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MULTI-CRITERIA EVALUATION + THE POSITIONAL APPROACH TO CANDIDATE SELECTION IN E-VOTING

Rasim Alguliyev [1], Ramiz Aliguliyev [1] and Farhad Yusifov [1*]

[1] Institute of Information Technology, Baku, Azerbaijan

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Abstract: *E-voting is one of the most important components of e-democracy and includes interesting research topics, such as the mechanisms of participation in elections, technological solutions to e-voting and the efficient application of those in e-voting. Currently, there are numerous voting systems adopted in many countries of the world and each of those has specific advantages and problems. The paper explores the e-voting system as one of the main tools of e-democracy and analyzes its advantages and drawbacks. Voting results always lead to a broad debate in terms of candidate selection and of whether the candidate elected to a position is suitable for that position. At present, the selection of qualified personnel and their appointment to responsible positions in public administration is one of the topical issues. In the paper, multi-criteria decision-making (MCDM) is proposed for the selection of candidates in e-voting. The criteria for candidate selection are determined and the relationship of each candidate with the other candidates is assessed by using a binary matrix. The candidate rank is calculated according to all the criteria. In a numerical experiment, candidate evaluation is enabled based on the selected criteria and ranked by using a positional ranking approach. The proposed model allows for the selection of a candidate with the competencies based on the criteria set out in the e-voting process and the making of more effective decisions as well.*

Key words: *e-government, e-democracy, e-voting, MCDM, candidate selection, election, e-Government Maturity Model, governance.*

1. Introduction

The implementation of information-communication technologies (ICT) has an impact on social, economic and political life. Especially, the development of ICT and e-

* Corresponding author.
E-mail addresses: farhadyusifov@gmail.com (F. Yusifov), r.alguliev@gmail.com (R. Alguliyev), r.aliguliyev@gmail.com (R. Aliguliyev)

government forming has substantially changed the public governance and political processes.

E-democracy is regarded as the engagement of citizens and government bodies in political relations and processes (Lee 2010; Van der Meer et al. 2014). This stage is characterized by the level of the close participation of citizens in socio-political processes and e-citizen problems. The efficiency in governance can be achieved with the close participation of citizens, as well as civil societies, in the process of politico-administrative decision-making. E-government is forming a new environment in this regard. E-democracy is mentioned as the evolutionary stage of several developmental models of e-government (Lee 2010). According to some researchers, a transition must be made from the use of the term 'e-government' to the use of the term 'e-democracy' (Meier 2012; Taghavifard et al. 2014) because e-democracy is considered as the evolutionary stage of several developmental models of e-government (Lee 2010). The strengthening and development of democratic institutions, the use of ICT and the information infrastructure for the expansion of civil participation in public and political processes reflects the essence of e-democracy (Anttiroiko 2003; Carrizales 2008; Strielkowski et al. 2017).

Currently, the study of the role of e-voting in the countries which have adopted the formation of e-democracy as a priority is deemed as an integral part of investigations in the field of e-democracy (Musial-Karg 2014). The dynamic development of ICT and the enhancement of social media tools have resulted in significant changes in the functioning of modern countries and societies. ICT has started to play an important role in practically all fields of human life, including political processes. As one of the important components of e-democracy, e-voting encompasses interesting research topics, such as participation mechanisms in elections, the provision of legitimacy, technological solutions and the efficient application of those in the e-voting process. In this regard, e-voting can be considered as one of the forms of e-democracy (Musial-Karg 2014). In this study, approaches regarding the development of new e-voting mechanisms are analyzed.

Nowadays, human resources are considered as the main strategic resource of the government. The selection of qualified personnel at the government level and their appointment to responsible positions are important issues in economic and political processes. Candidate selection is understood as a process in which the best candidates are selected for a particular position. Different methods and technologies that help decision-makers to predict how successful a candidate will be in the future workplace are applied in the recruitment and selection processes (Dursun et al. 2010; Kabak et al. 2012; Tuan 2017; Afshari et al. 2017). In the literature, multi-criteria decision-making (MCDM) is widely used in various fields, such as the selection of appropriate personnel in the recruitment process, the choice of equipment in production, the selection of projects, etc. (Kabak et al. 2012; Kazana et al. 2015; Tuan 2017, 2018; Mukhametzyanov & Pamučar 2018). There are research studies on the comparison and review of MCDM (Stanujkic et al. 2013; Zavadskas et al. 2014; Mardani et al. 2015, Khorami et al. 2015).

