The Feasibility of Adopting a Secure E-voting Based Biometrics Authenticity: The Jordanian Parliamentary Elections

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Abstract **– This paper aims at investigating the feasibility of adopting a secure e-voting based on the authenticity of biometrics in conducting the election of Jordan parliamentarians consol. It firstly investigates the Jordanian citizens' acceptance level of an e-voting system based on biometric credentials as a supportive solution to their attitude, intention, and trust in actual participation. The successor phases are directed to validate the feasibility of adopting a biometric-based e-voting system by involving the Delphi method of three rounds for collecting and analysing data. The initial use case diagram, interview questions, and resultant queries are all mapped to construct the proposed conceptual framework. The results of multi phases methodology allow for development and recommend a conceptual framework for implementing an e-voting system with all acting schemas that represent the different stages of the election process. Moreover, the proposed conceptual framework was developed with thematic regulations that align with the experts' consensuses and the current Jordan parliament election law.**

Keywords **– E-voting, Jordan parliamentarians, E-election, Biometrics, Delphi, TAM.**

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1. Introduction

In accordance with the Jordanian National Constitution, the Independent Election Commission (IEC) is responsible, as an institutional mission to organize and carry out elections. The IEC was established in 2012 as an unbiased organization involved in overseeing and directing the electoral process without interference or pressure from any party, with the aim of ensuring the holding of parliamentary elections in accordance with international standards. However, the main objective for the 21st century is a need felt by the IEC to prepare to reach the levels of technological development required to face the new century full of challenges and expectations. This means that the IEC should act promptly, keeping up with the progress and demands of this modern world that requires higher rates of efficiency, economy, speed, and responsibility in the fulfillment of its public functions.

In line with the digital transformation in the provision of government services, which adopt e-government services solutions, it has become necessary to design an electronic voting (e-voting) system and to abandon the traditional methods of conducting elections. In addition, the marvelous development in the Information and Communication Technology (ICT) should be exploited in conducting the electoral process to reduce issues related to the transparency and integrity of elections. As the current modest use of ICT in conducting the Jordanian parliamentary elections, which is limited to verifying the identity of the voter and his eligibility to vote by matching them with voter records, is not considered sufficient to ensure the transparency and integrity of the elections. Furthermore, continuing to use paper – based elections expose it to criticism and skepticism by the parties to the electoral process and is always accused of [1].

Several countries use of test different types of e-voting systems.

But Jordan still not using this technology this technology [1]. However, with the rapid developments in ICT and the pace of information transfer, the legislative election system in Jordan remains one of Jordan's political approaches, depending on conventional methods of execution[1] .

When approaching the trend towards e-government services in Jordan, the pace of which increased during the outbreak of the Covid-19 pandemic, we find that there is a real opportunity for adopting a secure e-voting system with that ensures transparency and integrity for parliamentary elections or any elections organized by the IEC. Therefore, this paper adopts the design of an e-voting conceptual framework based on the current electoral law of the Jordanian Parliament, with activating the use of Biometrics to verify the voter's identity and the eligibility to vote.

Smart biometrics refers to using specific physiological or behavioral features of humans to identify or verify a person[2]. Biometrics assesses the distinctive physical or behavioral attributes of individuals to recognize or authenticate their identity. Connected biometric authentication systems help to prove identity and use specific characteristics and behavioral features to identify and authenticate access to electronic assets in the form of a fingerprint, iris, speech, and facial recognition [3], [4].

In this paper, a proposed conceptual framework for an authenticated e-voting system is presented. It has been designed based on the current election law for the Jordanian parliament house of representatives using the requirements model and UML CASE tools. Moreover, the paper sought to examine the willingness of Jordanian citizens to accept an e-voting system using a questionnaire based on the Technology Acceptance Model (TAM)[1] . Then, it triggers the validity and feasibility of the proposed conceptual framework using the Delphi technique [5] to streamline the validation process as evidence of the validity of a secure e-voting adoption using multiple biometrics measures. A total of (10) experts in various fields of legal and legislative experts, information technology experts, and biometric experts agreed to participate in the Delphi process.

