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College Electronic Voting Environment (CEVE)

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Abstract: The traditional usage of the pen and ballot paper to elect new student leaders at the College of Computing and Information Sciences (CoCIS), Makerere University has been rendered ineffective due to various recurring errors. Long tedious queues, ballot stuffing allegations, voting multiple times, high operational expense, depict the voting process at CoCIS. The study therefore aimed at developing an electronic voting environment to address these challenges. We reviewed literature and studied the current voting process to attain the user and system requirements. The key design tools were Entity Relationship Diagrams (ERDs), Context Diagrams and use case diagrams. Through extensive user involvement and research, we developed and implemented using Hypertext Preprocessor (PHP) and Structured Query Language (MySQL), tested and validated a fully functioning system to solve the challenges. The College Electronic Voting Environment (CEVE) automates the current manual voting process such that voters register and cast votes online from anywhere as long as they have internet access.

Keywords: College, Electronic Voting, Voting Environment.

1. Introduction

Electronic voting is emerging as significant alternative to other conventional systems in the delivery of trusted elections. It embraces both electronic means of casting a vote and electronic means of tallying votes. Electronic voting technology includes specialized voting kiosks and involves transmission of ballots and votes through private computer networks or the internet. According to Jordi, (2012), pilot e-voting projects have run in Estonia, France and Switzerland but the main areas of focus are trust, privacy, voter freedom, accessibility and the role of stakeholders.

At the College of Computing and Information Sciences (COCIS), voting is an annual process that has over the years been handled with utmost professionalism and competence by both the voters and electoral committees using the traditional pen and ballot mechanism. The manual voting faces a number of challenges including human errors, inability for remote voting, ballot stuffing allegations, long queues, multiple voting, and high operational expenses among others. Voters are subjected to long tedious queues in difficult weather conditions that lead to time wastage during the election process. This has contributed to low voter turn up and dissatisfaction with the voting process. This manual voting process leads to wastage of resources like paper and manpower. Furthermore, it is shunned by many students due to the hard to bare circumstances involved on election days. Observations show that only one ballot box is used for a population of close to 7,000 students which has led to deliberate boycott. Therefore, there was need for an automated college electronic voting system to solve these challenges. We therefore developed a

system that enables students to vote for college leaders regardless of physical location with less human intervention.

2. Objectives

The main objective was to develop a fully functioning electronic voting environment for CoCIS. Specifically we studied the current voting system to establish the necessary user and system requirements needed for developing the environment. We then designed, implemented, tested and validated the environment. The scope of this project was basically CoCIS where the investigations were carried out. The sample population was the College Electoral Commission, student electorate and the administrative staff. System utilization does not have a geographical limitation, as long as voters are authenticated as CoCIS students, they can cast a vote from any location.

The project is significant because it is a more secure Electronic Voting Environment. The developed system uses Message-Digest algorithm 5 (MD5) checksum encryption scheme to protect the privacy of voters' credentials. The CEVE efficiently generates a detailed voters' register with minimal or no errors. After voter registration, a detailed voters' list is ready for download for reference. The system reduces costs and expenses that have been incurred as a result of the manual voting system. Currently, close to 7 polling assistants are employed for the oversight of the manual voting process. After successful implementation, CEVE will render such manpower unnecessary since it requires single entrusted personnel for operation. Voters with internet access can cast their vote online from anywhere. Considering the issue of timeliness, not all students at CoCIS get time to move to the college premises to vote due to other jobs commitments. However, the designed voting environment caters for such issues through the use of the internet. The project will be used by researchers to develop related electronic voting environments. Therefore, once successfully implemented at CoCIS, CEVE will act as a pilot e-voting system to others to be implemented in the future.

3. Methodology

This section presents the methods and techniques that were used in data collection, analysis, designing, implementation, testing and validation and how the objectives were achieved generally. We used the Systems Development Life Cycle (SDLC) approach which is a seven-step process that contains a procedural checklist and the systematic progress required to evolve an IT system from conception to maintenance. We describe the seven phases of the SDLC followed when developing CEVE below: -

Conceptual planning was the first step of the system's life cycle where we defined and committed resources like time to the project. During requirements elicitation, observation and questionnaires were used to gather system and user requirements. Participatory observation of the current environment gave us a closer chance of identifying what the students' need. The observation method involved a careful study of the current voting system to understand the data flow of the whole election process. This method was cheap, easy to use, and readily available and helped us to learn about the problems involved in the current election process. We made use of available tools like Microsoft Excel that provided aggregate functions and other necessary quantization while observing.

