

Enhancing Student Election Integrity through a Secure Online Voting System

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Abstract:

Student elections are crucial for ensuring democratic representation in academic institutions. However, traditional voting methods often suffer from inefficiencies, security vulnerabilities, and human errors. At Polytechnic Ungku Omar (PUO), student elections were previously conducted using Google Forms, which posed risks such as unauthorized access, multiple voting attempts, and inaccurate vote counting. To address these issues, this study presents the PUO Voting System (VPUO), an innovative online voting platform that enhances security, efficiency, and transparency. The VPUO system integrates multi-layered authentication mechanisms, including QR-code scanning, two-factor authentication (2FA), and one-time password (OTP) verification, to ensure only eligible voters participate in the election. The system also automates vote tallying, reducing the risk of human errors and expediting the results. Developed using the Waterfall software development model, the system underwent extensive testing, including unit testing, integration testing, and user acceptance testing, to ensure reliability and effectiveness. Results from real-time election implementation at PUO demonstrated significant improvements in security and efficiency. The authentication success rate was measured at 98%, preventing unauthorized access and multiple voting. Additionally, the system processed election results instantaneously, eliminating delays caused by manual vote counting. A post-election survey indicated a strong preference among 95% of respondents preferred the VPUO system over the previous Google Forms method, citing improved security, ease of use, and reliability. The findings suggest that the VPUO system provides a secure and efficient alternative to traditional voting methods. Future enhancements could include the integration of biometric authentication and the development of a mobile application for greater accessibility. This system serves as a model for other educational institutions aiming to modernize their election processes.

Keywords: Online Voting, Two-Factor Authentication, QR-Code Verification, Election Security, PUO Voting System

Introduction

Elections play a crucial role in democratic institutions, ensuring representation and governance through an organized process. In educational institutions, student council elections provide a platform for students to elect their representatives, who act as intermediaries between the administration and the student body. However, traditional voting methods often present challenges, including security risks, inefficiencies, and lack of transparency.

At Polytechnic Ungku Omar (PUO), the Majlis Perwakilan Pelajar (MPP) election has historically been conducted using Google Forms, which lacks robust security measures. This method is vulnerable to unauthorized access, multiple voting attempts, and inaccurate vote counting. Moreover, the absence of secure authentication mechanisms allows fraudulent votes to be cast, thereby undermining the credibility of the election process. Manual vote counting also leads to delays, increasing the chances of human errors and administrative burden.

To address these challenges, this study aims to develop and implement a secure and efficient online voting system, known as the PUO Voting System (VPUO). The primary objective is to enhance election security and efficiency by integrating multi-layered authentication mechanisms, automated vote counting, and user-friendly interfaces. The research question that guides this study is: How can multi-factor authentication enhance the security and efficiency of student elections at PUO?

The proposed system incorporates advanced security features, including QR-code scanning, two-factor authentication (2FA), and one-time password (OTP) verification. These security layers ensure that only registered voters can access the system and cast their votes. Furthermore, the system automates vote counting, reducing human error and to ensure timely and accurate election results.

The development of the VPUO system follows a structured methodology, incorporating the Waterfall software development model. This approach ensures that each phase, including requirement analysis, system design, implementation, testing, and deployment, is executed in a systematic and organized manner. To evaluate the system's effectiveness, unit and integration testing are conducted to ensure reliability, security, and user satisfaction.

By implementing this system, PUO aims to enhance the integrity of student elections, fostering trust among voters and administrators. The system's ability to provide secure, transparent, and efficient elections is expected to set a benchmark for other educational institutions seeking to modernize their voting processes.

Research Methodology

The methodology employed in this study follows the Waterfall software development model, which consists of sequential phases, ensuring systematic development and implementation of the PUO Voting System (VPUO). The following sections describe each phase of the development process.



1. System Design and Development

The system was designed using a combination of front-end and back-end technologies. For the front-end, HTML, CSS, and JavaScript were employed to create an interactive and user-friendly interface. On the back end, PHP was used for server-side scripting, while MySQL handled data storage and management. Together, these technologies ensured a seamless and responsive user experience. The system architecture also incorporated a secure authentication framework, a comprehensive voter database, and an automated vote counting mechanism.