A literature review highlights a few research studies on the application of MCDM for candidate selection in the election process. Royes et al. (2001) use fuzzy MCDM in election predictions. The use of a computational system was proposed as a practical means of election forecasting. According to the decision-maker (the system user), the proposed flexible system allows for a choice of fuzzy weights and fuzzy evaluation functions in respect of the selection criteria. Kazana (2015) showed that a total of 15 criteria were taken into account when selecting deputy candidates for political parties. The weight of the criteria is evaluated by the party representatives by means of the

analytical hierarchy process (AHP) by using the FARE (Factor Relationship) method. Candidates are assessed based on the criteria selected by applying MCDM. An empirical assessment is carried out in the research work and the candidates to the deputies are ranked through MCDM. The recent research works of the authors Alguliyev et al. (2019) have proposed an MCDM model for the selection of candidates in e-voting. The rating of candidates is calculated based on MCDM and candidates are selected based on the importance of the criteria. The proposed approach enables us to select a candidate with more relevant competencies within the framework of selected criteria. In a numerical experiment, the five candidates selected on the three criteria (education, work experience, and professional competencies), are evaluated and the candidates are ranked according to the importance of the criteria.

Note that the effective functioning of the government is directly dependent on human resources, and the participation of qualified personnel with competencies in governance is an issue of national importance. From this point of view, the selection of a candidate with appropriate competencies for the appointment of elected candidates to administrative positions as a result of e-voting, as well as the criteria and factors that should be considered in the selection process, are referred to as topical issues. The paper considers the application of MCDM in candidate selection in e-voting.

2. The e-Voting System as an Important Component of e-Democracy

The concept of e-democracy that emerged in the 1990's has started being perceived as the evidence of changes taking place against the backdrop of democratic principles in government. The support of the application of ICT in the political arena has facilitated the emergence of e-democracy, which encompasses new methods of the governance of democratic government. Political institutions, parties and politicians utilize ICT in the three main processes in the political arena, including the issues of information, communication and voting.

E-government maturity models are constituted of a sequence starting at the base stage all the way to the advanced stage, these stages determining the e-government maturity level. The proposal for methods for determining the development level of e-government and ranking e-government portals is considered as the main advantage of mature models (Fath-Allah et al. 2014). Moreover, mature models may assist organizations in promoting the efficiency of e-government. Concha et al. have proposed that mature models of e-government should be categorized into three groups, namely: governmental models, holistic approach models, and e-government maturity models (Layne et al. 2001; Andersen et al. 2006; Concha 2012).

According to developed countries' practices, research in this three categories has shown that e-government maturity models bear large importance from the standpoint of e-democracy development. The analysis of the existing e-government maturity models in the literature shows that there are several models in place, as proposed by Layne and Lee (2001), Wescott (2001), Siau et al. (2005), Chen et al. (2011), and other researchers and numerous organizations (Fath-Allah 2014; Layne et al. 2001; Wescott, 2001; Siau et al. 2005; Andersen et al. 2006; Shahkooh et al. 2008). Among those models, the formation of e-democracy has been proposed by several authors, including Wescott (2001), Siau et al. (2005) and Shahkooh et al. (2008), as the last stage of e-government development. While exploring the above-mentioned models, it is evident that e-voting, public forums, open government, the analysis of the public opinion and the development of feedback mechanisms are demonstrated as the

foundation of the formation of e-democracy, which is deemed to be the evolutionary stage of e-government development. In this regard, the development of e-democracy mechanisms and e-voting technologies is necessary in order to boost transparency and efficiency, and constitutes the basis of the open government concept.