Open and closed questions were used in the questionnaires to collect data, because they maintain uniformity and cover many respondents in a short time. The College has a fairly large population size that could not be reached for opinions in a short period of time. Purposive sampling was used when choosing the questionnaire respondents because we wanted to collect requirements quickly and proportionality was not the main concern. Students who had cast a vote in the recently concluded College elections were chosen as

respondents. We used "Sample Size calculator" sampling tool available on surveysystem.com to determine the sample size. With a confidence interval of 1 and a sample size of 50, 95% was the average confidence level realized. During the course of the two days elections, a sample size of 50 respondents was given questionnaires that they filled in and handed back at the voting station. Respondents were handed 5-tickable agreement options consisting of "Strongly Disagree", "Disagree", "Neutral", "Agree", and "Strongly Agree" and indicated how they agreed or disagreed with a given statement, and had space to formulate their replies. Data collected was closely studied, edited and compared removing inconsistencies, so rendering it useful to the researchers. It involved looking for key responses that drove the group's activity, patterns of behaviour, testing data sources against each other, triangulation of data and reporting findings in a convincing and honest way to produce information that was accurate, relevant and viable in system design and development. Data was processed and analysed to determine the system requirements and documented for future reference with limited effect on validity and reliability. Microsoft Word and Excel provided tabular representation of findings and aggregation respectively as depicted in table 1 to draw meaningful conclusions from the respondents.

Table 1: Tabular Representation of results from Questionnaire Analysis

Question Number	Response per Question		Percentage of Sample Size	
1 (one)	17 had voted once		34%	
	19 were voting for the 2nd Time		38%	
	14 were voting for the 3rd Time		28%	
2 (Two)	12 respondents answered with Yes		24%	
	38 Had "No" as the answer.		76%	
3 (Three)	0 respondents had used an electronic voting before.		100%	
4 (Four)	No response since none had used an electronic voting system before.		0%	
5 (Five)	45 strongly Agreed	5 strongly disagreed	90%	10%
6 (Six)	Rated Poor by None		0%	
	Rated Fair by 19 citing time wastage, tiresome etc.		38%	
	Rated Good by 31		62%	

From the results it was in no doubt that the representative population supported the idea of an automated electronic voting system. However, none of the representative population had used an electronic voting system before and thus universal usability principles were used while developing the system. The results showed that however much the representative population supported the realization of the system, a bigger percentage (62%) of them rated the current voting system "Good" thereby giving an implication that the system will not replace manual pen and ballot but rather will operate as a parallel system or act as an alternative to voters. 76% said the system was unfavourable coz of long tedious queues and the fact students who study in the evening have to forego work commitments to cast a vote. This triggered the necessity of having the system accessed through the World Wide Web rather than over a private network. Finally, the results further indicated that the biggest number of voters was 2nd year students, followed by 1st year students and then 3rd year students with the least percentage.

The system study findings show that the current voting process at CoCIS is completely paper based, that is, from gathering the voter details to voting, data is written on paper, and so there are mistakes and corruption in the process. The weaknesses of the existing system

include expensive paper and logistics, high costs for paying the polling agents, ballot boxes, and long queues on election days. Many students despise voting due to the time wasted while waiting to cast their votes, multiple voting and rigging because the polling agents are fellow students.

Based on the challenges with the existing system, system requirements were determined, both functional and non-functional requirements. The Functional Requirements are specified the inputs the system should accept like students registration number, the outputs the system produces like the interface to cast the vote, the data stored that other systems might use like student details, voting status and the ability to export raw data for further analysis. Non Functional Requirements are the specified criteria that was used to judge the system operation, rather than specific behaviour. The non-functional requirements include the following: -

