mVote: A Mobile Voting System to Conduct Election during COVID-19 Pandemic

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Abstract—Over years, the voting system has been a democratic way to make a collective decision to express an opinion or selecting a leader. In organizations, voting can occur to elect members of the committee or to choose the roles of candidates. At present, in this era of technological advancement, the voting process became a major issue in order to avoid vulnerabilities like missing votes, multiple voting, and miscount in an election. The manual or semi-automated systems of voting are quite a time consuming, inefficient and unfortunately lack security. Moreover, for COVID-19, physical manual vote taking has become colossal. In this paper, a secure android based mobile voting system named 'mVote' is developed for conducting vote at different institutes and organizations during and post-pandemic situation. The usability and usefulness of the 'mVote' mobile application were evaluated through the System Usability Scale (SUS) which was replicated with 75 participants. The findings of the evaluation study showed that the developed 'mVote' application is usable and will help different organizations and institutes to improve the voting experience during and post-pandemic situation.

Keywords—Biometric information, mobile application, Covid-19, System Usability Scale (SUS), electronic voting

I. INTRODUCTION

Voting is a critical feature of any democratic process and is a vital expression of the people's power of choice [1]. Voting plays an important role to know the opinion about an issue or selecting an appropriate representative from a certain group of people. For centuries, the paper-based ballot voting system has followed all around the globe. Voting methods vary from traditional voting systems to electronic voting systems [2]. Electronic voting systems [3] translate the manual process of conducting election using techniques like paper ballot into a more effective software system. Day by day, to provide reliability, security, time minimization, efficacy, and ease of use, voting is currently shifting from manual paper-based process to automated electronic process. By implementing a voting system using the mobile platform, additional co- variance and portability are introduced [4]. Now-a-day, a wide range of applications of voting includes its use in student union elections, passing of legislation in parliament and many more [5].

The COVID-19 was first identified in Wuhan, China in December 2019 [6]. The pandemic has caused social, economic, political, and public health crisis worldwide [7]. COVID-19 pandemic has placed unprecedented pressure on countries, states, and organizations as to whether to hold or postpone scheduled elections, amid controversies, in either case, [8]. Different approaches to manage elections during a pandemic were proposed. But several questions raised about the risk to democracy in the presence of an external threat of the kind the world has experienced with the spread of COVID-19. These questions were mainly raised concerning the risk of public participation in the election [9]. Therefore, further research and development are required to provide an effective mobile voting system to conduct elections at non-profit organizations and associations during and post COVID-19 pandemic.

Therefore, the objective of this paper is to present our mobile application that integrates a biometric fingerprint along with a time-stamp for developing an effective voting system that can help different organizations and institutes to conduct elections during and post-pandemic situation. The paper is organized as follows. Section II gives an idea about the related works that have been done so far in this field. In Section III, we have discussed the requirement analysis. Section IV shows, conceptual design, methodology, and implementation of the system. Section V presents the evaluation and discussion of the whole system. Finally, Section VI concludes the paper.

II. LITERATURE REVIEW

A limited number of researches had been conducted focusing to develop a solemnly mobile application-based voting system for organizations during the COVID-19 pandemic. This section briefly discusses research works related to the electronic and mobile-based voting system.

With the development of information technology, nations all over the world are replacing archaic punch cards and mechanical voting systems with electronic voting systems (e-voting) aimed at increasing voter participation and speeding up the release of election results [10]. Literature suggests that improvements in voting systems started as early as in 1892

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with the introduction of the lever arch machine, then the introduction of optical-scan machines and punch card systems for voting [11]. Since then, with the development of technology, the voting system has increasingly incorporating technologies like integrating fingerprint, cloud-based database etc. Smartphones are a popular communication form worldwide in this century and likely to remain as such, especially among adolescents [12]. The phone has evolved from basic communicative functions–calls only–to being a computer-replacement device, used for web browsing, games, instant communication on social media platforms, and work-related productivity tools, e.g. word processing. Smartphones undoubtedly keep us connected; however, many individuals are now obsessed with them [13], [14]. Mobile phones exhibit some unique characteristics that distinguish them from the online medium for voting during a pandemic like COVID-19.

III. Requirements Elicitation Study

The objective of conducting a requirement elicitation study is to reveal the fundamental requirements to develop a mobile voting system for the pandemic situation.

