A modern electoral system in Malaysia using E-Voting with the implementation of Blockchain Technology.

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***Abstract* - Since its independence, the electoral system in Malaysia has always been unchanged, whereby voters are asked to be present at the polling station to cast their votes. This has unfortunately led to an accumulation of countless limitations that pertains to the current voting system such as inefficiency, lack of trust and transparency, high budget for each election, etc. The time for a change may be near, and this research paper aims to propose an E-Voting system which incorporates Blockchain technology for the Malaysian electoral system. Blockchain technology is known for its security, reliability, and anonymity. The flow of this study follows a mixture of both quantitative and qualitative methodology and the selection of respondents through two separate sampling methods- stratified sampling and judgement sampling, for the citizens of Malaysia and researchers & experts in the technologies behind the proposed system.**

***Key Terms* - Blockchain, E-Voting, Elections, Malaysia, Security**

1.0 Introduction

The country in which this research takes place in is a democratic country called Malaysia. At the time of this research, the electoral system which the country uses to this day is known as First Past the Post (FPTP) [4]. The system practiced is based on a process whereby votes are casted on paper ballots with indelible ink by the citizens of the country [6] and lawmakers are chosen based on simply "winning a plurality of votes cast in a particular constituency" [5].

The electoral processes are overseen by the Election Commission (EC) which consists of 7 officers appointed by the King himself upon advice from the Prime Minister. During the counting of votes, the ballots will be tallied by the EC officers in front of each electoral candidates and/or their election agents along with one counting agent for each candidate.

The democratic system in Malaysia allows its citizens to exercise their constitutional rights to elect who they want the country to be governed by, namely at the federal and state level elections, and by-elections. Though by law, in a democratic society like Malaysia, it is not compulsory for eligible voters to cast their votes during elections, however, the act of voting does signify not only the patriotism and concern one has for their country, but stands as a democratic symbol, hence sealing in the importance of voting in Malaysia [6].

Unfortunately, the current electoral system has limitations in a number of areas which inevitably leads to a lack in efficiency, transparency, trust, cost, integrity, etc. [6]. As previously mentioned, the counting of votes is tallied by the EC in front of electoral candidates and/or other authorized individuals. This makes it a very tedious and time-consuming process, and during this process, countless factors must be taken into consideration including ensuring that the votes casted on the ballots are valid and are not spoiled, the counting of ballots itself, announcing the vote count accurately, etc., which makes the system fairly inefficient and prone to human error. However, whether or not spoiled votes are due to voters purposefully disobeying or were simply unaware of the voting rules, nobody knows as it is not recorded and shown to the public, causing a lack of transparency and distrust making citizens question the integrity of not only the ballots but the EC as well.

Moreover, the cost to provide ballots and pens, and indelible ink for those who have voted at every single voting station across the country is costly. The total budget allocated for each election may vary, however, there is no doubt that it is never a small figure. Taking the recent GE14 as an example, the total budget allocated for the election was RM500 million, making it RM100 million higher than that of the budget allocated for the previous election, GE13 [7]. A total of RM72 million was allocated for the replacement of 50,000 old ballot boxes in the country's 12th election which happened back in 2008 [6]. Furthermore, a total of the RM42 million budget was allocated to the 1995 election, RM11.42 million of which was spent on printing the paper ballots as well as electoral documents [6]. On top of that, in the 2004 election, RM6.9 million was used for the purchasing of 216,600 bottles of indelible ink that was used to prove that an individual has casted their votes, with an additional cost of RM200,000 used on packing, transporting, and storing of the inks [6]. Sadly, the RM2.4 million worth of bottles of ink was later incinerated when they ended up not being used [6]. Moreover, a number of cases regarding the allegations on voter frauds has risen in recent years. According to a news article written by Aljazeera,

Bersih, a coalition of non-governmental organisations (NGOs), has noted "serious electoral fraud" against the 13th general elections which happened on May 5th, 2013. Furthermore, another article reported on the findings of possible electoral fraud for the then upcoming 14th general election which happened on the 9th of May 2018 that included the existence of a 121-year-old voter, more than 500,000 cases of voters registered under the same address, and even more than two million voters registered without an address [8].

