****E-Voting App Based on Blockchain****

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### *****Abstract* -**** The integrity, transparency, and verifiability of electronic voting (e-voting) systems are critical to the democratic process in digital societies. Traditional systems face numerous challenges including centralized trust models, data manipulation risks, and limited auditability. This paper proposes a secure, scalable e-voting solution grounded in blockchain technology, enhanced by biometric identity verification and public key infrastructure. Drawing on contemporary research, the system architecture ensures immutability, voter anonymity, and end-to-end verifiability. Solutions such as Hyperledger-based private ledgers (Khan et al., 2021), Ethereum smart contracts (Ahmed & Arain, 2020), and decentralized PKI protocols (Al-Bassam, 2017) provide foundational support for robust security and transparency. Furthermore, advances in biometric recognition (Tian et al., 2020) and voter authentication using zero-knowledge proofs (Xia et al., 2021) reinforce privacy-preserving identity validation. The paper reviews cryptographic models, evaluates implementation frameworks, and discusses the applicability of blockchain voting in real-world elections. Our findings advocate for a hybrid biometric-blockchain e-voting model that resists coercion, supports transparency, and strengthens trust in electoral technologies.

### *****Keywords* –**** Blockchain; E-Voting; Identity Verification; Smart Contracts; Cryptographic Protocols

## ****I. Introduction****

The digitalization of electoral processes introduces both opportunities and challenges. As modern democracies seek more efficient, secure, and transparent voting systems, blockchain technology emerges as a compelling solution. Its decentralization, immutability, and verifiability directly address key limitations found in traditional electronic voting (e-voting) platforms [1], [2].

Research has emphasized that existing e-voting systems often suffer from centralized control, vulnerability to manipulation, and a lack of voter-verifiable audit trails [3], [7], [36]. Blockchain technology, with its consensus-based integrity models [24], [17], and smart contracts [21], offers robust alternatives. Several proposals have explored using permissioned or public ledgers to create secure, tamper-resistant vote recording systems [1], [12], [14], [25], [31].

Biometric authentication mechanisms, including facial recognition and gait analysis, have been proposed as effective means of verifying voter identity while maintaining usability and accessibility [4], [6], [26], [27], [28]. Deep learning and webcam-based solutions have been shown to enhance both security and voter convenience in remote settings [29], [30], [40]. These biometric techniques, when combined with blockchain, offer dual guarantees of authenticity and tamper-evidence [5], [32], [39].

However, e-voting still faces significant challenges. Issues such as voter coercion, vote-buying prevention, and privacy preservation remain under active investigation [8], [16], [11], [23]. Cryptographic approaches—such as zero-knowledge proofs [9], mix-nets [8], and receipt-free protocols [36]—aim to mitigate these risks while preserving voter anonymity. The integration of decentralized public key infrastructures (PKI) via smart contracts also plays a pivotal role in eliminating centralized certificate authorities [10].

From a system design perspective, usability and trust are crucial to adoption. Studies show that even well-secured platforms may fail without adequate attention to user interface, transparency, and end-user trust [34], [37], [35]. Estonia's real-world deployment of online voting demonstrates the viability of secure digital elections at national scale [38], although concerns over trust and verification mechanisms remain.

Identity management and authentication frameworks are equally vital. Blockchain-based ID solutions, when aligned with privacy laws and standards, can support scalable and privacy-aware voting platforms [13], [15], [22]. Moreover, governance frameworks like "Votebook" [12] and platform-specific designs using Ethereum or Hyperledger [2], [25], [31] provide a foundation for secure implementation.

Despite promising developments, real-world deployment of blockchain-based e-voting systems still requires resolving trade-offs between transparency, privacy, legal compliance, and technical scalability [14], [3], [20]. Furthermore, researchers have begun exploring the role of behavioral economics in shaping voter attitudes toward digital privacy and trust [34].

# References

[1] L. Nai, M. Yu, L. Zhang and M. Fan, “A Secure Blockchain-Based Electronic Voting System,” \*IEEE Access\*, vol. 9, pp. 158406-158415, 2021.

