Re-engineering Conventional Voting System through ICT: University's Perspectives

Khairul Nizam Abd Halim
Razulaimi Razali
Muhd Eizan Shafiq Abd Aziz
Universiti Teknologi MARA Pahang, Malaysia
Email: khairulnizam@pahang.uitm.edu.my

ABSTRACT

This paper focuses on the prospective of implementing an electronic voting system using web-based application technology. This research begins by considering university as a main sample and user before it can be planned to go further, probably to the first and second level of election which required several fields to be studied and identification of entities that will involve. An election conducted at the third level, for example, at the organisation or society level, in this context at the university level, usually involve the Student Representatives Council (MPP) election. An election will be conducted to appoint new representatives that will serve for MPP. Currently, conventional methods are being used at the back-end and front-end of the election. The emergence of ICT has driven researchers to incorporate ICT in the current electoral processes, which will cause changes to the current processes. Previous research have shown the advantages of ICT used in electoral processes. It is able to reduce cost and time, besides vote blank which is a very common issue occurred in the current electoral processes uses ballot paper. Based on identified issues, this paper tries to propose a new method in conducting the MPP's election that will reduce or/and eliminate the identified issues. A generic methodology which is based on BPR is used in re-designing the current electoral throughout this research and SDLC is used to develop the prototype of electronic voting system. Continuous re-designing is needed in order to provide better services in all aspects of e-electoral processes,

ISSN 0128-5599

where, further research on certain aspects such as security, trustworthy, user acceptance and few others will be conducted phase by phase.

Keywords: *election, electronic voting, re-engineering, voting*

Introduction

The purpose of this paper is to discuss an electronic voting system, which basically is planned to be implemented in the university environment. Electronic voting has become a heated subject in most countries in Europe, and also in the United States of America. However, the electronic voting system is being implemented only at the country level. Several pilot tests have been conducted and also will be conducted by these countries. Even though the tests are at the country level (parliamentarian), voting process does exist at the lower level, such as in the local election and and also at the organisation level (Krimmer, Triessnig and Volkamer, 2006). Election is also conducted at the student organisational level in higher education institutions. *Universiti Teknologi MARA* (UiTM), which will be the primary user of this information system, has been identified as an experimental user in this research. Therefore, the research scope is only within UiTM Pahang before it can be used by the other campuses or universities. The purpose of the election is to appoint student representatives from each faculty for Student Representatives Council (MPP), and appointed students (winners) will become intermediary representatives between students and UiTM management.

The current method applied in the election is using ballot paper for students to cast their vote. Therefore, in order to switch from the current method of electoral to the new method that incorporates ICT, a re-engineering process of current procedures is compulsory in order to suit the new procedures with electronic voting system that has been developed (Xenakis and Macintosh, 2006). Due to the emerging of ICT, it offers simplification of conventional processes by reducing time, cost, and manpower (Khairul Nizam Abd Halim, Razulaimi Razali and Roslan Jamaluddin, 2006). Some electoral processes will be converted or terminated when ICT is incorporated in electoral processes.

The purpose of this research is to suggest the use of ICT in Student Representatives Council (MPP) election in UiTM, whereby the prototype of the electronic voting system, named as E-Uvote, will be developed and will be tested phase by phase.

Research Methodology

Election parts can be divided into two categories, the "back-end" and "front-end". ICT has been incorporated at the "back-end" electoral processes since the emergence of computer. Electoral board has used ICT to record candidates' profile, vote count, broadcasting the result to the public and so forth. However, the "front-end" still lacks ICT involvement. This has been stressed by Jorba, Ruiz, and Brown (2003). The current electoral method applied in UiTM is still relying on ballot paper at the "front-end" and manual counting process at the "back-end". Therefore, the main purpose of this research is to change the scenario by implementing ICT at the "back-end" and "front-end" of electoral process.

Student Representatives Council (MPP) election in UiTM is conducted individually by every branch campus. This means that each branch campus in the UiTM system conducts its own election. The election is monitored and controlled by the campus' own Student Affairs Department.

Being part of the campus community, the researchers have reviewed the current processes together with important people and departments in UiTM Pahang that are involved in the election. After lengthy discussions, finally, new election processes that will incorporate ICT is released, and agreed by all people and departments (Khairul Nizam Abd Halim, 2008).