- Availability of CEVE for operations and use.
- Efficiency specifies how well the system utilized scarce resources like CPU cycles, disk space, memory, bandwidth, etc.
- Flexibility is the possibility of incorporating new functionalities into the system in future to cater for growing user needs and was catered for right from the design, development, testing and deployment of the system.
- Portability specifies the ease with which the system was installed on all necessary platforms and the platforms on which it run.
- Integrity defines the security attributes of the system, restricting access to features or data to certain users and protecting the privacy of system data.
- Performance constraints specified the timing characteristics of the system. Voting is time-sensitive, since it has to be done within a specified time period.
- Reliability specifies the capability of the system to maintain its performance over time. Since voting is sensitive the system should never fail.
- Reusability indicates the extent to which software components were designed in such a way that they can be used in applications other than the electronic voting environment.
- Robustness is important for error handling without failure and includes tolerance of invalid data, software defects, and unexpected operating conditions.
- Scalability specifies the ways in which the system scales up like increasing hardware capacity and adding machines.
- Usability stipulates the ease of use factors that constitute the capacity of the system to be understood, learnt and used by its intended users.

3.1 System Design

System Design is the process of defining the architecture, component models, interface and data for the system to satisfy specified requirements. It is concerned with how the system functionality is provided by different system components. During design, conceptual and logical models were developed using the Universal Modelling Language (UML) and enabled us to gain a clear understanding of the database objects and the relationships amongst the different entities. The data and the system were modelled using Entity Relationship Diagram (ERD), context diagram and a use case diagram because they were easy to use and interpret. ERD was the main tool for data modelling since it shows the clear breakdown of entities, the relationship between them and their attributes. The context diagram (*Figure 1*) was used for process modelling and gave the graphical representation of a system's components, processes and interfaces between them.

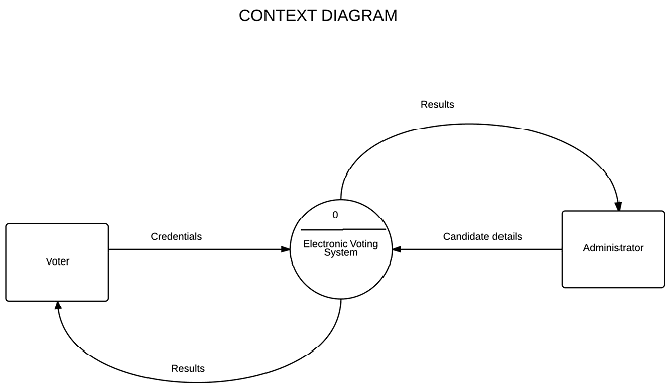

Figure 1: A Context Diagram for the Electronic Voting Environment

A use case diagram (*figure 2*) is a representation of a user's interaction with the system depicting the specifications of a use case. It portrays the different types of users in the system and the various ways they interact with the system. The use case diagram has several actors explained below: -

- Authentication: - the actors (administrator and voter) have to be authenticated before interacting with the system functionalities. It involves registration, providing a username and password to prove that a stakeholder is who they claim to be.
- Voting: - the actor voter is central to the process of voting and they cast a vote for a preferred candidate.
- Nomination- the actor voter can be nominated for a particular post within the voting system.
- Reporting - the administrator actor is central to reporting and is expected to provide election results after voting has been concluded.