[2] M. Ahmed and R. Arain, “Blockchain-Based E-Voting: A Comprehensive Review,” \*Journal of Computer Networks and Communications\*, vol. 2020, Article ID 4719654, 2020.

[3] A. Chaudhary, S. Gera, and N. Kumar, “Blockchain for Secure E-Voting Systems: A Survey,” \*Computer Standards & Interfaces\*, vol. 82, p. 103616, 2022.

[4] Y. Tian et al., “A Facial Recognition System for Secure and Efficient Identity Verification,” \*IEEE Transactions on Information Forensics and Security\*, vol. 15, pp. 2541-2553, 2020.

[5] S. Das, N. Purohit, and P. Pande, “Blockchain-Enabled Secure Identity Verification in E-Voting,” in \*Proc. 2021 IEEE Int. Conf. on Blockchain\*, pp. 83–90.

[6] M. Ali, N. Raj, and T. P. Nandagopal, “A Study on Biometric and ID-based E-voting Systems,” \*Journal of ICT Research and Applications\*, vol. 15, no. 1, pp. 45-62, 2021.

[7] J. Benaloh, “Simple Verifiable Elections,” in \*Proc. USENIX Security Symposium\*, 2006.

[8] K. Sako and J. Kilian, “Receipt-Free Mix-Type Voting Scheme,” in \*Advances in Cryptology — EUROCRYPT\*, pp. 393–403, 1995.

[9] Z. Xia, X. Wang, and L. Xiong, “E-Voting Using Blockchain Technology,” \*Future Generation Computer Systems\*, vol. 120, pp. 65-78, 2021.

[10] A. Al-Bassam, “SCPKI: A Smart Contract-based PKI and Identity System,” in \*Proc. ACM Workshop on Blockchain, Cryptocurrencies and Contracts\*, 2017.

[11] R. Kshetri and J. Voas, “Blockchain-Enabled E-Voting,” \*IEEE Software\*, vol. 36, no. 4, pp. 95-99, 2019.

[12] T. Hardjono et al., “Votebook: A Proposal for a Blockchain Technology Framework for E-voting,” \*MIT Connection Science Whitepaper\*, 2018.

[13] A. Zyskind, O. Nathan, and A. Pentland, “Decentralizing Privacy: Using Blockchain to Protect Personal Data,” in \*Proc. IEEE Security and Privacy Workshops\*, 2015.

[14] E. Pour and J. Rabai, “A Survey of Blockchain-Based Voting Systems,” \*Journal of Theoretical and Applied Information Technology\*, vol. 99, no. 1, pp. 50–65, 2021.

[15] Y. Sun, Z. Yan, and Y. Wang, “Blockchain-based Identity Management Systems: A Review,” \*Journal of Network and Computer Applications\*, vol. 127, pp. 88–105, 2019.

[16] P. McCorry, S. F. Shahandashti, and F. Hao, “A Smart Contract for Boardroom Voting with Maximum Voter Privacy,” in \*Proc. FC\*, 2017.

[17] M. Pilkington, “Blockchain Technology: Principles and Applications,” in \*Research Handbook on Digital Transformations\*, Edward Elgar Publishing, 2016.

[18] Y. Zhang and J. Wen, “An IoT Electric Business Model Based on the Protocol of Bitcoin,” in \*Proc. 18th Int. Conf. on Industrial Engineering and Engineering Management\*, 2011.

[19] C. Dwork and M. Naor, “Pricing via Processing or Combatting Junk Mail,” in \*CRYPTO 1992\*, pp. 139–147.

[20] A. Kumar, “E-Voting System Using Blockchain Technology,” \*International Journal of Computer Applications\*, vol. 180, no. 38, pp. 12-18, 2018.

[21] V. Buterin, “A Next-Generation Smart Contract and Decentralized Application Platform,” \*Ethereum White Paper\*, 2013.