In order to re-engineer the current procedures, the researchers have studied one methodology suggested by Xenakis and Macintosh (2006), which applied Business Process Re-engineering (BPR). BPR has been used extensively in different fields such as taxation, Criminal Justice System in UK, and organizational transformation of the National Mapping Agency of Great Britain.

The five stages in the suggested methodology are as follows:

i. Understanding the context of the existing electoral arrangements and the aspirations of the main government organizations concerned;
ii. Modeling (who, what, what, where, and how);
iii. Analysis (why);
iv. Re-design; and
v. Continuity of e-electoral re-design.

The next section will discuss activities carried out by the researchers according to the five stages of generic methodology defined by Xenakis

and Macintosh (2006). The procedural activities are believed to assist researchers in developing the E-UVote.

Re-designing the Current Procedures to New Procedures

This section focuses on re-designing the new electoral procedures according to five stages of generic methodology suggested by Xenakis and Macintosh (2006). Activities of each stage are explained briefly together with the findings of each stage.

Understanding the Context of the Existing Electoral Arrangements and the Aspirations of the Main Government Organizations Concerned

The first stage in this suggested generic re-engineering methodology is to understand the current electoral process, which will be re-designed to an electronic electoral process. With regards to the objective, the researchers have to identify agents in the first place and interview sessions will be conducted with several agents, i.e people who are involved in the election. Johansson (1989) and Xenakis and Macintosh (2006) explained, there are two categories of agents; 1) micro agents who are individual persons, and 2) macro agents which are entities such as organisations and companies. Micro agents are subset of macro agents.

The interview is purposely to gather internal data of previous elections, such as reports, statistics, costing, and so forth. These data are very useful for the modeling and analysis phase because it helps researchers to identify opportunities for improvement in order to understand available culture in the organisation. The researchers have identified the following agents as described in Table 1.

Table 1: Identified Macro and Micro Agents

Macro Agent	Micro Agent
Student Affairs Department (HEP)	Deputy Director of HEP of UiTM Pahang Assistant Registrar of HEP Electoral Officers Student (Voter)

The interviews concern on obtaining information such as tasks of macro and micro agents, responsibilities of each agent, and also, the most important understands the current activities in conducting the election. After collecting the information, the data were used to identify expected input and output of the current activities.

Once all the data had been collected, the researchers conducted data evaluation in order to proceed to the next re-engineering phases. All collected data were documented properly and set as a milestone. Below are opportunities for improvement identified by the researchers after completing this phase:

i. The use of ICT at the "back-end" and at the "front-end" is believed will create a new paradigm of MPP's election in UiTM Pahang;
ii. Critical issue, which is blank vote, can be avoided (Khairul Nizam Abd Halim, 2008);
iii. Cost of papers (ballot papers), human resources, time can be reduced (Khairul Nizam Abd Halim, 2008);
iv. Percentage of students who fulfill their right by casting their vote can be monitored;
v. Real-time result can be broadcast to the right persons or departments using online web-based;
vi. Legitimate voters can be verified quickly.

Modelling (Who, What, Where, and How)

Based on the identified macro and micro agents in the previous phase, the researchers identified the roles and responsibilities for each agent. The identification processes of proposed electronic election solution were based on three basic models available in the methodology of this phase which are as follows:

i. Process stage modeling (what needs to be done and when)
This model enables parallel activities in the election being monitored by agent who is in charge of the whole electoral process. To extend descriptive functionality of each agent, identified agents are included in this process stage modeling.
ii. Contractual relationships modeling (who should deliver what and who expects what)
This model is to show dependencies of deliverables of each agent, who should deliver what and who expects what.

iii. Agent role modeling (how should agent act)
This model focuses on how the agent should act according to his or her identified roles, responsibilities, and activities (which the combination of those activities leads to the overall electoral process).

Table 2 describes the controlling agents for the processes and their responsibilities.