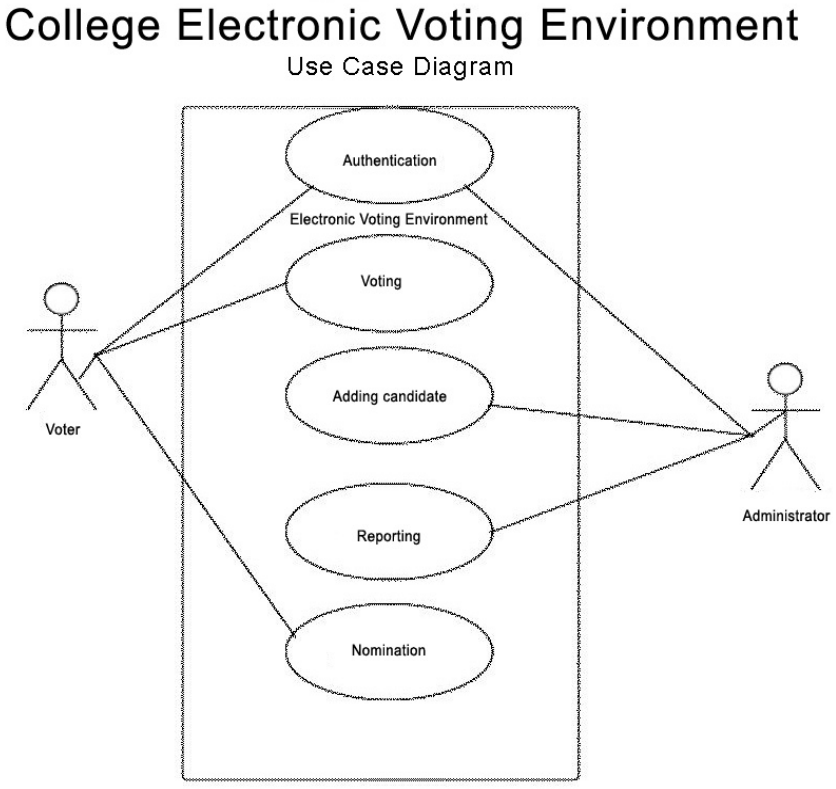

Figure 2: A Use case For the CEVE

System Architecture is a high-level view was used to describe "top-level" goals of the system and its overall features. It was more abstracted and typically more concerned with the voting environment as a whole elaborating the data storage, and how it is accessed by the different stakeholders. CEVE was implemented using client- server architecture with a relational database as a central sever tied to a secure web interface that is used to perform transactions against the database. Figure 3 below represents a high level view of the electronic voting environment.

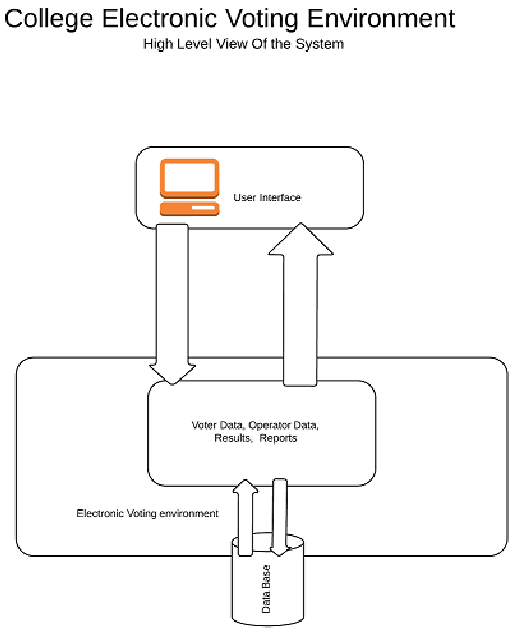

Figure 3: A High Level Representation of the Electronic Voting Environment

4. Technology Description

During Implementation of the web application, Hyper Text Markup Language (HTML) was used for page design because of the ease with which other languages can be fitted in its code. The front end which is the interface of CEVE was created using HTML which is a client side scripting language. The actual database was implemented with Standard Query Language (MySQL) because of its good compatibility with Hypertext Pre-processor (PHP), Java scripts and HTML. The back end - server side script used PHP to connect to the database. PHP code is interpreted by a web server with a PHP processor module which generates the resulting web page. PHP, Java script and Java applets were embedded in the HTML for database connectivity, validation, form management, and dialogue. These tools were chosen because they are simple to work with and can be used concurrently. Apache software was used as the web server because it is free and can run on different operating systems. In addition, Cascading Style Sheets (CSS) were used to define the appearance and layout of text and other material in the interface. CSS gave a rich interface and nice blend of college colors into the system as depicted by the screenshots. The result was a well-developed system that meets user needs and requirements.

The College Electronic Voting Environment (CEVE) has a front-end user interface for users to interact with, and a back-end database where candidate and voters details are stored. The students are required to register in the system before they can log in. The CEVE system was designed on the basis of a web-based environment that simplifies and automates the voting and application process. This ensures that college students cast votes with convenience thus increasing the number of voter turn up for student leader elections. The system is accessed through a Universal Resource Locator and rendered in a web browser over a network. The system generates history logs regarding what activities the

administrators / operators carried out on the system. The election commission authority is authorized to access the details but do not have permission to modify the details unless a collective decision has been made. Therefore the system minimizes rigging, diminishes corruption, and controls fraud by allowing only the system administrator to register voters. Voters are required to log into the system using their usernames and passwords. After, a voter has cast a vote, they cannot log into the system again to prevent multiple voting. In the system a voter selects their preferred candidate on a web interface where contesting candidates are displayed. Furthermore, the system generates MS Excel reports regarding the voting progress.