A. Participant's Profile and Study Procedure

The interviews were conducted with a total of 66 participants. Among them, 41 were undergraduate students, 20 serving faculties, and 5 guest teachers of different departments. Written consents were taken from the individual, and ethical approval was taken for conducting this research. The study was conducted following the semi-structured interviews. During interviews, the interviewee was asked some questions like *"How efficient the existing (ballot paper) voting system is?", "Can the existing system prevent false voting?", "How confidentiality and integrity are maintained in the existing system?", "How can be the time utilized best while giving vote?", "How to preserve a peaceful environment in a voting event?", "How to conduct voting during the pandemic?"*

B. Revealed Requirement

The interview responses were transcribed and analyzed through a qualitative data analysis approach. The concerns revealed through the qualitative data analysis were clustered into the following four categories.

a) Emphasize on supervisor control: 18 out of 66 (27%) participants stated to add more supervision power to the admin panel or authority who will conduct the whole voting process.

b) Ensuring confidentiality and integrity: More than 60% (40 out of 66) of the participants stated that confidentiality and integrity cannot be monitored properly in the existing system, and it is the main concerning issue in a voting event.

c) Smooth vote count and publication: Integrity problems may arise at the polling station or counting center where the ballots are counted and/or tabulated in the existing system. This is concerned by 33 out of 66 (50%) participants.

d) Usable and secure digital solution: Data security and privacy should be implemented strongly. 43 out of 66 (60%) participants were concerned about the security, usability, and privacy issues of the digital solutions or applications.

IV. Design and Developement

On the basis of the findings from the requirement elicitation study, a conceptual framework is proposed in Figure 1 to develop a mobile application. The proposed framework has two modules consisting of voters and admin. For voters, there are three main modules consisting of cast vote, view event result and apply for a candidate. Again, admin modules consisting of vote event creation, add candidates, accept new voter and update voter's profile to address the stated requirements for providing a smart voting system.

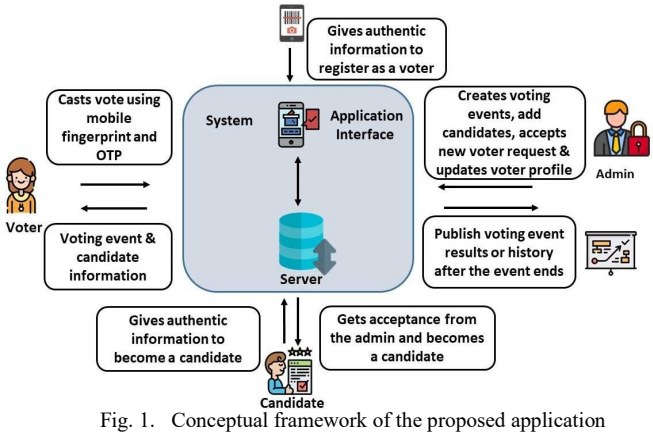


Fig. 1. Conceptual framework of the proposed application

The system will use the barcode of the user's ID card to sign up and sign in. The admin module will facilitate an admin to validate and accept the user's request to become a registered voter and update the registered voter's profile. It will help the admin to create a vote event and add candidates to the event as per requirements and view the vote event's history. The voter module will facilitate the registered voters to get voting events and candidate's information. It will help the voter to cast vote to an event using a mobile phone. The voter module will help the voter to view the vote event result and it will give the voter opportunity to apply for a candidate in a voting event.

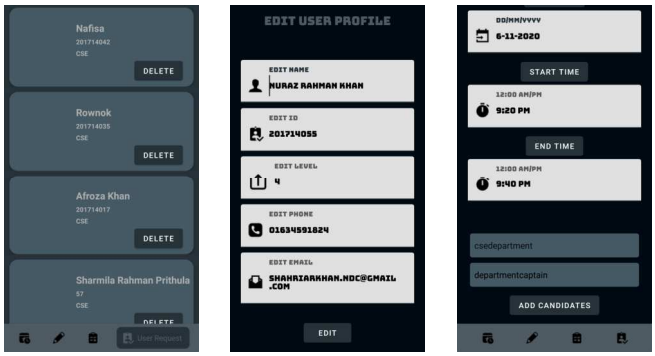
A smart mobile-based voting application named 'mVote' was developed based on the proposed conceptual framework. Android studio and java language was used to develop the User Interface (UI) of this application. The application has two main modules: the Admin module and Voter module.