Table 2: Identified Agents with Roles and Responsibilities

Macro Agent	Description (Roles & Responsibilities)
Student Affairs Department (HEP)	Organises, conducts, and monitors electoral process from the beginning until the end • Selects and verifies candidates • Prepares election places • Ensures electoral processes run smoothly • Broadcasts the result to the right receivers
Deputy Director of HEP of UiTM Pahang	Monitors electoral processes and activities • Ensures election preparation is prepared and in place • Announces official election result
Assistant Registrar of HEP	Acts as a system administrator • Enters candidates' & voters' profile into a system • Assigns election officers • Opens and closes electronic voting system
Electoral Officers	Monitor electoral activities at the voting terminals/places • Open and close voting terminals • Verify students' identification before they are allowed to cast their vote • Assist students if they experience problems at the voting terminal
Candidates	Check and verify voting server before the election starts • Provide profile to Assistant Registar of HEP • Ensure voting server is fraud-free
Student (Voter)	Casts vote at the voting terminals • Ensures bring along legitimate identification during the election day • Fulfills right and responsibility to cast vote

Analysis (Why)

Here, the researchers have conducted analysis towards all the collected data. The purpose in conducting the analysis is to understand process stages, contractual relationships and roles of identified agents. The understanding of existing processes is described in the Table 3 below. The next stage is where researchers entered the re-design process of existing electoral process. The brand new processes are based on the existing processes except several processes are converted to the electronic due to the ICT capabilities.

Table 3: Existing Processes Used in Current Election (Khairul Nizam Abd Halim, 2008)

Steps	Description
# 1	Ballot box is checked by candidates or candidates' representative
# 2	Open voting terminals
# 3	Only registered and qualified voters are allowed to proceed to voting terminal after fulfill these two conditions:Voter has valid student cardVoter's profile exists in registered and qualified list
# 4	Voter will be given a ballot paper
# 5	Voter goes to voting terminal to cast his/her vote
# 6	Voter votes candidates
# 7	Voter put in the ballot paper in ballot box
# 8	E-UVote asks for a confirmation from voter
# 9	E-UVote throws a successful message after confirmation is completed
# 10	E-UVote stores digital ballot paper in the server
# 11	E-UVote will repeat Step # 3 for next voters
# 12	When election time period is over, electoral board will close all voting terminals, monitored by candidates or candidates' representative
# 13	E-UVote will broadcast the results as follows automaticallyPercentage of voters who cast their votesElection result
# 14	Broadcast the election result

Re-design

At this stage, the expected outcome is the new re-design electoral process as shown in Table 4. A second round of interview was conducted in

Table 4: New Election Processes Incorporated with ICT (Khairul Nizam Abd Halim, 2008)

Steps	Description
# 1	E-UVote's server is checked by candidates or candidates' representative
# 2	Electoral officers open all voting terminals and monitor by candidates or candidates' representative
# 3	Only registered and qualified voters are allowed to proceed to voting terminal after fulfill these two conditions: 1. Voter has valid student card 2. Voter's profile exist in E-UVote system
# 4	Registered and qualified voter proceed to voting terminal
# 5	E-UVote verifies student number and NRIC of voter
# 6	E-UVote reveals candidates to voter on the screen
# 7	E-UVote verifies voted candidates selected by voter, and ensure only two candidates are voted
# 8	E-UVote ask for a conformation from voter
# 9	E-UVote throws a successful message after conformation is completed
# 10	E-UVote stores digital ballot paper in the server
# 11	E-UVote will repeat Step # 3 for next voters
# 12	When election time period is over, electoral board will close all voting terminals, monitor by candidates or candidates' representative
# 13	E-UVote will broadcast the results as follows automatically 1. Percentage of voters who cast their votes 2. Election result
# 14	Broadcast the election result

order to clear cut several parts before the new election processes were created. As the process progresses, the electronic voting system, named as E-UVote was already at the construction stage. Findings from this generic methodology have become requirements to the construction of the information system.

As mentioned earlier, some processes will be converted or terminated when the use of E-UVote is decided. Ballot paper will no longer used be in the coming election. Since ICT offers advanced technology, it also comes with greater speed, accuracy of ballot tabulation, and greater convenience for voters Jorba, Ruiz and Brown (2003). Digital ballot paper will be calculated automatically, thus, real-time election result can be broadcast to the right people or departments during the election time

period. The most important thing is, it is believed to able to reduce vote blank, which normally occurs in the conventional method.

The need to re-engineering the current electoral process is very important since ICT will replace current processes that is no longer needed when ICT is applied. Reviewing and comparing current and new electoral processes are necessary in order to come out the new electoral processes as shown in the Table 4.

Continuity of E-electoral Re-design

Entering this stage means more research will and should be conducted in the future. Areas such as security of the electronic voting system, trustworthy, transparency, and few other areas have become primary concerns in this matter. New requirements from environment that lead to the change of the information system for improvement will be considered carefully as well as other technological issues such as social and government issues.