To tackle the limitations existing in the current voting system, the proposed system, a modernized electoral voting system which incorporates Blockchain Technology whereby voters may cast their votes via their own electronic devices, may be considered. With this system, voters need not cast their votes on physical papers, but instead, cast their votes electronically after signing into their own registered account. Such a system will eradicate human error and spoilt votes, improve trust and transparency, and reduce the cost needed for every election, voter fraud by ensuring every individual who is eligible to vote and has registered is who they claim to be, etc. With the incorporation of Blockchain, once individuals have casted their votes, their votes and their personal information will be stored in blocks, linking them to one another, essentially making it extremely difficult and highly impossible to alter. In addition, the counting of votes can be done and achieved in a more timely manner, and since the system will be decentralized, no entity owns the data, allowing everybody to see whatever that is happening on the system as it happens while staying anonymous, ensuring further trust and transparency amongst one another.

2.0 Literature Review

2.1 Research Domains

2.1.1 Blockchain Technology (BCT)

Blockchain has been a hot topic in the tech industry ever since its first widespread application in the ever-famous cryptocurrency, Bitcoin, back in 2009. The concept was first proposed as a research project [2] back in the 1990s by Nick Szabo [9]. Szabo described the concept as "a set of promises, specified in digital form, including protocols within which the parties perform on these promises" [10][9]. However, the inventor of blockchain technology is actually considered to be Satoshi Nakamoto who had published a paper on Bitcoin back in 2008 titled "Bitcoin: A Peer-to-Peer Electronic Cash System" [13]. Today, blockchain is a set of technologies which combines "the blockchain data structure itself, distributed consensus algorithm, public key cryptography, and smart contracts" [9]. Blockchain is essentially a decentralised peer-to-peer digital ledger of transactions which allows the ledger to be distributed either publicly or privately to all users [11] without the ability to tamper, in terms of alteration, deletion and destruction of, the blocks in which the information is stored [2] all the while staying anonymous. There are two types of blockchain networks, namely permissioned blockchains, which are proprietary networks where specific individuals and entities use it to conduct actions such as financial transactions by a group of banks and are often developed by companies for their own private commercial use, and permissionless or public blockchains, which are open-source networks whereby anybody can use and access the network such as users who use bitcoin as a payment method with one another [11].

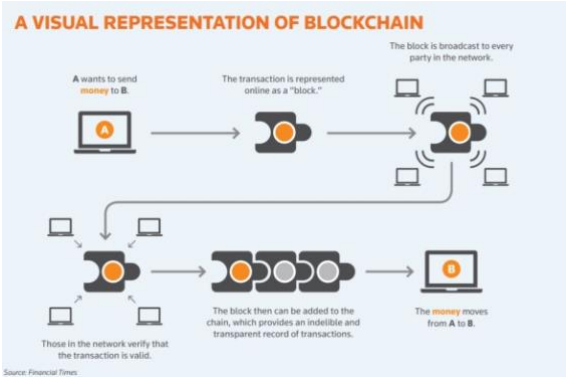

Figure 1.0: Visual representation of blockchain
Source:https://www.steptoe.com/images/content/1/7/v3/171269/LIT-FebMar18-Feature_Blockchain.pdf

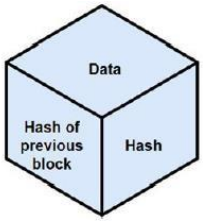

Figure 2.0: Block of a Blockchain
Source:https://pdfs.semanticscholar.org/4053/0e860912fd05e219e0b303a36309b8165ac5.pdf

When information is stored into a block, that block will be linked to a newly added block, ultimately creating a chain of blocks, hence the name of the data structure, blockchain. Each block in a blockchain contains three things, the data itself, the hash of the previous block and the hash of the current block itself [12]. Network participants, known as "miners", create the chain line of transactional records [6] which are then stored in a database which is spread out among several network nodes at various locations, essentially creating

redundancy while maintaining the fidelity of data stored in the nodes [2]. When an attacker tries to alter data, the changes will cause the hash of the original block to change, this change will then be cross-referenced with that of the hash of the same block in the other nodes and if in fact, the hash value does not, no changes will be made, making it highly impossible for a threat actor to hack into any blocks and make changes as they wish [12]. The only way for a threat actor to succeed in performing a 51% attack, the threat actor will have to "simultaneously control and alter 51% or more of the copies of the blockchain" in order for the new changed copy to become the majority copy, ultimately, being the agreed-upon chain [2].

A permissionless or public blockchain is not only decentralized but is also offers transparency. Just like the nature of Bitcoin's blockchain, transactions that are happening in real time are recorded and displayed for anybody to see, while keeping the identities of users anonymous. Therefore, based on the current development of BCT, the proposed system will use a permissionless (public) blockchain to ensure transparency and decentralization of the votes casted and the identities of each voter.