2. Literature review

Electronic Election (EE) refers to the instead use of Electronic Voting (EV) methods and ICT to carry out election process. Generally, e-voting consists of recording, authenticating, and approving, polling ballots, counting votes, and confirming votes. The e-voting is a common term that covers a wide variety of structures, solutions, and applications.

It can offer many benefits, including the avoidance of bribery, the reduction in human participation, the acceleration in the collection of votes, the decrease in spoiled ballots through better display and automated confirmation of ballots, the reduction of costs due to decreasing overhead polling, the increase in participation in the electoral process due to ease of access (online voting) and the opportunity for remote voting [6], [7].

In [8], they developed an electronic voting system for the election of presidential and vice-presidential candidates, national and provincial legislatures, and local representative assembly members in Indonesia. Their form was accepted because most of the respondents are willing to use the electronic voting system. Similarly, in the work of (A. Mishra & Ahmad, 2019), they developed a software application that uses a web API and the concept of a Dynamic Systems Development Method (DSDM) with an object-oriented methodology. During their work (Chalabi et al., 2021), they developed an electronic voting system that was validated by a focus group. In the Jordanian context, [1] proposed an approach to this issue by recommending an e-voting system for the Jordanian elections. They studied the readiness of the Jordanian elector for the e- voting system and suggest a real system. However, their model has not been validated.

An e-voting system, therefore, should be concerned about the minimum requirements of : guarantee that only people with the right to vote are able to vote, guarantee that each vote is considered and that it is counted only once[11], maintain the right of the voter to form and express their opinion freely, without any type of intimidation or undue influence, protect the secrecy of the vote in all phases of the voting process, guarantee accessibility to the largest possible number of voters, especially people with disabilities[12], and increase voter confidence by maximizing the transparency of information about the operation of each system[13].

For authenticity issue, there are two models of biometrics, as identified by [4], [5]. The first one called Unimodal Biometric (UB) system, which is a single unique feature used in a unimodal biometric system to identify or verify an individual. While the second one called Multimodal Biometric (MB), which is a device that requires more than biometry to be stable and effective and more accurate uses multimodal biometrics.

Creating a biometric identity in combination with a known system of identity’s authentication gives the eligible voters more confidence.

This is a specific identification framework for implementing a biometrics system capable of handling fingerprints, iris scans, and other data types for integrating the power of biometrics to provide a safe identity verification solution for voters. On the other hand, biometrics address the prevalent identity problem, which is now a global dilemma [9], [10]. In this paper, a multimodal biometric is recommended to hack up with all available technology and voter's needs.

3. Statement problem and questions

In Jordan context, there have been great efforts to overcome the issues related to Traditional Election (TE) systems. These efforts try to utilize online systems to computerize the whole process. However, these attempts for deploying EE systems are limited to the process of casting and counting votes rather having the whole election process automated[7]. Therefore, the limited utilization of IT facilities in the election processes needs to be extended to solve the problem of voters' trust, since bylaws are funded, created, and implemented by the centralized third-party IEC. In addition, these e-voting systems of the first generation have been a lack of authenticity, tractability, power, integrity, and privacy for voters[11], [12]. Moreover, the literature gap appears in the review of the theoretical framework of the study context related to Jordan Parliament Election Law (JPEL), as it revealed its lack of validation and feasibility of the designed e-voting system.

Therefore, this paper comes to fill the addressed theoretical and practical gaps by answering the following questions that makeup the design process of the proposed conceptual framework:

1. Do Jordanian citizens accept practicing a Biometrics- based EV system?
2. What do experts consider important of legislative and technological competencies in implementing Biometrics- based EV system?
3. How do the experts view the implications of adopting a Biometrics- based EV system?

4. Methodology

The adopted methodology is structured into several phases. It starts by reviewing the literature and JPEL and ends up with constructing a conceptual framework with feasibility results (i.e., validation). Figure 1 shows the research methodology and workflow procedures.

