interpretation of the results. This facility is left to the administrator since this kind of statistical process is assumed not to be essential for all polls conducted.

The appearance of the final result is made visually through graphical representation (Fig. 5). These graphical representations are accompanied by percentages in order to make results comprehensible to inexperienced users of the application.

The graphical results are given in using bars to represent the percentage of each answer on the whole poll population.

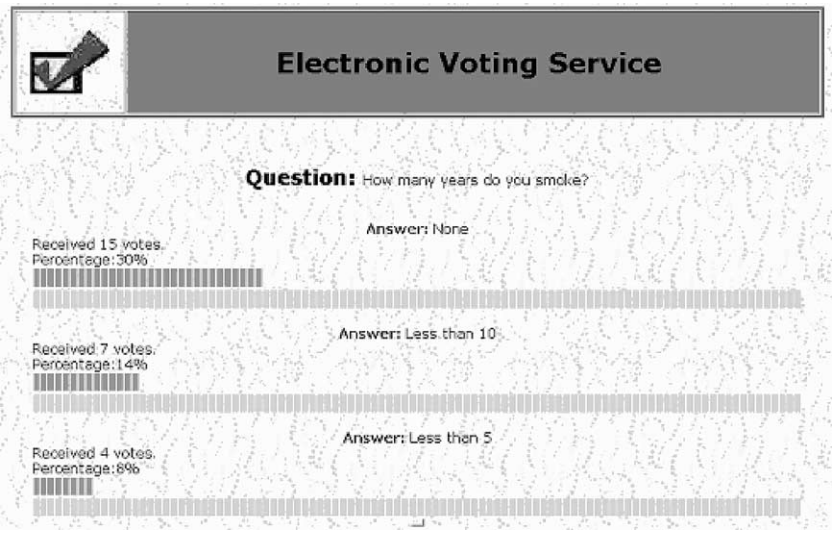

Fig. 5. Preview of the results of a specific poll.

5. Conclusion and future work

The work reported here is preliminary, but provides a sound basis for future research. The aim is to produce a tool that public administrations can use in order to collect public opinion on specific administrative, environmental, economic and social issues. The system will serve as a pilot for the development and deployment of similar systems in Greek Authorities.

The exchange of information through the Internet requires a data security mechanism, since only authorised access to this information should be granted. Our system deals with only parts of the range of security issues and safety mechanisms should be applied to prevent unauthorised access. This will lead to a more robust system secure against possible misuse.

The system was planned and implemented in order to be easily expandable. We intend to incorporate public-key cryptographic techniques in order to prevent tracking, ensure user and ballot authentication and verification of the voting procedures. Careful improvement to the electronic voting mechanisms in the next few years will increase public participation while preserving voting integrity.

We intend to support the electronic voting service with an automatic mechanism to check and select the representative sample used in each electronic voting procedure. At present, the checking of an appropriate sample can be done manually offline, after the end of the voting procedure. An online automated mechanism would be preferable and could enhance the accuracy of the respective results (the voting procedure would be ended after the collection of an appropriate sample of voters).

In order to support more citizen-sensitive political procedures local authorities need to offer a forum for citizens to express themselves. Although voting procedures can enhance the decision-making process though increasing public participation, in such surveys, a forum allowing people to post their opinions and arguments about the specific issues is needed. This forum will facilitate the people's desire to be informed about all possible arguments related to the issues under discussion.

The results gained from public opinion need to be communicated and evaluated by specialists, citizens, politicians and public administration. Thus the results of such polls are the raw material for raising public awareness of and discussions on specific issues, for the formation of panels between citizens and experts and for electronic meetings and other discursive procedures and forums. The participants can gain strongly from a support tool where they will be able to hold more or less formal electronic meetings and conversations.

The system must be enhanced with the capability to conduct detailed statistical processing by providing relevant interfaces to statistical software available already in the market or by developing a more advanced processing tool. The main advantage of surveys as a decision-making tool results from the fact that the decision makers can process the results using different parameters to draw conclusions.

Finally we would say that the whole system has been developed to operate using the Internet structure and its main intention is to improve the potential for democratic engagement. It is one of many attempts, which will lead to a 21st century "on

line democracy''. Projects like the one described in this work, are a reminder of the promise and the challenges of democratic renewal.

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