2.1.2 E-Voting systems using blockchain technology

Though BCT made its breakthrough from its applications in cryptocurrencies such as Bitcoin, Ethereum, etc., many other industries are now implementing BCT into their systems and infrastructures and Electronic Voting (E-Voting) systems are not one to shy away from this technology. E-Voting systems have been around for many years now but has recently been incorporating BCT into their system's infrastructure. The first E-Voting system ever used by a country for the purpose of vote casting is Estonia in October 2005 [14] and the first E-Voting system with the application of BCT, named Agora, was partially tested during the vote in Sierra Leone in March 2018 [15]. Following this, a number of countries has since started using E-Voting systems which incorporates BCT, specifically in the year 2020, including the Presidential election in the county of Utah, the United States using Voatz, Japan using a platform named LayerX, and Russia using a platform called Exonum which was built on Bitfury's open-source platform [16].

Many other E-Voting systems today that incorporates BCT includes platforms such as Follow my Vote, Polyas, Luxoft, and Polys [9]. These platforms may differ in terms of the main features the platforms offer, the framework used, the language it was coded in, the cryptographic algorithm used, and consensus protocol used, however, they are nevertheless blockchain-based E-Voting systems. According to Uzma J. et. al. (2021), common frameworks used includes Bitcoin and Hyperledger Fabric while the common programming languages used are Python and JavaScript, while ECC and ElGamal are some of the common cryptographic algorithms used in these systems.

Based on a research paper written by a group of researchers [6], findings on an experiment carried out by two individuals named Gilbert and Handschuh, found that due to the characteristics of a hashing algorithm, SHA-256, such as being able to produce various types of patterns and high computational probability, any attack on systems using this hashing algorithm is very complex. From the same research paper, a separate study carried out by another group of researchers suggested that their proposed block will consist of the node's ID, a timestamp, along with three other segments, which includes the results of the election, the hash of the previous block, and the digital signature whereby it will be broadcasted to other nodes.

Based on the experiment by Gilbert and Handschuh, the proposed system will use the hashing algorithm SHA-256 due to the unlikelihood of attacks from happening on data being hashed with this algorithm. Each block of the blockchain will also include a number of essential elements such as the usual - unique block ID, timestamp of when the block was created, the hash of the current block and the previous block and a data signature [6].

2.2 Similar Systems

2.2.1 Voatz

Established as a smartphone-based voting system, it uses blockchain to allow voters to cast their votes remotely and anonymously and verify that the votes were indeed counted correctly [9]. According to Voatz's official website, under the How It Works tab, in order for voters to cast their votes using the platform, there are 5 simple steps, voters must follow. First, they must ensure that their jurisdiction supports the casting of votes via mobile and submit a request to their elections coordinator to receive a ballot on their smartphone. Once that has been done, voters must download the Voatz application on their devices, create an account using their mobile number and email, as well as choose a security PIN. Next, voters will have to verify their identity by pairing their identity to their phone's biometric or PIN, which will then delete all personally identifiable information (PII) and complete the verification process. Voters may now cast their votes by marking their choices, reviewing them, and submit their votes using either their biometrics or

their secure PIN. After the vote has been submitted, voters will receive an anonymized receipt for voters to verify their selections. The same receipt will then be used by the voters' jurisdiction for the purpose of post-election audit.

However, a group of MIT researchers, [17], who analyzed the usage of Voatz in the 2018 midterm elections in West Virginia found a number of security vulnerabilities pertaining to the app which allows "different kinds of adversaries to alter, stop, or expose a user's vote". On top of that, the researchers also found that Voatz has a number of privacy issues which stems from the usage of third-party services for crucial app functionality [17]. Due to this research done by the group of researchers, one county in Washington has decided to abort their use of the app in the 2020 primaries.

2.2.2 Agora

Established in 2015, and previously mentioned that it was partially implemented in Sierra Leone's presidential election, its architecture is built on a number of technological innovations, which includes "a custom blockchain, unique participatory security, and legitimate consensus mechanism [9]. According to Agora's official website, the platform is tamper-proof – alterations of the ballots and results by any third parties is not possible, transparent – entirety of full transparency and publicly verifiable voting process, private – choices and identities of voters are kept anonymous, accessible – voters may cast their votes remotely in a "modern, convenient and fair way", affordable – reduction in election costs, and tension-less – violence caused by questionable results are eliminated.

2.2.3 Compare and contrast table

Table 1: Compare and contrast table of similar systems.

	Voatz	Agora
Auditability	✓	✓
Vote counting	✓	✓
Anonymity	✓	✓
Verifiable by Voter	✓	✓
Framework used	Hyperledger Fabric	Bitcoin
Transparency		✓
Security		✓

From Table 1, it is safe to deduce that Agora puts an emphasis on the transparency and security of the platform which makes the use of it in a nationwide/statewide scale for the elections a rather safe and promising option. Voatz, on the other hand, though it is a promising platform, due to the research done by MIT researchers, it has shown that the platform is less reliable to be used in nationwide/statewide scale for the elections.