Figure 4 shows the interface that a voter accesses when the URL address is put in a web browser. It also has provision for a voter to be authenticated into the system to perform the desired functions.

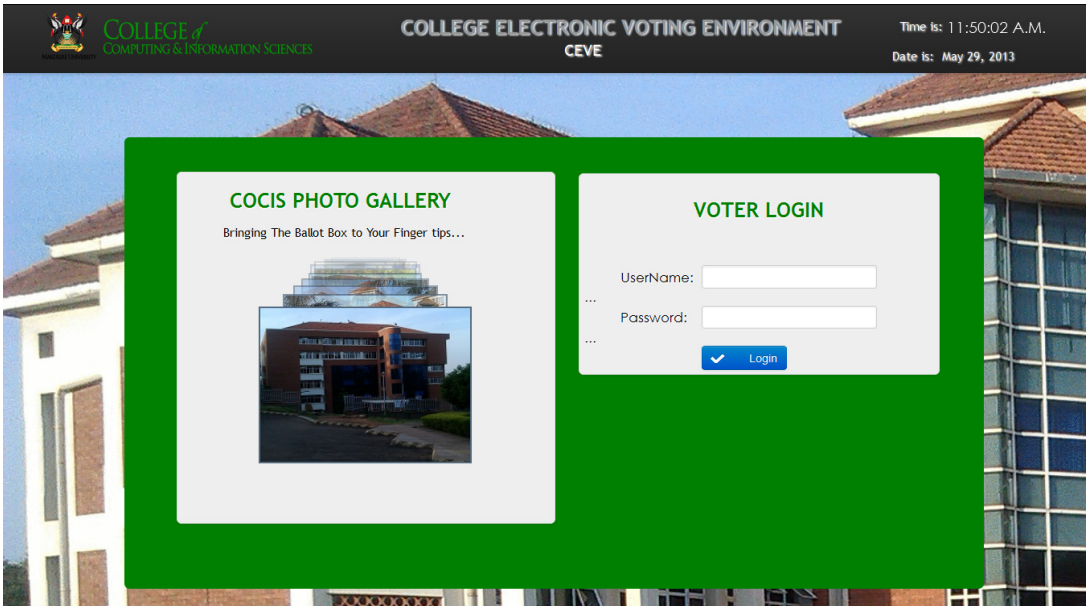

Figure 4: Voter Authentication

Figure 5 is a representation of the voting interface that appears after authentication. The candidates for president and vice president appear above the guild representatives.

Figure 5: Voting Interface

5. Developments

Testing was done by individuals with expertise in the field of electronic systems. The system was checked against a functionality checklist using documented results obtained from the investigation process. Testing involved internally checking the implemented system by the developers to identify errors and weaknesses for correction before presenting it to the intended users. Unit testing involved testing each system module while integration testing studied how two (or more) units worked together within the system. System testing was then carried out when all the modules were integrated. The results of the tests were systematically recorded to audit and check that it had been done correctly. The system suffered from compatibility impairments across different web browsers but changes were made to rectify this issue. The various system modules including user registration, authentication, activity logging, report generation, feedback, and database administration were tested using sample data. The database triggered MySQL warnings onto the voter and users' interface which raised concern for code review and was corrected.

The Validation process checked input data to ensure that it was complete, accurate and reasonable. Although it was impossible to guarantee that valid data was entered into the system, a suitable combination of validation checks were implemented to ensure that most errors were detected. During user validation the complete system was presented to end user representatives who verified that the developed system addressed all requirements and satisfied the intended user needs. As a result, adjustments were made accordingly to make sure the system was more user-friendly and it was availed to the users thereafter. For validation results, sample data was used and the system manifested its ability to cast votes, add voters and candidates, export reports and perform other functions as required by the users.

5.1 Client Side Validation.

End users always make mistakes whilst filling out web forms. By validating form responses before being accepted by the system, users will be notified of their possible mistakes which helps to improve user experience. JQuery validators were employed to make client side validation a success.

Figure 8 shows testing database connectivity. It took us time to realize that the default password and username for the server side software (Ampps server) had a default password hence the message "No database selected".