A. Admin Module

The admin must be registered to the system. After the authentication is completed, the admin will be able to access the admin module. There are four main features in the admin module including the voter request, edit and update voter profile, create vote events and add candidates to the event. A few screenshots of the Admin UI is shown in Figure 2.

In the user request section of the admin module (see Figure 2(a)), the admin can easily view any user request and approve or delete the request. When the admin approves a user, the information of the user is saved in the database and the

admin can't approve the user twice because the information is cross-checked with the database. In the edit and update voter's profile section (see Figure 2(b)), the admin can edit the user's information and update it to the database.



(a) User request (b) Edit user (c) Create vote event

Fig. 2. Screenshots of the admin module.

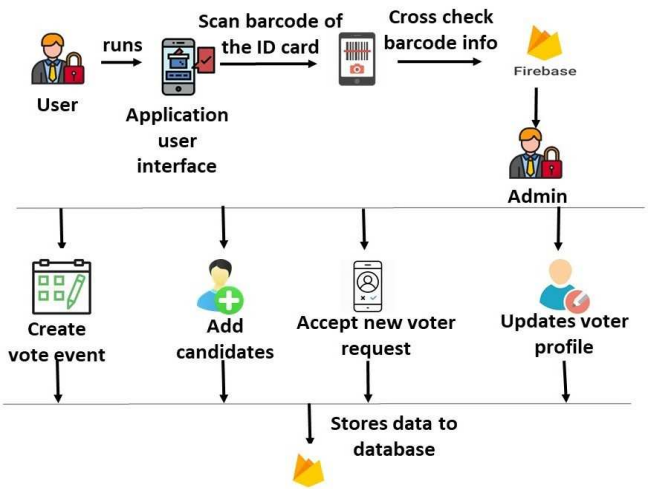


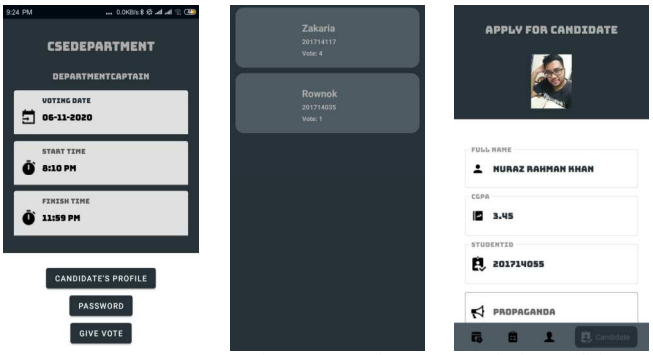
Fig. 3. Data flow diagram of admin module

In the create vote event section (see Figure 2(c)), the admin can set the date and time of a vote event, select the appropriate event and post, add candidates to the event from the add candidates section as per requirement and finally create the vote event. The vote event information is stored in the database. The data flow diagram of the admin module is shown in Figure 3.

B. User Module

The user must be registered to the system to access the user module. If the user is not registered, he or she is sent to the registration page. After completion of registration and confirmation from the admin, the user is validated as a voter and can access to the voter module. The voter module has three main features including cast vote to an event, view voting event result, and apply for the candidate. A few screenshots of the Admin UI is shown in Figure 4.

The data flow diagram of the admin module is shown in Figure 5. In the cast vote section of the voter module (see Figure 4(a)), a voter can choose a voting event and a post



(a) Cast vote (b) Event result (c) Apply for candidate

Fig. 4. Screenshots of the user module.

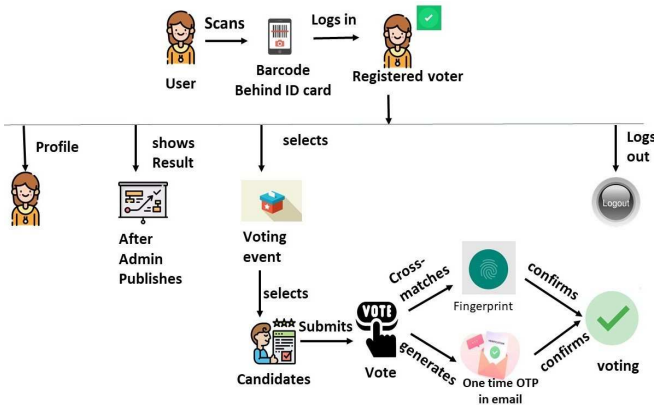


Fig. 5. Data flow diagram of user module

from that event. If the voting event date is expired or the date is yet to come, then the voter can't access the event and cast a vote. Else, the voter can access the event information and candidate's profiles of that event.