E-UVOTE: System Architecture

This section discusses the electronic voting system which is called E-UVote. As mentioned earlier, findings from applied methodology will become inputs to the development of this information system. The development is based on generic software development methodology called Software Development Life Cycle (SDLC) (Shelly, Cashman, & Rosenblatt, 2003). Figure 1 illustrates data flow diagram of E-UVote. Three entities were identified: 1) System Administrator, 2) Voter, in this case, a student, and 3) Management, which is the Student Affairs Department (HEP) and also the Chancellor of UiTM or Campus Director of UiTM Pahang. This information system will deliver real-time election result and statistics to identified management entities online.

Before the election starts, System Administrator has to ensure qualified voters' profile, candidates' profile, and electoral officers' profile are already uploaded in the database and it must be agreed by all people, the Management and candidates. This electronic voting system only allows qualified and registered voters to cast their votes. Qualified and registered voters here means only UiTM Pahang students who have permission to cast their votes. This is one of the security measures that will be applied in this electronic voting system.

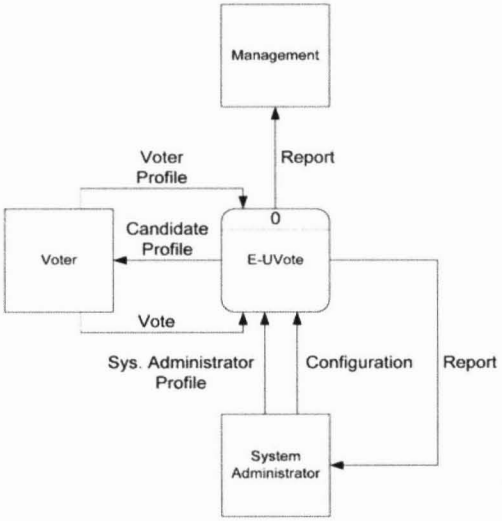

Figure 1: Data Flow Diagram (DFD) of Proposed E-UVote (Khairul Nizam Abd Halim, 2008)

The next step is to represent the system architecture of the proposed system in Unified Modeling Language (UML) to provide crystal clear perspective to all users. The four identified users or actors of the system which are: System Administrator, Management, Electoral Officer, and Voter (student). Actor is a person who interacts with the system, i.e a person who uses the system. Each actor has their own roles towards the system.

All four identified actors will go through one security identification except for Management that does not have to because they are only permitted to view the real-time results and statistics. In the proposed electronic voting system, the security identification that is going to be applied are: 1) username and password, which will be used by System Administrator and also Electoral Officer to access the electronic voting system, and 2) UiTM's student number and Malaysian National Registration Identification Card (NRIC) number for voters, in order to allow them to cast their votes.

In the future, more research will be conducted exactly in the area of electronic voting system security identification especially at the front-end. Several identification methods that have taken into account are Transaction Number (TAN), biometrics, and smart cards. Those methods have been mentioned by Krimmer, Triessnig and Volkamer (2006), instead

Table 5: Identified Actors and Their Roles in UML

Actor	Roles
System Administrator	Ensure system is ready to be used during the election Upload list of legitimate voters and candidates into the system Manage login account for electoral officers Run final check witness by candidates and management Manage the opening and closing of E-UVote based on given time duration Manage real-time results and statistics are broadcasted to right receivers
Management	Ensure legitimate voters and candidates have been uploaded Monitor real-time results and statistics
Electoral Officer	Run voter's identity identification before allowing voters to voting terminal
Voter	Cast vote at the right voting terminal

of applying the username and password method. Transaction Number (TAN) is widely used in the web application and online banking. Usually, few combinations of alphanumeric characters generated by system are used to execute one transaction or more. These numbers only last for few hours before it expires. Therefore, this method is relevant to be used in electronic voting system, where, each voter will have their own transaction numbers generated by the system after they successfully go through identity identification. These numbers will be used again at the voting terminal where voters have to enter the transaction numbers together with their UiTM student number or/and Malaysian NRIC number.

The biometrics method requires voters to have unique and individual biometrics properties such as fingerprints, and, cornea or iris images. These properties will be stored in special memory card or computer. By using biometrics, a special kind of biometrics reader depending on what kind of biometrics method is required. Another method is smart card where it can be implemented easily if each student of UiTM Pahang has his/her own card. Supposedly, property pattern of voter is stored in his/her smart card and electronic voting system will check through smart card reader against the voter's property when casting a ballot (Krimmer, Triessnig and Volkamer, 2006). Further research will be conducted in the security area in order to provide better security as it prevents from

unnecessary situations such as identity theft or fraud, DOS, hacking, and few others that able to create disaster. The research is believed will help the university to decide what kind of security method to be applied and the decision will be based on the results of the research.

