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KYUSHU UNIVERSITY

The Current State and Issue on the Implementation of Electronic Voting System in Internet

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ABSTRACT

Due to the proliferation of the Internet and WWW (World Wide Web), a diverse range of application programs have been researched on and developed, providing tangible benefits to our daily lives. An electronic voting system is one of such application programs and provides not only a new paradigm in voting but also a basis through which voter turnout can be enhanced. This research proposes an electronic voting system based on encryption of the voting details and system security via the public key algorithm feature of the Internet and WWW (World Wide Web) that are gaining on prominence. Also, we analysis the current state of e-voting that has been developing and studying in many countries.

1. CONVENTIONAL VOTING METHOD

1.1 Paper Ballots

This method was adopted first in the Australian state of Victoria in 1856. In the years immediately following, the concept was adopted in other Australian states. Thus, it came to be called the 'Australian ballot'[18].

This method is the oldest of the conventional methods where voters make a mark on ballots on which all candidates' names or the content for which to vote are listed and puts it directly into a voting box. Because all processes are done by hand, it incurs the most loss in terms of manpower and cost but is still used widely in a number of countries. Because the vote counting needs to be done manually as well, it leaves a lot of room for errors.

1.2 Punch Card Machines

Punch card machines automated the counting process using the computer technology of 1960s.

Voters visit voting places and receive a voting card with the candidates' list on it from an election administrator. The voter then inserts this card into a slot and perforates a hole next to a candidate he is voting for and puts it into a voting box.

There are two variants of the punch card- one is the DataVote, the other is the VotoMatic. At the end of the day, election workers put the cards into a sorter that counts the number of perforations next to each candidate[3].

1.3 Mechanical Lever Machines

At the end of the 19th Century, mechanical lever machines were introduced in New York state, and by 1930 every major metropolitan area had adopted lever machinery [3]. This method employs a steel booth with a card inside that has candidates, political parties, or voting content and there are switches below them for each option. The voting is done by pulling the lever upon which the voting is recorded by the counter located behind the machine. After the voting is completed, machines in each voting district are tallied. One reason for the acceptance of the machines was the existence of significant fraud in the use of paper ballots[18].

1.4 Optically Scanned Ballots

Optically scanned ballots, also known as 'marksense' or 'bubble' ballots, offer another method for automating the counting of paper ballots[3]. To the next of a candidate's name of the voting content is marked a small hole with a light source such as a sensor. The vote counting after the voting is implemented by an optical scanner.

1.5 Direct Recording Electronic

Direct Recording Electronic (DRE) is an electronic manifestation of the lever machines. Voters use touch screens or push buttons to select choices, which are stored electronically in the memory of the machine[7].

Let us look into the evolving changes of the conventional voting method based on the technology report by Caltech and MIT[3]. Table 1 displays the wide variation in machines used in the 1980 and 2000 election. Similar data can also be found from Roy G.Saltman's[18] "Accuracy, Integrity, and Security in Computerized Vote-Tallying."

Table 1. Usage of Voting Equipment in the 1980 and 2000 Elections <%>

	Percent of Counties Using Technology		**Percent of 2000 Population Covered by technology**	
	1980	**2000**	**1980**	**2000**
Paper Ballots	40.4	12.5	9.8	1.3
Lever Machines	36.4	14.7	43.9	17.8
Punch card **'VotoMatic'** **'Data Vote'**	 17.0 2.1	 17.5 1.7	 30.0 2.7	 30.9 3.5

Optically scanned	0.8	40.2	9.8	27.5
Electronic (DRE)	0.2	8.9	2.3	10.7
Mixed	3.0	4.4	10.4	8.1

2. Problems with the Conventional Voting Method

Democracy and voting are inseparable and because the majority opinion determines the outcome of an election or policy, voting is by far the most important means in democratic decision-making. Although numerous voting methods have been implemented since the dawn of democracy, a certain degree of trial and error could always be expected according to which voting method was used.