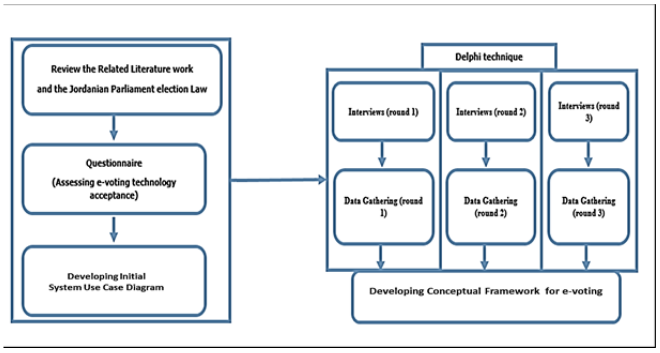

Figure 1 Research methodology

Based on figure 1, this paper aims at exploring the level of Jordanian citizen's acceptance of practicing EE based biometric conceptual framework and identifying what the experts view as important for developing an e-voting system-based biometrics. Hence, the drawn methodology includes the following ordered phases:

Phase 1: Reviewing the related literature and the JPEL to build the TAM based questionnaire.

Phase2: Developing and disseminating the TAM based questionnaire and provide the results. The TAM is used to identify the Jordanian citizen's acceptance of practicing EE based biometric conceptual framework. Figure 2 shows the structure of the TAM[13], [14].

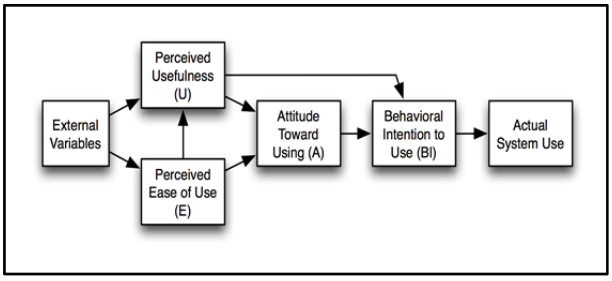

Figure 2 TAM Structure

The TAM is utilized to discover the acceptance of new e-technology or new e-services [14]. This model is extensively used to measure the acceptance and practice of originated technology by users. A connection was found between the beliefs of users about a technology's facilities, the mindset, and the purpose to use the technology. Therefore, we opt to use PU and PEOU in developing the proposed conceptual framework. The Perceived Usefulness (PU) refers to the degree to which a citizen believes that using EE system-based biometrics would enhance the confidence level of the election process through the variables of security and privacy, trust and subjective norm. The Perceived ease-of-use (PEOU) addresses the degree to which a citizen believes that using such system would be effort-free.

Phase 3: Developing an initial system use diagram that considers the results in phase 2 and addressing the critical Delphi questions. Thus, the review of related literature and the parliament election law allow to develop the readiness measurement (the TAM questionnaire) and design an initial system use case diagram.

Phase 4: Applying Delphi technique based on the interview rounds setting with the selected experts, the experts, who were selected based on their professional and knowledge about the investigated topic. They are asked to address the important of legislative and technological competencies in implementing the proposed EE system-based biometrics. This phase is repeated until reaching a consensus on the biometric -based e-voting conceptual framework with linkage to legislative and technological competencies required. The use case diagram along with its description, results or TAM questioner, and the pre-defined questions were sent to the experts of Delphi chain for conducting the debates rounds.

The critical Delphi questions, which are:

1. What do experts consider important of legislative and technological competencies in implementing the EE based biometrics project?
2. How do the experts view the implications of adopting an EE based biometrics?

Delphi technique used to validate the proposed e-voting conceptual framework, which has been designed based on JPEL and the results of TAM of Jordanians' citizens for practicing EE. The Delphi process allows multi rounds till reaching a consensus, which is acceptable if reaches at minimum between 75% to maximum 85%, and when the matter to be settled has stronger ethical implications, they can be 100% [14]. Figure 3 shows the Delphi process.

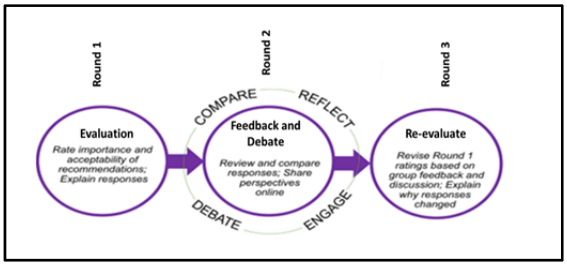

Figure 3 Delphi Process

Before proceeding to Delphi rounds, the selection of subjects for the Delphi analysis is the most critical step in the whole process.