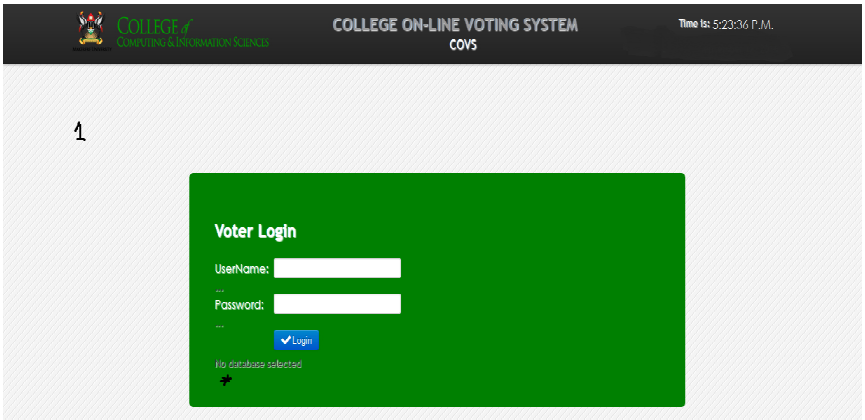

Figure 6: Testing authentication logic.

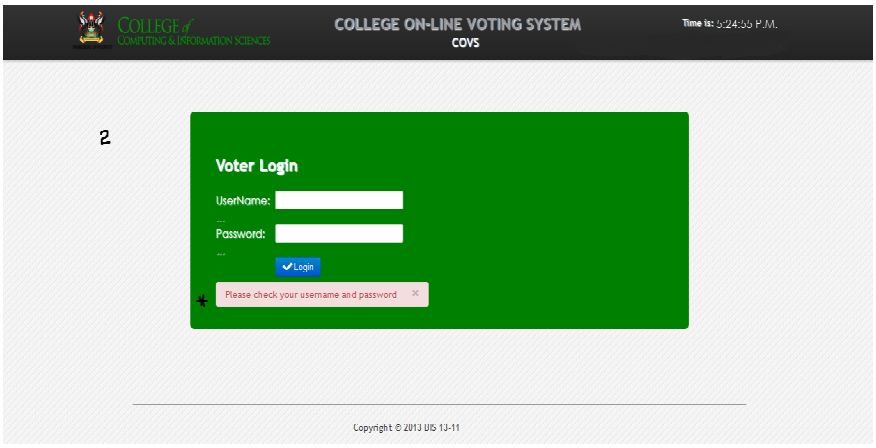

Figure 7: Testing authentication logic.

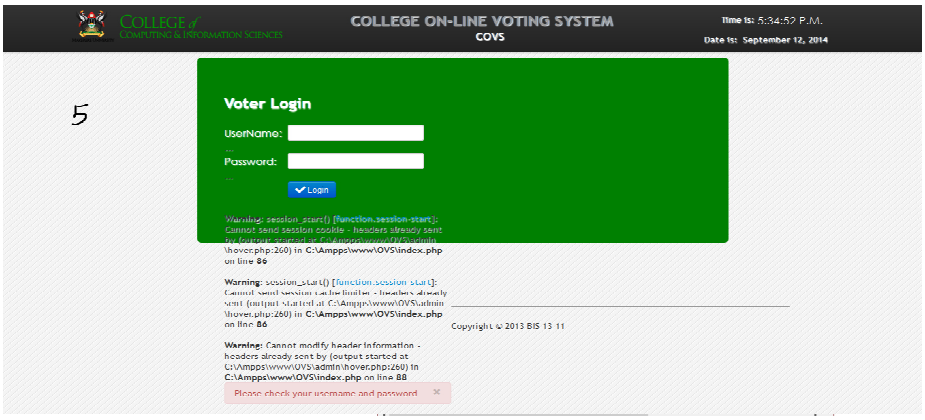

Figure 8: Testing Database Connectivity

However, a major challenge was faced after system development and implementation. The system was designed to be used through a web browser client and a given section of students manifested insufficient web browsing knowledge during the test cases to efficiently utilize the developed environment. This challenge was however addressed by training. Issues with cross browser incompatibility were also faced and still need to be addressed in future developments.

5.2 Server Side Validation

In *figure 9*, we tested the ability of the system to establish a session for two different users (Admin and voter) at ago. Success was achieved after using the "E_ALL & ~E_NOTICE " function in the "Php.ini" file located on the server to identify and test against any possible errors like the one in screenshot 4 and 5.