The biggest problem with the conventional voting method was in the most significant loss in terms of manpower, time, and money. In addition, there is a great deal of dispute as to the validity of the votes cast and especially, there is a significant loss of time till the ballot counting. As an example, one can cite the Presidential Election of 2000 in the State of Florida in the United States. Palm Beach County of Florida implemented a card-type voting based on a ballot in the shape of butterfly for the past U. S. Presidential Election. To cater to the elderly who typically suffered from weakened vision, the ballot was made in two pages to accommodate larger fonts. But such implementation resulted in a large number of votes that could not be deciphered one way or another with certainty at ballot counting, causing a great deal of controversy. To prevent this from recurring, a new legislation is in the making for introducing new voting procedures and methods[19].

Also, the problem with the most DRE machines as currently designed, is that there is no difference in the result seen between a voter's failure to cast a vote and the machine's failure to record a vote[18].

3. E-VOTING

3.1. Methods in e-Voting

The e-voting method is a voting method based on network such as the Internet. Methods such as poll site, kiosk, and voting by phone are currently being used or developed. The fundamental objective in using this online voting lies in emphasizing convenience, efficiency, and accuracy in voting.

Poll Site

Poll site is a method relying on computers connected to the Internet for WWW (World Wide Web) voting. This method requires the production of a website for listing voting content and implements voting after authenticating voters. It has not come into use due to certain issues with accuracy, safety, and security and is mostly used for opinion gathering. It will, however, evolve into one of the forms of the next-generation voting through persistent research and development efforts.

Kiosk

Kiosk was developed similar to an ATM (Automatic Teller Machine) machine of a bank, for the purpose of voting only. Moving beyond the traditional places for voting, the voting device will be installed in convenient locations, including schools, libraries, and shopping malls and the voting, carried out via keyboard or touchscreen. The voting devices will be controlled by the election management committee. When the voting content is displayed on screen, the voter will vote after going through voter authentication and the voting result will be stored separately in a storage device. After the election is completed, the election management committee will carry out the automatic counting of votes.

Voting by Phone

Voting by phone takes the concept of convenience even further where a voter will vote from his or her mobile phone and the voting result will be transmitted wireless. Thus, this method would require an even higher level of security. Although it is still at an experimental stage, when it actually comes into use, it would revolutionize the voting method.

Aside from the aforementioned methods, small variations of e-voting are being developed. For instance, there are methods that employ satellite communications or dedicated private lines, rather than the Internet.

3.2. Advantages and Disadvantages of E-Voting

Even the new e-voting system would not be eradicate all problems associated with the conventional voting system. On the same token, few problems do exist with e-voting as well. Voters who are not familiar with e-voting equipment may not be able to vote as they wish. This may be true especially for the elderly. Also, the system could face attack from the unknown mass, heightening the potential for not only alteration or forgery of the voting result but also voting failure. Of course the security device will be bolstered with double and triple protection but the 100% security is not guaranteed on networks. E-voting devices should not only lead to facilitated connection by voters but also implement an even higher level of security to prevent alteration or forgery of the voting result. Therefore, devices naturally become more complex and sophisticated, which in turn, tends to push the equipment cost higher[8].

As previously stated, there are certain advantages associated with an electronic voting system. First, voters can take advantage of the home-centered tele-vote, rendering the process convenient. Second, automatic voting and ballot counting can be implemented. Third, an improvement in the turnout of voters can be expected by eliminating the now increasingly outdated voting method.

Among its disadvantages are: First, certain technical

issues exist. In comprising an electronic voting system, technical problems exist in terms of how the installation and operation of the system should be implemented. Second, the problem of multiple voting by a single person and voting by proxy could result and this problem is that of voter authentication. Third, there is a possibility of fabrication in voting and ballot counting. While the voting system and the tallying system of an Election Administration Committee are being tallied, an alteration of the results could perspire from within or without.

3.3 The Requirements for E-voting System

1) E-Voting Equipment

In 1869, Thomas Alva Edison was granted the U. S. patent 90,646 for an "Electric Vote-Recorder". Congress eclined to use it because it reported votes "too quickly" [17]. The first requirement for the e-voting equipment is in convenience in its use by voters. In other words, the equipment should not pose a difficulty when the voter uses it to cast a vote and not cause confusion when she casts a vote. At the moment, the ones based on telecommunications terminals (including wireless telecommunications devices) including computers and machines dedicated for voting are being developed or in use.