It allows to choose the apt subjects, who directly stress the quality of the findings achieved.

Since the qualifications of the participants are more important than the number of participants, only 10 experts have been chosen who possess fundamental knowledge in their field and what serves the research topic.

The participants were contacted face to face or through the Zoom and Team applications.

5. Results

This section presents the descriptive and analytical findings of the study. Subsections, tables, and figures below highlight the results.

TAM Results

Since the current paper is multi objective, it is rational to present the results of the TAM model shown in figure 2. The inclusion of both PU: security and privacy, trust and subjective norm, and PEOU: free effort reflects the citizens' attitude toward practicing EE system, which in turn, if positive, maximizes the behavioral intention to participate in the election process for actual use. Table 1 shows the perceived results by (2200) individuals, who participated in an online survey designed for assessing their acceptance to promote EE system based biometric to response to the first Research Question (RQ1)"Do Jordanian citizens accept practicing an EE system-based biometrics?

Table 1 Descriptive analysis for the responses to TAM

Variable	Mean	Std.d	Degree
PU	4.6	0.52	High
PEOU	4.5	0.51	High
Attitude toward practicing EE system	4.6	0.49	High
Behavioral intention	4.5	0.78	High
Actual Use	4.8	0.63	High

Results in Table 1 indicate that Jordanian citizens believe that applying EE based biometrics contributes positively to their attitude, and then their intention to participate in the elections once actually conducted. This positive attitude toward EE based biometric allows to construct the system use case diagram, as shown in figure 4, to be used for describing the election process along with setting up the Delphi critical questions for further analysis.

Figure 4 System Use Case Diagram

The standard use case for an electoral system, as seen in Figure 4, is about IEC and people. The IEC offers lists of voters and candidates in this scheme, collects biometrics, and provides scientific conditions and procedures to the system administrator. The system administrator then builds a SC to validate, execute, and verify the voters. All the votes of anonymous voters are included at the end of the election in the sequence of its origin. Therefore, the official results will be revealed within minutes after the election ends.

Delphi rounds results

Using N-Vivo application software, the participants' responses are codified regarding proposed model development, technology, and legal aspects. Several contributors described effective observes in a narrative form where they labeled the techniques that were used to develop and evaluate the model or the legal and technical aspects and through this narrative debate, researched or posed follow-up questions to ensure that the contributors describe an operative practice rather than merely narrating their own development experience. As participants described effective practices, their answers could be classified into one of the subcategories indicated in Table 2.

Table 2 Coding Categories of Round one results

Competency	Code	Short Description	Related RQ
Legislative & Technological	TA	Technology tolerant	RQ1
	SPD	Secrete, Public Direct	RQ1
	CVR	Candidate and Voter Rights	RQ1
	CV	Central Voting	RQ1
	TF	Technological Feasibly	RQ1
	VP	Voting Process	RQ1
	VR	Voting Regulations	RQ1
	RI	Required Infrastructure	RQ1
	EEB	Electronic Election Benefits	RQ1
Biometrics	HAS	High security and Assurance	RQ2
	CF	Convenient and fast	RQ2
	NT	Non-transferrable	RQ2
	SP	Biometrics are hard to fake or steal	RQ2

In the first round of the study, the participants discussed the current electoral system and its defective problems. After evaluating the initial use case diagram, they recommended technical, procedural, and technological improvements, after which the legal aspect and the extent of its implementation were discussed based on JPEL.

The answers gathered from the first round were restructured to specific questions to be answered in the second round. The questions were mapped into two categories based on RQ1 and RQ2, and the codified attributes extracted form round 1. The process then defined a set of queries to determine the technological and legal competencies surrounding the adoption of EE based biometrics. The defined queries were sent to the experts for proceeding to round 3.

In round 3, 9 out of 10 participants responded by stating their agreements of (88%) with the practices extracted form round 2. The three rounds of organ screening used through the Delphi study led to the creation of a final list of agreed effective practices for developing an EE model-based biometrics with implementation feasibility, considering the legal safeguards for implementation. Figure 5 shows the experts' agreement level on the defined queries, whereby the final proposed model was validated and designed as shown in figure 6.