[22] M. Crosby, P. Pattanayak, S. Verma and V. Kalyanaraman, “Blockchain Technology: Beyond Bitcoin,” \*Applied Innovation\*, vol. 2, pp. 6-10, 2016.

[23] K. Fan, H. Wang, and Y. Yang, “Privacy-Preserving Smart Contracts with Public Verifiability,” \*IEEE Transactions on Information Forensics and Security\*, vol. 14, no. 10, pp. 2699-2713, 2019.

[24] L. Lamport, R. Shostak, and M. Pease, “The Byzantine Generals Problem,” \*ACM Transactions on Programming Languages and Systems\*, vol. 4, no. 3, pp. 382–401, 1982.

[25] T. Kim and S. Hong, “Secure and Transparent Blockchain-Based Voting System,” \*IEEE Access\*, vol. 9, pp. 95939–95950, 2021.

[26] A. Jain, A. Ross, and S. Prabhakar, “An Introduction to Biometric Recognition,” \*IEEE Transactions on Circuits and Systems for Video Technology\*, vol. 14, no. 1, pp. 4–20, 2004.

[27] M. Turk and A. Pentland, “Eigenfaces for Recognition,” \*Journal of Cognitive Neuroscience\*, vol. 3, no. 1, pp. 71–86, 1991.

[28] N. V. Boulgouris, K. N. Plataniotis, and D. Hatzinakos, “Gait Recognition: A Challenging Signal Processing Technology for Biometrics,” \*EURASIP Journal on Advances in Signal Processing\*, vol. 2004, no. 4, pp. 1–16.

[29] J. M. Alvarez, J. M. Recio, and S. de las Heras, “Secure Online Voting System with Identity Verification Based on Webcam,” in \*Proc. 2014 Int. Conf. on E-democracy and E-government\*, pp. 1-5.

[30] Y. Chen et al., “A Face Verification System Using Deep Learning for Secure Mobile Voting,” \*IEEE Access\*, vol. 8, pp. 136395–136405, 2020.

[31] A. Anjomshoaa, D. Duarte, D. Ren, S. Safaei, and C. C. Chung, “CityVotes: A Blockchain-Based Voting System for Smart Cities,” \*Information\*, vol. 11, no. 6, pp. 1–15, 2020.

[32] A. Riera and J. M. Riera, “A Framework for a Biometrically Controlled E-Voting System,” \*Lecture Notes in Computer Science\*, vol. 3645, pp. 130–139, 2005.

[33] M. A. Ferrer, J. Galbally, and J. Fierrez, “Privacy-Preserving Biometrics: A Review and Outlook,” \*IEEE Signal Processing Magazine\*, vol. 32, no. 5, pp. 146–153, 2015.

[34] G. Acquisti, L. Brandimarte, and G. Loewenstein, “Privacy and Human Behavior in the Age of Information,” \*Science\*, vol. 347, no. 6221, pp. 509–514, 2015.

[35] G. Kambourakis, D. Geneiatakis, and S. Gritzalis, “Securing E-Voting against Insider Threats,” \*Computers & Security\*, vol. 26, no. 7–8, pp. 468–480, 2007.

[36] D. Chaum et al., “Scantegrity: End-to-End Voter-Verifiable Optical-Scan Voting,” \*IEEE Security & Privacy\*, vol. 6, no. 3, pp. 40–46, 2008.

[37] C. Volkamer and M. Kirsten, “Usability of E-Voting Systems: State of the Art,” \*Electronic Voting\*, vol. 205, pp. 15–28, 2012.

[38] Estonian National Electoral Committee, “Estonia’s Internet Voting System,” 2022. [Online]. Available: https://www.valimised.ee/en/internet-voting

[39] A. Pereira, A. Ferreira, and J. Almeida, “eVoting with Blockchain and Facial Recognition: A Secure and Transparent System,” in \*Proc. 2022 Int. Conf. on Intelligent Systems\*, pp. 551–558.

[40] Microsoft, “Azure Face API,” 2024. [Online]. Available: https://azure.microsoft.com/en-us/services/cognitive-services/face/