In the case of poll site, it utilizes the Internet by employing computers connected to the Internet. In December of 1999, the U. S. President Clinton ordered NSF (National Science Foundation) to conduct a research related to online voting. NSF, in turn, instructed IPI (Internet Policy Institute) to hold a workshop for Internet voting. The first workshop was held in March of 2001 and a report submitted[7].

The very first Internet voting in the United States took place for real during the Democratic Presidential Primary in Arizona from March 7 to 11 in 2000. The state government of California has also created a task force team to adopt an Internet-based system and active discussion is ongoing.

Yet another method relies on modular telecommunication method. (including satellite telecommunications) Boltblue of Great Britain plans to test a voting based on module phones with support from Liberal Democratic Party[25]. As modular phones are in use more extensively than computers, they could also help in enhancing voter turnout rate. There are various problems to overcome, however, for this method to be introduced in actual voting.

Kiosk is a device dedicated for voting and is currently being implemented. In the United States, Caltech and MIT are developing a voting machine that would prevent the chaos during and after the voting in the past presidential election[3][15].

2) Voter Authentication

The voter authentication can be considered a core technology, along with the encryption of voting result. Differences exist, however, in voter authentication methods according to which e-voting system is used. The method where a password is given to each voter from a voting place through an election management committee is used most frequently. But a diverse range of methods have been proposed, including a special electronic citizen identification and fingerprint recognition device. Differences also exist whether the voting place will be traditional voting places or the voter's home, office, or public buildings. Certainly the former would be considered more secure than the latter but the latter would coincide with the development path of e-voting. Only valid voters should be allowed to vote.

3) Encryption of Voting Result and Its Transmission

The crux of the voting system is in proper voting and accurate tallying. The introduction of new e-voting in place of the conventional voting method could find justification in its convenience and accuracy. On the issue of accuracy, the encryption technology is mandatory in order to prevent alteration or forgery of vote counting. But the tandem of security and hacking and that of encryption and decryption is an endless struggle. There are scholars who go as far as saying, 'Cryptography is not the problem. Many wonderful cryptographic voting protocols have been proposed'[16]. But the encryption technology need to be developed on a sustained basis as long as hacking exists. Especially, if the voting result is transmitted via connection through a network, the potential for its alteration or forgery could be greater. This aspect quite critical to the point of determining the success or failure of the e-voting system.

4) Computerized Vote-Tallying and Ballot Counting

The most important aspects in computerized vote-tallying are accuracy, integrity, and security. Accuracy, especially, is the most fundamental factor in computerized vote-tallying and is based on integrity and security. This aspect is one of the purposes of developing e-voting in the first place and could also minimize the loss in manpower and time associated with the conventional voting method.

5) Storing Voting Records

Voters often wonder whether the vote she cast was tallied properly. She may want to confirm her voting records. In addition, this issue needs to be resolve in preparation of recounting when problems occur in vote tallying. The voting result could be recorded on a voting device through which e-voting was conducted, it could be transmitted to the computer at the election management committee, and both of these options could be employed simultaneously. This element is a must in clarifying any suspicion that could arise about rigged voting.

3.4 E-voting using the PKI

1) PKI components

Usually, the PKI makes used of digital signature (or

Electronic signature)in the network. PKI is based on the use of public key cryptography. Public key cryptography play an important
This is provides the assurances users need before they can confidently transmit sensitive information over the Internet and other network.
The components of PKI is the following [13].
- PAA : Policy Approving Authority
- CA : Certificate Authority
- ORA: Organizational Registration Authority
- Clients
- Directory Server

There are certificate and CRL (Certificate Revocation List) in the management of PKI.The message form of PKI which IETF PKIX(Public Key Infrastructure X.509) defined , is as Table 2 following :

Table 2 . The message form of PKI

Header	Body	Protection (Optional)	ExtraCerts (Optional)

2) The role of PKI in the E-voting

Public key cryptography plays an important role in providing security services such as confidentiality, authentication, digital signatures, and integrity. Especially, It is the voter certification. One person (certificate)- One voting, that is prevented the multi - voting. And the only legitimate person can voting. The role of PKI in the e-voting via Internet was figured as Fig 1 the following.