The evolutionary stage envisions the formation of new requirements and the expansion of the degree of civil participation in processes by altering the relationships between the government and the citizen. The majority of the existing developmental models incorporate democratic processes, such as political participation, e-participation, wiki democracy, interactive democracy and digital democracy (Van der Meer et al. 2014). All of these terms pertain to the democratic processes based on the transformation of the relations between citizens and the government. E-democracy has been included in these models as the last stage of a developmental model. Logically, the government must complete the preceding information, interaction and transaction/integration stages in order to proceed to the e-democracy stage.

As a new concept, the implementation of e-voting is based on reducing errors during election processes and is oriented towards maintaining the integrity of the election process in general. In the scientific literature, e-voting is considered as the use of computers and devices connected to computers in the election process, and more precisely, this term has been adopted so as to characterize elections carried out via the Internet (Abu-Shanab 2010).

The e-voting system has offered the election process numerous advantages. For instance, the facilitation of the participation of physically disabled persons, no requests for additional employees to print the election ballot papers, and a cost-effective and efficient organization of elections. In general, cost-effectiveness, the expansion of participation and the broadening of voting options, a faster and accurate registration and calculation of votes, as well as accessibility and flexibility against deviations can be considered as the main advantages of e-voting (Abu-Shanab 2010).

Research studies on e-voting have gradually become an important issue. The reason for that is a growing number of scientific-research works conducted on the development of new voting methods via the Internet and mobile services in European countries and worldwide. As a result, the terms of e-democracy, e-participation and e-voting are frequently encountered in the context of e-democracy. In European practice, the studies in the field of e-voting are mainly represented by the empirical studies conducted by Estonia, Switzerland, Poland, Norway and other countries (Drechsler et al. 2004; Braun et al. 2006; Trechsel 2002, 2007, 2016; Musia-Karg 2012, 2014; Vassil et al. 2016).

Despite the growing number of the studies devoted to researching the impact of new technologies on democracy, there is a need for conducting comprehensive research studies in the field of e-voting. In particular, it is essential to analyze the issues such as the implementation of e-participation solutions on the example of European countries and the factors necessitating the rejection of its implementation due to various drawbacks, the application opportunities of e-voting, the existing barriers and effectiveness. Hence, the development of mechanisms for and specific technological solutions to e-voting, its effectiveness and a study of undesirable results in comparison with traditional voting are deemed to be the topical research directions.

Currently, e-voting for elections and referendums at the local, regional and country levels is rapidly developing at the global scale as a more efficient and more feasible alternative to traditional voting and it favorably affects the development of democratic government. Alongside, despite the widening international practice regarding the application of the e-voting system, several challenges are still being encountered given the national interests related to legal and social problems and its implementation.

Scientific and public discourse in the field of e-voting has been broadening in the last decade. E-voting systems are categorized as location-bounded and remote voting. In the first case, the voter is required to participate in the election due to the dependence of the voting on the location. Remote voting has been applied in various countries, such as Estonia, France, The Netherlands, Switzerland, and so on. E-voting has a great potential for the expansion of the democratic participation of the public by facilitating the participation of non-represented groups in the political life, including youth and physically disabled persons. Moreover, e-voting fosters economic effectiveness and facilitates the effective organization of elections in comparison with traditional voting (Chondros et al. 2014).

In spite of the advantages of the implementation of e-voting, transition to a new technology is accompanied by numerous social, legal and technical problems (Wang et al. 2017). Among those, equal access to voting points, privacy maintenance, fight against interventions, the verification of information, examination, alteration and other procedures, universal verification, the right to vote, the one-voter-one-vote principle, strictness against errors, etc. can be considered. The necessity of transforming legal obstacles into technical and security solutions can specifically be mentioned amongst these (Wang et al. 2017). Nowadays, broad discussions are held on holding elections from a legal standpoint; as a result, it is believed that solving legal issues plays a bridging role between the law and technology.