3.0 Problem Statement

For many years, both Malaysians and non-Malaysians, young and old, has seen their fair share of fluctuation in the Malaysian politics, particularly in the recent years. Regardless of the political events that the country has seen, it's no secret that whenever such events occur, especially during the post general elections, there is one topic that will either make headlines in the news, or at the very least, finds its way in between day-to-day conversations, and that is; the allegation of electoral fraud.

To tackle the issue on such allegations, gain trust and ensure democracy in our modern society, an e-voting system which uses blockchain technology may be implemented. E-voting solves a number of problems pertaining to the current voting process such as the time to count votes, votes being unverifiable by voters [1], risks of a rigged election [12], and many more.

Blockchain technology has been around for a long time originally described in the early 1990s but had only made its first widespread breakthrough when it was applied in a cryptocurrency, Bitcoin, in 2009 [2]. In March of 2018, Sierra Leone became the first country in the world to verify its votes in an election by using blockchain technology [3]. What makes blockchain the best technology for voting systems is the inability to change or delete information from the blocks.

4.0 Research Aim

The aim of this research is to propose a new possible electoral system in the Malaysian context by creating an e-voting system.

5.0 Research Objectives

- To develop an E-Voting system to be implemented as a new electoral system for Malaysia to rid the limitations of the current electoral system.
- To incorporate blockchain technology into the proposed system to provide a higher standard of security.

6.0 Research Significance

As technology advances, the need to switch over to a more efficient system which operates on current technological advancements is more apparent than ever. However, in order to do so, extensive research

and analyses on both hypotheses and real-world applications must be done for a system as big as an electrical electoral system to be used in a country's elections, such as Malaysia. That being said, the findings of this research will benefit mainly 2 parties both in Malaysians and experts in the field of computing. 1) The citizens of Malaysia: By shedding light on topics like this, it may determine the likes of the proposed system in the perspective of Malaysian citizens. Those who have the rights to vote should always feel comfortable when exercising their constitutional rights in acts like voting during the general elections. On top of that, when the public is well informed of the technology in which a system that they will be using is known, especially one that involves the Internet of Things (IoT) devices where concerns regarding the safety of their personal information is present, all doubts and worries will be greatly minimized. 2) Computing experts, with great respect to those who focuses on the development of both BCT and E-Voting systems incorporating BCT all around the world: Since the development of these technologies are constantly still in the works, as with other current and emerging technologies, there are bound to be loopholes and limitations. Therefore, the findings of one research, along with the recommendations listed from one researcher to another, a solution is bound to emerge, resulting in greater understanding in the technologies. The topic on E-Voting systems which incorporates BCT is definitely not restricted to security experts but ranges from computing experts such as data analysts, programmers, etc., to mathematicians, all the way to lawmakers. It is a topic area which involves the works of experts from many fields and therefore by compiling one's knowledge with another, greater advancements in the world can be achieved.

7.0 Research Methodology

7.1 Respondents:

In this study, there are two groups of respondents identified by the researcher, the first group being Malaysian citizens and the second group being researchers/experts in the technologies behind the proposed system. The first group will be mainly targeted for the collection of data regarding their personal two cents on the current voting system as well as their acceptance on the implementation of a new voting system, that of which will be done electronically. The latter group will be targeted for the collection of data regarding the pros and cons of the technologies used behind the proposed system as well as to better understand how the technologies can be integrated into the proposed system.

7.2 Sampling method:

Given the nature of this study, the first group of respondents, the citizens of Malaysia, are of different backgrounds in terms of career, age group, ethnicity, etc., therefore, there is a great importance to formulate accurate judgements to be made from respondents inclusively. This study will implement both a probability sampling method, specifically one of the complex probability sampling methods, known as stratified sampling, along with a non-probability sampling method, specifically one of the purposive sampling methods, known as judgement sampling, to gather useful data.

For respondents of stratified sampling, the total population will be divided into several subgroups categorized with various elements such as of their age group, area of work- city or urban, gender, etc., which will ultimately allow for the collection of precise data [18] by conducting quantitative research using a survey. While for the respondents of the judgement sampling, the researcher will be conducting qualitative research with the use of interviews.