The E-UVOTE Enable Voting Through Intranet

The actual implementation and operation of E-UVote is within the Local Area Network (LAN) of UiTM Pahang. Management, to be more specific, Student Affairs Department (HEP) will decide numbers of voting terminals to be placed in a few strategic places, where, each programme will have one place, and one place can have more than one voting terminals. The Student Affairs Department (HEP) is responsible to appoint electoral officers who will manage and monitor the electoral processes at the identified places. Before the election could start, the System Administrator has to upload the list of voters and candidates into the system. On the day of the election, all candidates, management, and electoral officers will be invited to run final check on the system to ensure that the system does not receive any vote before the election starts. Once everything has been agreed and confirmed, the System Administrator will open the system. Here, electoral officers will be informed first that the system has been opened and officers will log into the system to open voting terminal. Two security measures will be applied to open the system, first by the System Administrator, and second by the electoral officers.

One electoral officer will run the identity identification of a voter by checking information in student card against data on the system. If the system shows voter has legitimate data, then he/she will be allowed to proceed to voting terminal. At this point, a voter has to enter his/her student number and Malaysian NRIC number into the system to view voting screen. Each voter is allowed to vote at least two candidates. If he/she chooses less or more, the system will throw an error message to choose again. Before submitting the digital vote, a confirmation message will be prompted asking a confirmation from voter. As long as the voter does not click to confirm, he/she will be able to change his/her vote. However, if the voter chooses to confirm the votes, the digital votes will be submitted to the system, and the votes are counted. This will update the current voting statistics at the back-end. Next, the voter is allowed to leave the voting area soon he/she fulfill his/her right. The system will

record date and time every time voters cast their votes. This will prevent redundant votes by the same voters. It is considered as a security measure applied into the system. This system has the capability to show which voters do not fulfill their rights yet. Therefore, the management, through the Heads of Programme in UiTM Pahang is able to inform the voter to attend to the voting place immediately. This is one of the system requirements needed by the management.

The real-time results and statistics are broadcast through the UiTM's Local Area Network (LAN) called UiTM*Net to allow the management in UiTM Malaysia to view the results and statistics. Election is conducted within determined time interval. Once the closing time is reached, the System Administrator will close the electronic voting system server. One single click will close the system immediately. Then, the real-time results and statistics will go through final check by the management of UiTM Pahang and all candidates. Once every party agrees, the Deputy Director of Student Affairs Department (HEP) will officially announce and declare the results as official.

The Infrastructure

The basic infrastructure of E-UVote is composed of the network and a server. It has been decided that E-UVote will be running on UiTM's LAN, the UiTM*Net. The server is protected by few layers of firewall. Since the electronic system will be running on UiTM*Net, it cannot be accessed from the Internet. The server will use IIS web server to host the electronic voting system. Voters' profile and digital vote's data are placed in the same database. Even though voters' profiles originally come from different database, in order to avoid inconsistent speed or slowness of the electronic voting system, developers have decided to use one database only. Regarding the full control of the E-UVote possessed by System Administrator, the appointed person will be able to open and close the system at any time, and appointed electoral officers will be able to open voting terminals where he/she is assigned at. Electoral officers will not be able to open the terminals unless System Administrator opens the electronic voting system.

The Security

The first prototype of E-UVote will use username and password as a security at the administrator's side, and student number and Malaysian NRIC number at the voter's side. However, the researchers have looked forward to conduct research on several other security methods that suitable for E-UVote. Chevallier, Warynski, and Sandoz (2006) suggested 11 criteria of security specification defined by COE (2003). However, the specification is for national implementation, which is bigger than organisation level. Some of the specifications are useful and will be considered to be applied on E-UVote. The 11 criteria defined by COE (2003) are as in Table 6. Based on Table 6, it can be seen that only one criterion does not match with the electoral requirements in UiTM. It is because each voter has two votes but the voter has one opportunity to vote and it must be within interval time of election. As the electoral processes run, System Administrator has to make sure the hardware and software work correctly. Once the electoral time is over, the System Administrator will close the system and disconnect the system from