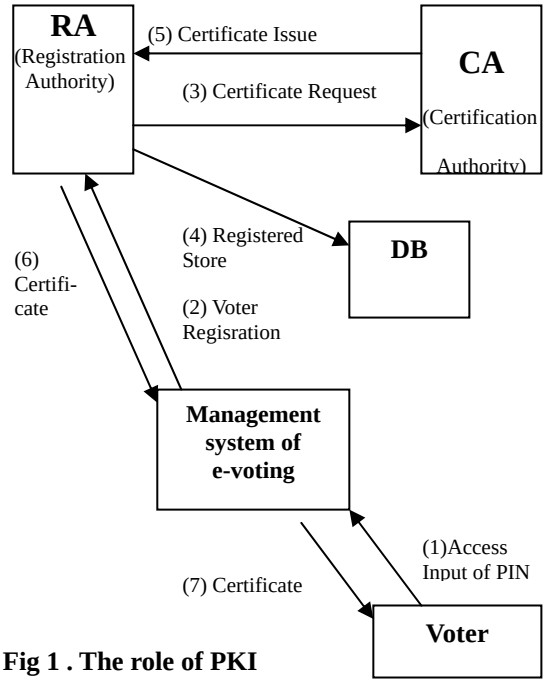

Fig 1 . The role of PKI

4. IMPLEMENTED E-VOTING USING THE INTERNET

4.1 The Outline of the Implemented E-voting

1) The outline of the implemented e-voting system

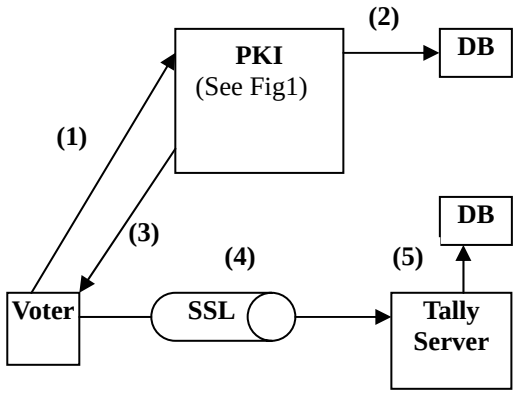

Fig 2 . The overview

2) The voting step

■ **Registration step (1)(2)(3)**
- Access the PKI for registration
- The PKI send the Voter's public key for the encryption
- Generate ID and send the encrypted data (voter's ID and Korea-PIN)
- After decrypt and identify a voter's data, Certificate lssue (including K-PIN and Registered information together Tally server's public key)

■ **Voting step (4)**
- If voter is voting , be send the encrypted contents and K-PIN of vote via SSL
- After decrypt using Tally server's private key, automatic counting and store the DB

■ **Counting step (5)**
- Compare the number of counting and DB, announce the result of voting
- DB is utilized the inspection of voting

4.2 Composition of E-Voting System

1) Web Page

A web page that could act as a polling place needs to be constructed. By incorporating the data such as candidates' credentials, the voters can be aided in making their choices. The web page for the proposed electronic voting system, as can be seen in the diagram, consists of the following four parts: voter authentication, voting, introduction of candidates' credentials, and voting results. The Web Page1, which falls in the realm of voters, needs to be constructed so that it can be used in conjunction with the voter's secret key of the PKI algorithm since relying on the simple password scheme leads to low levels of security.

2) Web Server Security (SSL)

SSL (Secure Socket Layer) has been installed at the server computer of the Election Administration Committee. This measure was implemented so that the ever-increasing hacking of web servers and alteration of the web page taking on the role of a polling office can be prevented. There is obviously an additional advantage of being able to affect a secure web transmission by a new encrypted channel via an authentication process between the server and polling place. The SSL protocol was developed by Terrisa and has been used as the main protocol for encryption by Netscape and Netsite. This protocol allows for web security through the use of RSA and X.509 for certification between the server and clients. In addition, by providing for the secure encrypted socket channels at network layer for transmission and reception, rather than the HTTP service at application layer for implementations at the present, it guarantees data integrity as can be seen from the diagram. Moreover, as the system operates at network layer, it will be able to support various services at application layer, an upper layer. The electronic voting system of this research supports the HTTP service among various services at application layer.