7.3 Data collection method:

As previously mentioned, the data collection method that will be used for quantitative research is a survey. This survey will be a google form, self-administered by the researcher, and distributed via social media. The ideal number of respondents for this particular study is 100-200 respondents, which is not a lot of respondents in comparison with the population of the entire country, but due to time constraints, the expected number of respondents is fairly reasonable. The survey will consist of mainly closed-ended questions, which are list and ranking questions, following the Likert-style, but also open-ended questions, including objective, subjective and speculative questions, where respondents will be allowed to elaborate on their choices and feelings toward the proposed system.

The data collection method used for qualitative research, however, will be interviews. Based on the researchers of past research papers referenced in this study, a number of suitable candidates have been identified for the interviews. The interviews will involve no more than 3 respondents, all 3 of which are from the computing industry, due to time constraints. The interview will be semi-structured to allow predetermined questions to be asked first, eventually causing the interviews to freely flow as the respondents elaborate on the questions asked; leading to a one-answer-leads-to-another-question phenomenon to occur. Each interview will be conducted via social media, such as Microsoft Teams, a Zoom meeting, email, etc., depending on

the comfort of the respondents, and will operate on a one-to-one basis to ensure that no respondent feels pressured during the interviews.

8.0 Proposed System Overview

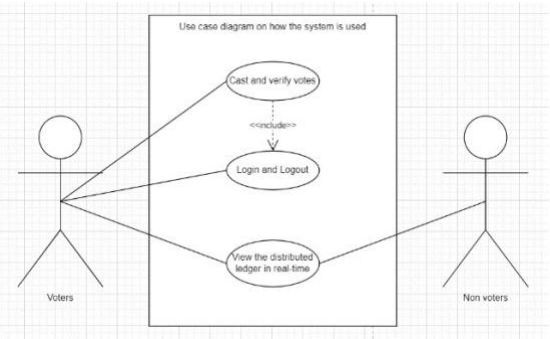

Figure 3.0: Use case diagram of the proposed system.

To illustrate the overview of the proposed system, a use case diagram was used as shown in Figure 3. Though the system may be accessed by both eligible voters and non-eligible voters of Malaysia, it can really only be used for the purpose of casting votes by eligible voters. The system allows mainly 3 functionalities to eligible voters, logging in and out of their account, casting and verifying votes, and view the distributed ledger in real-time, all shown on the user interface (UI). Nonvoters are only permitted to view the happenings of the election from the distributed ledger and not cast their votes as shown in the figure above. The ledger will contain the number of people who have casted their votes, as well as the tallied number of votes for each candidate and political party.

The proposed system will rid the limitations of the current voting system as it ensures that all votes are casted securely whereby no one can manipulate the votes once it has entered a block, making it highly unlikely for voter fraud to occur as every registered voter will have their information verified before the creation of their voting account, create a more efficient and transparent environment as the system will automatically tally the total number of votes along with the specific number of votes each political candidate and their party have as these figures will be shown in the distributed ledger as it happens, and lower the cost of elections in the long run. The voting process of a voter is illustrated in Figure 4.

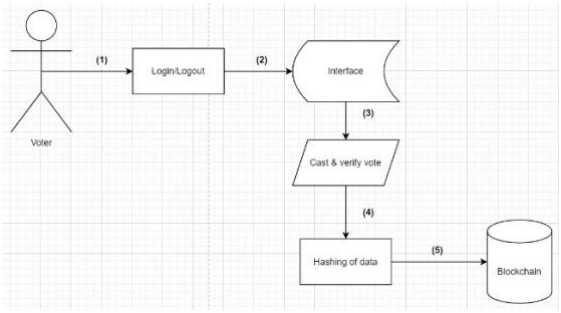

Figure 4.0: Simplified representation of the proposed system.

Voting process:

(1) : Before a voter can cast their votes, they must first authenticate themselves by logging into their registered account.

(2) : Once logged in, the user will be brought to the UI of the system which includes a number of things including a section whereby voters can cast their votes or witness the voting process as it happens from the distributed ledger.

(3) : When a voter chooses to cast their votes, before submitting their votes, they may verify that they have voted on the correct candidates representing their area.

(4) : After submitting their votes, each voters' votes will be hashed with SHA-256.

(5) : Finally, once the votes of the voters are hashed, it will then be stored in a block of a blockchain.

9.0 Conclusion

This study involves the proposal of an electronic voting (E-Voting) system with the incorporation of Blockchain technology to be implemented in the context of Malaysia. The system is decentralized, which does not require the reliance on trust, and can be accessed remotely by voters to cast their votes [19]. Since the system incorporates Blockchain, the ledger will be publicly distributed and verifiable in a way that the identities of the voters will remain anonymous and that no party will be able to manipulate and corrupt it [19].

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