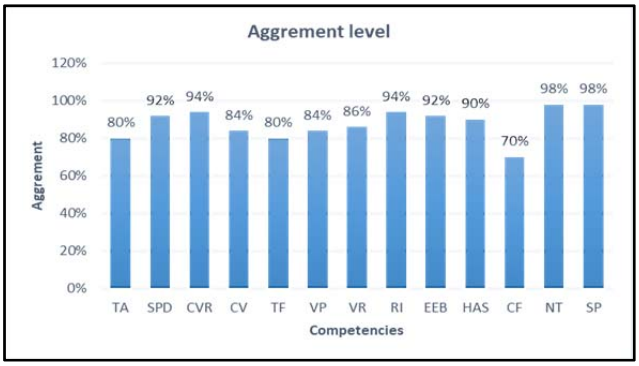

Figure 5 Agreement level

Figure 6 shows that the experts conditionally agreed on the competencies of the e-voting after considering their high consensus on the query items in the third round. Therefore, the following model is designed to include all stages of the electoral process based on the use of biometrics in the process of verifying the identity of the voter and candidate, as well as managing the voting process as shown in figure 6.

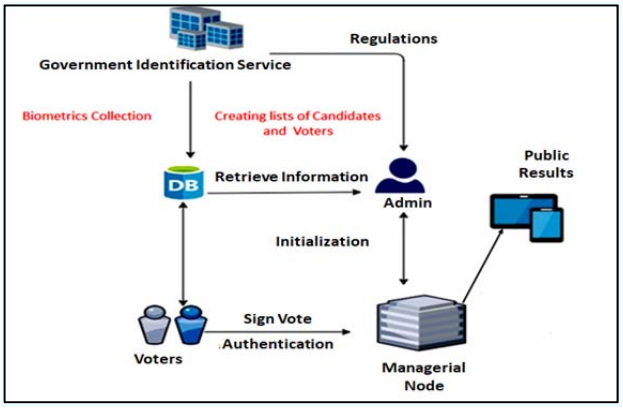

Figure 6 The Proposed Model

The proposed e-voting system keeps track to fulfill the standards of adopting EE by stressing a set of principles related to consistency [15], integrity [7], [16], identity verification [4],[14] ,eligibility [17], secrecy of the elector [10], resistance to tampering, uniqueness, and verifiability by individuals [12]. Thus, the rules that regulate the proposed system are explained as follows:

1. After providing the director of elections with conditions, procedures, lists, and essential measures, the IEC begins by preparing voters' and candidate lists and then collecting vital measurements relevant to them. IEC begins the process of elections and control their life cycle by: Specifying the type of the election; Creating the election; Deciding the lifespan of the election and the length of the election.
2. Voters: Voters are the registered participants in particular elections. The role of the voter includes authentication at the start of the voting process using biometrics credentials; casting a vote; verify that his\her vote has been counted after the casting.
3. Managerial node: It is a networked server of a stand location station machines that receives all verified votes with votes projections on candidates. this server node projects the votes and allows the results published for public based after decision of election stopping time limits by the IEC.

6. Conclusion

This paper attempts to outline a conceptual framework for E-voting system based on general E-voting standards and JPEL. Thus, the paper carries out an intensive literature review related to e-voting systems linked to Jordan context. It employs multi strategies to achieve its aim by investigating the attitude and intention of EE participation of Jordanian citizens using TAM. The validation process of the proposed conceptual framework involves the use of Delphi method with three rounds continued to settle with high level of experts' consensus. The results of the multi phases methodology allow to develop and recommend a conceptual framework for implementing e-voting system with all acting schemas that represents the different stages of the election process. Moreover, the proposed conceptual framework developed with a thematic regulation that align with expert's comments and JPEL standards.

7. Future Work

The proposed conceptual framework focuses on involving the biometrics to improve authenticity regulation and increase voter trust in the election system. This conceptual framework can be expanded to include the concept of Block Chain (BC), which addresses more security issues related to tampering with results and the reservations about the adoption of internet or remote voting instead of centralized voting process and place. Moreover, Machine learning applications can be used to design e-voting models through the use of its various applications in terms of security and networking [18], [19], [20], [21].

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