2. Authentication Mechanisms

To enhance security, the system integrates multiple authentication layers:

QR-Code Scanning: Each voter is assigned a unique QR code that must be scanned to access the voting system.

Two-Factor Authentication (2FA): After scanning the QR code, users must enter a one-time password (OTP) sent to their registered mobile number.

reCAPTCHA Integration: To prevent automated bots from accessing the system, reCAPTCHA was implemented. These security measures ensure that only legitimate voters can participate in the election, eliminating duplicate and fraudulent votes.

3. Database and Data Security

A MySQL relational database was used to store voter credentials, candidate details, and election results securely. Encryption techniques were applied to protect sensitive data, ensuring data integrity and preventing unauthorized access. The database was designed with predefined access roles to restrict administrative privileges and protect against potential cyber threats.

4. System Implementation and Testing

The implementation phase involved coding the system components and integrating them into a functional online voting platform. The system underwent rigorous testing, including:

Unit Testing: Individual system components were tested to identify and fix bugs before integration.

Integration Testing: Ensured seamless interaction between the authentication system, database, and vote tallying mechanism.

User Acceptance Testing (UAT): A group of students and administrators tested the system to evaluate its usability, security, and efficiency.

5. Evaluation and Deployment

Upon successful testing, the system was deployed for real-time elections at PUO. Feedback from users was collected to assess system performance, identify potential improvements, and enhance future iterations of the VPUO system.

Results

The implementation of the PUO Voting System (VPUO) resulted in significant improvements in election security, efficiency, and user satisfaction.

- Enhanced Security Measures:** The system's multi-layered authentication process successfully prevented unauthorized access and fraudulent voting. The integration of QR-code scanning and OTP verification ensured that only registered voters could participate. The reCAPTCHA mechanism effectively blocked automated bots from tampering with the system. During testing, the authentication success rate was measured at 98%, demonstrating the system's reliability in verifying user identities.
- Real-Time Vote Counting and Efficiency:** Compared to the previous manual vote counting process, which took several hours, the VPUO system automated the vote tallying, providing instant results upon election closure. This significantly reduced administrative workload and minimized human errors associated with manual counting. The system successfully processed and displayed voting results within seconds of vote submission.
- User Feedback and Acceptance:** A post-election survey was conducted among students to assess user experience and system reliability. The survey revealed that 95% of respondents preferred the new system over the Google Forms-based election process. Additionally, 80% of users rated the system's security, ease of use, and transparency as excellent. Respondents particularly appreciated the elimination of duplicate voting and the ability to verify their identity securely before casting their votes.
- System Performance and Reliability:** The VPUO system was tested under varying loads to assess its performance and scalability. The system successfully handled simultaneous logins and vote submissions from over 500 users without experiencing lag or crashes. Server response time remained below 2 seconds for most operations, ensuring a smooth voting experience for all participants.
- Reduction in Voting Irregularities:** The VPUO system effectively addressed common issues such as multiple voting attempts and unauthorized access. By requiring voter authentication through QR codes and OTPs, the system ensured that each voter could only cast one vote. Data logs recorded no instances of duplicate voting or unauthorized system access during the election period.
- Overall,** the VPUO system significantly improved the integrity, efficiency, and transparency of student elections at PUO, setting a new standard for digital voting processes in educational institutions.

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Conclusion and Recommendation

This study's findings highlight the VPUO system's significant impact on improving election security, efficiency, and transparency. By integrating QR-code scanning, two-factor authentication (2FA), and OTP verification, the system successfully mitigated security risks associated with unauthorized access and fraudulent voting. These security features provided a robust and reliable framework that ensured the integrity of the voting process.

While the system demonstrated high reliability and efficiency, some challenges were identified. The requirement for internet connectivity and QR-code scanning devices posed accessibility issues for some users, particularly those with limited technological resources. Additionally, the reliance on mobile OTP verification required users to have active phone numbers, which may not always be feasible for every student.

Despite these limitations, the advantages significantly outweigh the challenges. Future improvements could include the integration of biometric authentication, such as facial or fingerprint recognition, to further



enhance security. Additionally, developing a mobile application for the voting system could improve accessibility and usability, allowing students to vote conveniently from their smartphones.

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