Tasks carried out between the server and clients in the SSL protocol scheme provide following features: First, they confirm the connection between the clients and server. Second, they allow for secure data transmission between the clients and server via encryption technique. Third, data integrity is guaranteed. Wall, the server for the Election Administration Committee of this system, used the port 443 as the encryption socket channel for SSL protocol operation. One of the authentication messages is shown in the following diagram.

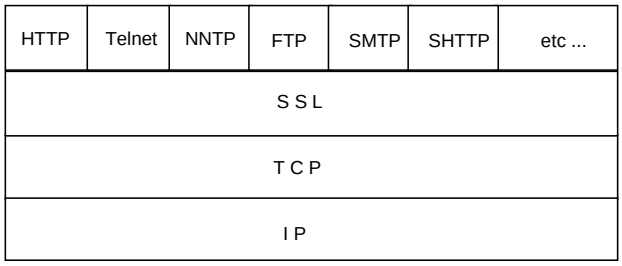

Figure 3. SSL Protocol

3) Firewall

In order to protect the network between the polling place and the Election Administration Committee, FWTK, one of the firewalls among various choices available, was installed and used. This firewall features the following two roles and advantages: First, it allows for a control of each service at application layer. Thus, in this system, only Telnet, ftp, and HTTP are provided while the rest of the services are excluded. Second, a control feature was implemented between the polling place and the Election Administration Committee through the use of IP addresses. It was done so that access by an external system can be prevented.

The installation of the firewall system for the polling place and Election Administration Committee was done as shown in the diagram.

4) Automatic Tallying Program

An automatic tallying system was implemented through the use of Perl (Practical Extraction and Report Language). Perl is a good utility language, is free, and can be supported at various platforms. In this research, a program that can be supported by Perl4.0 or higher was programmed and the wall server uses Perl5.003. Some of the features of the program for this system are as follows: First, the voting detail delivered via encrypted transmission is decrypted by the voter's PKI file. Second, the decrypted voting detail is tallied by *vote.cgi* where only the corresponding candidate's number is programmed in Perl and is counted. The web page showing the results is linked with the voting web page, showing the total number of votes received and the ratio of the votes received in percentile.

4.3 Characteristics of the Implemented Voting System

The electronic voting system implemented in this research has following characteristics[20].

(1) By performing electronic voting through the web, one of the Internet services available, one can not only obtain advantages associated with visual effects but also an improved voter turnout by obviating the existing voting method deemed old-fashioned and outdated.
turning the voter's secret key into 1024bit.

Figure 4. The Implemented webpage of E-voting System (1)

(2) The voter authentication feature has been

strengthened. The existing method that has been used for voter authentication can be construed as not sufficiently robust in terms of security by simply requesting the voter's password. But the method proposed by this research significantly bolsters security by turning the voter's secret key into 1024bits.

(3) The web security has been enhanced as well. Although it was also partly due to the strengthened user authentication security but the use of the existing HTTP as the SSL protocol enhanced the security even further. As the existing HTTP has virtually no security features and although new web server programs are coming out with strengthened security features, the security of the web server itself has limitations. Thus, this research proposed SSL, one of the new proposed methods.

Figure 5. The Implemented webpage of E-voting System(2)

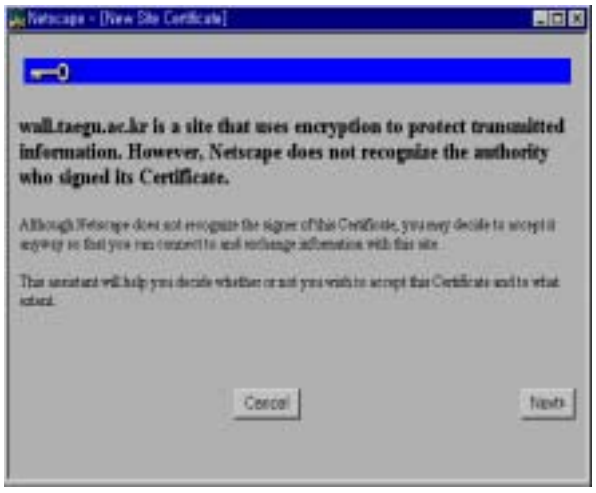

Figure 6. The message of SSL Authentication

(4) The encrypted transmission based on the public key algorithm was incorporated in the electronic voting system which is but a web program. As the web moves increasing toward commercialization, encryption of the data transmission on the web is being called for at an ever increasing pace.