3. MCDM-Model-Based Candidate Selection

Voting is a fundamental tool for decision-making in any consensus-based society and democracy hinges upon the accurate governance of nationwide elections. At present, numerous voting systems are adopted all over the world and each of those has specific advantages and problems. Some countries abandoned e-voting due to its risky nature. Other countries do not accept the advantages of e-voting in comparison with traditional voting. With the rapid development of the Internet, which started in the 1990s, a larger number of politicians, researchers and journalists have started reflecting upon whether e-voting proposes better solutions to elections or a referendum or not. Through numerous scientific incentives of non-government organizations at the global scale, the governments of European countries endeavor the use of the voting methods, ICT-based solutions, the application of which constitutes the basis of democratic processes (Zetter 2008; Voting system; Trechsel et al. 2016; Meserve et al. 2017). Nowadays, the majority of countries support e-voting and a growing number of countries consider the e-voting system as useful and practically apply it in their election processes. Furthermore, it is to be mentioned that, for the largest part, those efforts are still at the stages of testing and conceptual analysis. The benchmark practice regarding the application of the e-voting system at the global scale can be characterized by the USA's practice (Zetter 2008; Voting system; Trechsel et al. 2016).

At present, new voting technologies are being implemented not only in the USA, but also in several European countries (Voting system; Trechsel et al. 2016). Surely, the efforts to implement the above-mentioned e-voting system result in various outcomes in different countries. For instance, the analysis of e-voting results from the elections to the European Parliament, Country Parliament Elections (2011) and Municipal Elections (2013) shows that the interest in the implementation of a new system has systematically been growing, which is the reason for the conclusion that citizens consider this voting method to be more comfortable and more effective

(Zetter 2008; Voting system; Trechsel et al. 2016; Meserve et al. 2017). Note that the ratio of the Internet voters has grown from 1% in 2005 to 11.4% in 2014 (Mona et al. 2013; Musia-Karg 2014; Trechsel et al. 2016; McCormack 2016).

The participation of citizens in political processes and the facilitation of voting during the adoption of important decisions, as well as the provision of their direct participation, are considered as the basis of democracy. In spite of the broad implementation of ICT in business, various fields of the activity, education, public administration and government entities, the use of ICT in the voting process is treated with cautiousness in many countries. In addition, one of the main causes for the postponed implementation of advanced voting technologies is the differences in opinions and skeptical thinking when the Internet-based voting in societies is concerned (Mona et al. 2013; Musial-Karg 2014; McCormack 2016).

Despite the progress made towards a better development of e-voting systems, there is no classification for the purpose of understanding the general characteristics, aims and limitations of these approaches. Hence the absence of comparative research or the inaccurate determination of directions for selecting methods appropriate for specific requirements can be shown as the main drawbacks. In this regard, it is topical to develop efficient methods and mechanisms of e-voting by taking democratic processes into consideration.

The ability of e-democracy to overcome barriers causing the deterrence or limitation of citizens' participation in direct decision-making is considered as the main advantage of the development of effective e-voting mechanisms. From this point of view, e-voting is gaining the attention of government entities, political parties and politicians, and is deemed to be a powerful tool for sustaining democratic principles. The conducted research shows that e-voting has become one of the main tools of e-democracy by attaining greater importance (Musial-Karg 2014). In this regard, the development of e-voting technologies and the study of the implementation opportunities of new technologies are considered as important research topics.

The proposed approach to the research is based on the multi-criteria evaluation of the candidates, taking into account the relationship of each candidate with another candidate. Assume that, as a result of e-voting, the candidates are elected to be appointed to a relevant position. The intelligence quotient (IQ), age, education, work experience, health, conviction, etc. can be attributed to the criteria for the selection of competent candidates. A binary matrix is used for the evaluation of the candidates in the study.

The MCDM approach to candidate selection consists of the following stages:

Let $A = (A_1, A_2, ..., A_n)$ be the candidates and $C = (C_1, C_2, ..., C_n)$ be the criteria set.

Step 1. Each candidate constructs an evaluation matrix for the evaluation of the other candidates based on each criterion:

$$P_l^k = (p_{ij})_l^k = \begin{Vmatrix} (p_{11})_l^k & (p_{12})_l^k & \dots (p_{in})_l^k \\ \dots & \dots & \dots \ \dots \\ (p_{n1})_l^k & (p_{n2})_l^k & \dots (p_{nn})_l^k \end{Vmatrix} \quad (1)$$

where,

$$(p_{ij})_l^k = \begin{cases} 1, \text{ if according to the opinion of } A_k \text{ candidate, } A_i \text{ is superior to } A_j \\ \quad \text{according to } C_l \text{ criterion} \\ 0, \text{ otherwise} \end{cases}$$

The principal diagonal of the P_l^k matrix consists of zeros, $(p_{ii})_l^k = 0$, $(p_{ij})_l^k = (\overline{p}_{ij})_l^k$, if $i \neq j$, $\overline{0} = 1, \overline{1} = 0$.