Table 6: 11 Criteria of Security Specification Defined by COE (2003)

No	Criteria	Checked
1.	Votes must not be intercept, modified, or diverted	✓
2.	Contents of a vote must not be knowledgeable to any third party before the counting procedures	✓
3.	Only person enjoying the right to vote can participate	✓
4.	Each voter has only one vote and can vote only once	×
5.	It must never be possible to connect a voter and his/her vote, even during the counting procedure	✓
6.	The system must be able to resist denial of service (DOS) attacks	✓
7.	Voters must be protected against identify theft	✓
8.	The number of voters emitted must be equal to the number of votes received	✓
9.	Any difference must be clarified and corrected (possible to prove voter has voted)	✓
10.	The system accepts votes only within the interval time of voting	✓
11.	Assigned authorities must be able to verify that the system works correctly	✓

network and being online. Soon after the election results are declares as official, the system will get back to online by displaying necessary information such as results and statistics to the right receivers.

Scalability

E-UVote pilot test has been planned before it can be used on the actual election day. The test will be simulated according to actual situation but the number of voters is smaller than the actual one. UiTM Pahang has about 5000 students and this is the number that is going to use E-UVote. The pilot test is very significant to ensure E-UVote is capable in handling this huge number of voters. The first test will be done with smaller number of voters, while second test will involve huge number of voters, mostly during peak hours during whcih these voters have finished their classes. The test will also be very useful to determine the election server is capable in handling heavy loads and also unexpected situation. This is very important to see the scalability of E-UVote.

Conclusion

The introduction of E-UVote as an electronic voting system to be used in UiTM Pahang hopefully will create a new paradigm in voting procedure. However, many issues have to be evaluated and examined before it can be fully implemented. Switching manual or half manual voting procedures into computerized one probably will lead to unexpected risks that should be realised in the early phase. Going online means it opens to vulnerability such as DOS attack, hackers, and so forth. Proper and strong security needs to be in place to avoid unexpected situation.

In addition, the roles and responsibilities of identified people or agents who are involved in the e-electoral process have to be made clear. This will lead to a better understanding of who should be doing what in order to avoid redundant tasks performed by different agents. Most importantly is the support from UiTM Pahang's management as support from management can drive and determine the success of this electronic voting system – E-UVote.

References

Xenakis, A. & Macintosh, A. (2006). *A generic re-engineering methodology for the organized redesign of the electoral process to an e-electoral process*. International Teledemocracy Centre, Napier University, Edinburgh.

Jorba, A. R., Ruiz, J. A. O. & Brown, P. (2003). *Advanced Security to Enable Trustworthy Electronic Voting*. Retrieved October 12, 2008. http://citeseerx.ist.psu.edu/viewdoc/summary?doi=10.1.1.85.1169.

Chevallier, M., Warynski, M. & Sanchoz, A. (2006). *Success Factors of Geneva's e-Voting System.* The Electronic Journal of e-Government, 4(2), 55-62.

COE (2003). *Code of Good Practice in Electoral Matters, Recommendation 1595 [online].* Council of Europe. Retrieved on 10 October, 2008 at http://assembly.coe.intl/Documents/WorkingDocs/DOC03/EDOC9978.htm.

Johansson, I. (1989). *Ontological Investigations: An Inquiry into the Categories of Nature, Man and Society*. London: Routledge.

Khairul Nizam Abd Halim, Razulaimi Razali & Roslan Jamaludin (2006). *e-LEva Medium Penyelesaian Masalah Pengurusan Sumber Manusia Akademik.* Paper presented at the 2006 Konferensi Akademik UiTM Pahang, Pahang, Malaysia.

Khairul Nizam Abd Halim (2008). *E-Undi: Satu Penyelesaian Kepada Isu Pelangan Universiti.* Paper presented at the 2008 Science, Technology & Social Seminar (STSS) UiTM Pahang, Malaysia.

Krimmer, R., Triessnig, S. and Volkamer, M. (2006). *The Development of Remote E-Voting around the World: A Review of Roads and Directions*. Competence Center for Electronic Voting and Participation (E-Voting CC) Vienna, Austria, and, University of Passau, Institute for IT-Security and Security Law, Germany.

Shelly, G. B., Cashman, T. J. & Rosenblatt, H. J. (2003). *System Analysis and Design (5th ed.):* USA: Thompson Course Technology.