V o t e C o u n t 1

Figure 7. The example of voting contents (Before be transmitted)

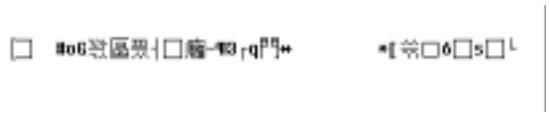

Figure 8. The Cryptography of Figure 7

4.4 Future of the Electronic Voting System Development

In order to allow for enhanced security and stability in electronic voting system in the future, sustained efforts and research would have to be carried out. This research proposes the following three suggestions for this purpose:

(1) The most critical aspect of the electronic voting system is that it should be immune from alteration, forgery, and interception during the vote transmission and the vote tally system should also be guarded from alteration and forgery. In order to implement this successfully, developing an encryption algorithm is called for in urgency.

(2) The voter authentication is also another important aspect of the electronic voting system. In order to make the home-centered tele-vote possible at the expense of voting at a polling place, the development of the voter authentication feature needs to be preceded. This issue not only hinges on the program itself but also depends on the development of hardware such as fingerprint recognition scheme. By implementing these measures as a prerequisite, voting by proxy and multiple voting by a single voter can be prevented and the home-centered tele-vote can also be implemented as well.

(3) While the voting details cannot be allowed to be discerned, whether a given voter voted or not should be recorded and stored. Currently, whether a given voter voted or not can be determined as the corresponding log leaves a trail but the manager of the Election Administration Committee system can discern even the voting details. This is something that needs to be rectified in the future.

5. CURRENT STATE OF E-VOTING

The e-voting is currently being employed in some countries, including the Netherlands, Belgium, and

Brazil and the trend is expected to proliferate. This e-voting method takes a form of visiting a voting place in person and voting through a computer or terminal installed at the location after which the voting result is sent to a tallying place for computerized tallying. Estonia became the first country that allowed online voting and plans to implement it for elections, beginning in 2003[21].

5.1 America

The very first Internet voting in the United States took place in real-life situation during the Democratic Presidential Primary in Arizona from March 7 to 11 in 2000. After the U. S. Court recognized the legal validity of Internet voting, it was conducted in two ways. Voters could either access the website of Election.com that oversaw the process during the specified 5-day period for voting or go to a voting place on March 11, the official voting date, by using the computer there. The voting proved to be a success. The total number of voters reached 85,750, a 622% increase from 12,800 recorded for 1996. The Internet voting was used by 39,942 people, assuming 46.5% of the total voters and no technical problems were reported [2][3].

Palm Beach County of Florida implemented a card-type voting based on a ballot in the shape of butterfly for the past U. S. Presidential Election. To cater to the elderly who typically suffered from weakened vision, the ballot was made in two pages to accommodate larger fonts. But such implementation resulted in a large number of votes that could not be deciphered one way or another with certainty at ballot counting, causing a great deal of controversy. To prevent this from recurring, a new legislation is in the making for introducing new voting procedures and methods. In addition, Caltech and MIT are developing a new machine for voting [3]. The voting system in the United States consists of four components: voter authentication, communication of voter preferences, the counting of these preferences and security of the voting system. First, there is a method for authenticating voters. Second, there is a process for communicating preferences: balloting. Third, there are procedures for counting ballots. Fourth, there is a security system [3].

5.2 Europe

The CyberVote project[5] officially started on 1, September 2000 and will end on 1 March 2003.