The voter has to cast vote for his or her favorite candidate through a two-step authentication process. The fingerprint sensor of the android device is normally used for the biometric authentication process. This process increases the security as faking biometrics is difficult. The biometric information is not saved in any database or server. Biometric information is encrypted and stored in a completely inaccessible part of the smartphone device. This information can't be exported, so it's impossible to steal anyone's biometric information from his/her smartphone. A library named 'Fingerprint Manager' was used in the 'mVote' application, to cross-match the voter's fingerprint with the biometric information stored in the voter's android device. After the biometric authentication, the voter needs to pass the final authentication process. To ensure security and clarity of the voting process, two-step authentication is developed in the 'mVote' application. An OTP is generated from the application. This OTP is sent to the voter's email address and stored in the database simultaneously. Only the voter can see the OTP, sent to his/her email address. When the voter types in the OTP, it's cross-checked with the password stored in the database. If both conditions are fulfilled, then the vote is successfully allocated to the voter's favorite candidate. In the voting result section (see Figure 4(b)), the voter can see the final result of a vote

event. The voter can't view the result of an ongoing event. A voter can apply to become a candidate for a voting event's post. In the apply for candidate section (see Figure 4(c)), the request is sent to the admin. After confirmation from the admin, the voter is approved as a candidate for a particular event's post.

V. Evaluation of the System

The application's performance from the usability perspective was measured using the System Usability Scale (SUS) apparently. This section will briefly discuss the participants' profile, the study procedure, and the results of the evaluation.

A. Participant's Profile

To perform the evaluation study, 75 participants (40 male, 35 female) of different age groups ranging from 18 to 55 years of age were recruited. All participants were familiar with the internet and smartphone. None of them has used 'mVote' and any other application related to the online voting system.

B. Study Procedure

All test sessions were conducted in the participants' own houses. For each test-session, the following steps were followed. At first, participants were briefed on the purpose of this study in an online session, and a participant consent form was signed and collected via email. Then, the app was demonstrated and asked them to explore the app for 5-8 minutes. After that, the participants participated in an online voting event. Finally, the participants were asked to provide their opinion on the SUS questionnaires [15].

C. Analysis and Result

The scores of the SUS analysis are shown in Figure 6. All odd-numbered questions are positive statements, and all even- numbered questions are negative statements. The overall SUS score of the developed application is 76.624. According to [15], SUS scores 0-64 are not suitable; 65-84 are acceptable and 85-100 are excellent. The resulting SUS score, therefore, shows that the 'mVote' application is usable and useful to the participants.

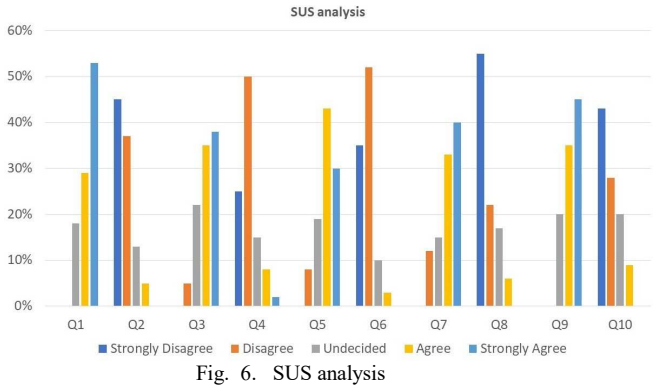


Fig. 6. SUS analysis

VI. Conclusions

In this research, a voting application named 'mVote' is deployed that increases the transparency of voting events, the privacy of voters, ensuring security, and ultimately, allowing only the eligible voters to participate. Security and integrity are maintained as the fingerprint of the voter are cross-matched with the fingerprint stored in the mobile and OTP is sent to the user's email address from the system, which is Cross-matched with the database.

Despite having several features, the system has some limitations. The system presently is on the android platform and IOS version is not supported. The android device should have a good and clean fingerprint sensor else the voter will not be able to cast vote using this feature. The fingerprint sensor of the android device may not work if it's not clean. Internet connection is needed as voter's information are cross-matched with the database. The deployed application was evaluated only by SUS method despite having different evaluation methods. As our future work, a block chain-based voting system will be implemented to improve security in the voting event and to increase the trust of the voters.

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