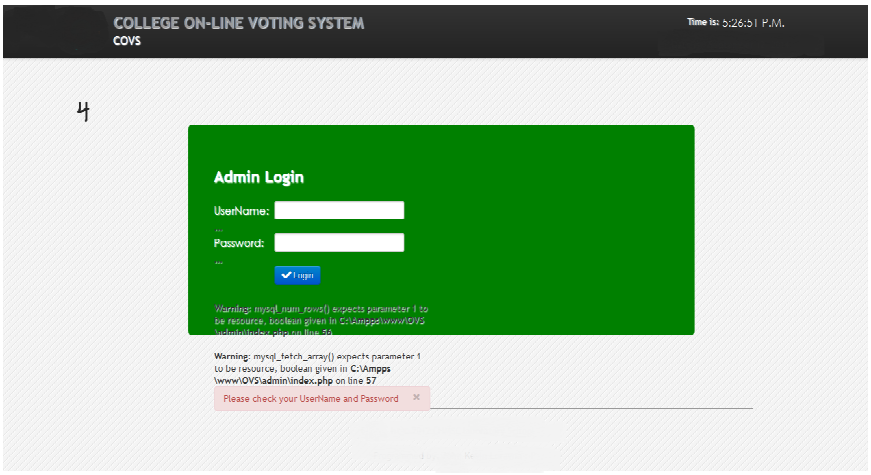

Figure 9: Trails with Session Establishment.

6. Results

In spite of the large amount of research published in the field of e-Voting, there are still many possibilities to advance our understanding of e-Voting research and practice. Most research has been done on applicants' attraction, image and perception of Nations and agencies. The navigational usability of the applications affect stake holders like voters, polling agents and others. The influence of e-voting on the overall election process has received little attention worldwide. But above all is the need for a lot more research of the entire e-Voting field, to address the huge amount of gaps and confirm current knowledge. The electronic voting environment promises a lot to the future of e-voting.

The results and findings can be used as a basis for developing another e-voting system for a bigger scope. Researchers need to work further on the operation compatibility of the system in a UNIX environment, because the electronic voting system exhibited undesired effects when deployed on a Linux server during test cases .We highly recommend that future work should consider the need to automatically deny voters access to the system after a desired time period.

7. Business Benefits

The researchers feel that the main objective to develop and implement a system that enables COCIS students to vote for their leaders without geographical limitations was achieved. A lot of effort has been put in developing the electronic voting environment and consultations from influential personnel have been vital. The stakeholders identified in e-Voting include college administration who own the system after its development and realization, CoCIS students who are the electorate in this case, student leaders (electoral commission) charged with monitoring and supervising the voting process and finally the candidates aspiring for posts. Electronic Voting entails casting votes using electronic devices connected to a Local Area Network, a Wide Area Network or any other type of network. The achievements of the research include the following: -

- The ability to deal with complex elections easily.
- Less polling staff with a simpler process which guarantees proper time management and less fatigue.
- Reduction of regular mistakes at the polling center since there is no need for issuing and monitoring ballot papers and boxes.
- Elimination of invalid and incorrect ballots to save time.

- Accurate tallying of results which elaborate clearer progress and vote status, hence reducing rigging.
- Improved ballot accessibility which makes the process more engaging to more literate groups.
- The system provides a high level of voter anonymity which helps keep the voting process private.
- There is a possibility of a voter casting the vote later after they have been logged in which makes the process convenient.
- The system administrator reviews the registered details to verify that only COCIS students are on the voters' list.
- The system was developed with a non-repudiation functionality that logs all activities that system administrators and/or operators carry out when logged into the system.
- The ability to export results into a MS Excel file provides for ability to manipulate results further.

However, a major challenge was faced after system development and implementation. The system was designed to be used through a web browser client and a given section of students manifested insufficient web browsing knowledge during the test cases to efficiently utilize the developed environment. This challenge was however addressed by training.

8. Conclusions

During the study, existing systems and e-voting portals were considered, analyzed and their weaknesses noted. Literature review about related and existing systems was analyzed and an electronic voting system with improved functionalities was developed. The implementation was done using PHP and MySQL, tested and validated to address the user requirements.

We recommend that once installed, the system should also be used for other voting events apart from college student leaders only. The system can be used to vote for college administrators by the senior and junior academic staff and can be improved for national elections. This calls for further research by groups and individuals about the use, development and management of electronic voting systems.

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