This system will be tested in 2003 during trial election that will be held in Germany, France and Sweden. These trials will involve more that 3000 voters and will allow full assessment of the system before any potential product launch. This project aims to an improvement of the democratic process by increasing voter participation and there by increasing the number of votes. Figure9 [6] gives an overview of the InternetStem system. Both the client and the server part of the voting engine were implemented in Java, the voting client as a Java applet and the voting server as a Java application. The client PC was allowed to be behind a firewall or proxy, which causes no problem unless the firewall is very restrictive. On the server side actually two servers were used to do the work(not counting the firewall). The front-end was formed by an SSL-enabled webserver and the back-end consisted of the actual voting server.

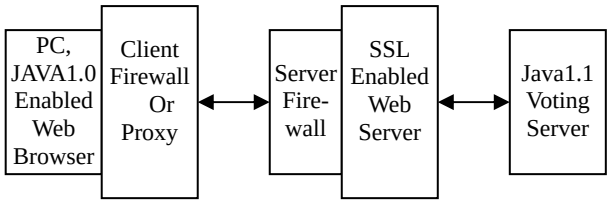

Figure 9. Overview of the InternetStem system in Europe

5.3 Japan

The General Affairs Office of Japan announced on the 23rd of the past month, "A proposal for revising the election law for public offices will be submitted to the Diet in order to allow electronic voting and ballot counting." The Japanese Government plans to conduct an electronic election as early as the election for the provincial governorship of Hiroshima in November of 2001 and is working on revising the related laws and regulations. Japan plans to implement e-voting in the Hiroshima governorship election as a trial and plans to widen its scope ultimately to the general election after correcting for the problems that could perspire[17].

5.4 Korea

In Korea, several companies have plans for forging an alliance with foreign companies and PIBKorea has started an election agency business through the Internet by collaborating with evotesystem.com. The Korean-style e-vote system will be linked with the IMT-2000 Project and is being pushed forward with research on wireless Internet voting system and individual authentication [23].

6. A RESEARCH TASK OF E-VOTING

6.1 Voting Place

One of the things that needs to be considered first in implementing an e-voting system is where the voting would take place: whether it should be done at a specified voting place or at a location convenient for the voter such as home, office, and various public locations. This would require online registration. As for the methods in online registration, a number unique to a given voter, fingerprint recognition, and electronic citizen identification, among other things, are being used.

6.2 Education

Voters who are familiar with the voting method that has been used for a long time may be reluctant to use a new voting method. At the same time, voters who are not familiar with the new voting equipment may encounter problems during the voting process. This may be true especially for the elderly. Avi Rubin[1] cited

coercibility, vote selling, vote solicitation, and online registration as the problems with e-voting. administrator(officer) or people whose interest coincide with the candidates may impose themselves on voters, ask favors, or disburse money for votes. Therefore, educating the voters on the new voting method in advance and promoting and educating the importance of proper exercise of voting right are vitally needed.

6.3 Safety to Voting Equipment

All e-voting systems are always exposed to risk. This kind of risk may be of more serious nature than that of the conventional voting method. An intentional error by a system administrator, attack from outside, system malfunction, and even unexpected system problems could occur. A secure e-voting system would result only when all possible problems are reviewed and appropriate measures instituted.

6.4 Compatibility among Voting Equipment

E-voting equipment currently under development typically rely on a single kind of device but in the future, more than one device (personal computers, personal digital devices, mobile phones, web phones, etc.) will be used in e-voting. In order words, voters will be able to vote by choosing the device most convenient for her. In turning such conception into reality, the issue of compatibility among various devices, including operating systems that drive devices, browers, and input devices, will have to be considered [7].

7. CONCLUSION

The first important purpose to developing of the e-voting caused by a decrease in voting ratio. Moreover, at the moment, the voter's political indifference poses a more significant threat. Due to such reasons, the development of new voting method can be said to be an important project of national significance. It is said that Vote(Election) is the flower of democracy. This is said the important of vote(election).

The new voting method will be able the step closer to realizing direct democracy that enhances political participation of citizens by supplementing problems related to representational democracy of the day.

Before such system can be implemented, the first, It is working on revising the related laws and regulations. The second, in order to reliable e-voting, the issues related to technology must be solved. The last, the most people signifies that although the necessity of a new method such as e-voting is recognized, the credibility on the new voting equipment is quite low. So it is need that the previous education about the new voting system.

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