Step 2. Thereafter, the $Q_l = (q_{ik})_l$ outcome matrix is entered and the elements are calculated as below:

$$(q_{ik})_l = \sum_{j=1}^{n} (p_{ij})_l^k, \quad i = 1,2,...,n; \; k = 1,2,...,n; \; l = 1,2,...,m, \tag{2}$$

$(q_{ik})_l$ - reflects the final opinion of the candidate A_k on the candidate A_j, based on the criterion C_l (in comparison with all the candidates):

$$Q_l = \begin{Vmatrix} (q_{11})_l & \dots & (q_{1n})_l \\ \dots & \dots & \dots \\ (q_{n1})_l & \dots & (q_{nn})_l \end{Vmatrix} \tag{3}$$

Step 3. The overall opinion of the candidate A_k on all the candidates is based on the criterion C_l and is calculated as follows:

$$O_l^k = \sum_{i=1}^{n} (q_{ik})_l, \; k = 1,2,...,n; \; l = 1,2,...,m \tag{4}$$

Step 4. The ranking of the candidate A_i based on the criterion C_l is determined by applying the following formula:

$$R_i^l = \sum_{k=1}^{n} (q_{ik})_l \quad i = 1,2,...,n; \;\; l = 1,2,...,m \tag{5}$$

The last relationship expresses the final opinion of all the candidates on the candidate A_i based on the criterion C_l.

Step 5. In order to obtain the resulting rank of the alternatives, the resultant rank computed by means of the following formula is used (Aliguliyev 2009):

$$\text{Resultant rank} = \sum_{s=1}^{\eta} \frac{(\eta - s + 1) r_s}{\eta} \tag{6}$$

where r_s denotes the number of the times the method appears in the s-th rank and η is the number of the alternatives.

4. A Numerical Experiment

Assume that a total of six candidates are presented based on four criteria (for example, education (C_1), work experience (C_2), age (C_3) and professional competencies (C_4)). Based on the formula (1), the evaluation of the candidates according to each criterion is given in Tables 1-6.

Based on the formulas (2) and (3), the final opinion of the candidate A_k on the candidate A_j is calculated according to the criterion C_l (in comparison with all the candidates) and is given in Table 7.

Table 1. The criteria-based evaluation of the candidate A_1

	C1						C2					
	A1	A2	A3	A4	A5	A6	A1	A2	A3	A4	A5	A6
A1	0	0	0	0	1	1	0	1	0	1	0	1
A2	1	0	1	0	0	0	0	0	0	1	1	1
A3	0	0	0	1	0	1	1	1	0	0	0	1
A4	1	0	0	0	0	1	0	0	1	0	0	1
A5	0	0	1	1	0	1	1	0	1	1	0	0
A6	0	0	0	0	0	0	0	0	0	0	1	0
	C3						C4					
	A1	A2	A3	A4	A5	A6	A1	A2	A3	A4	A5	A6
A1	0	0	1	0	0	0	0	0	1	0	0	1
A2	1	0	1	0	1	1	1	0	0	1	0	0
A3	0	0	0	1	1	0	0	1	0	1	0	0
A4	1	1	0	0	1	1	0	0	0	0	0	1
A5	1	0	0	0	0	0	0	0	1	1	0	0
A6	1	0	1	0	1	0	0	1	1	0	1	0

Table 2. The criteria-based evaluation of the candidate A_2

	C1						C2					
	A1	A2	A3	A4	A5	A6	A1	A2	A3	A4	A5	A6
A1	0	0	0	1	0	1	0	1	0	1	0	1
A2	1	0	1	0	0	0	0	0	0	1	0	0
A3	1	0	0	0	0	0	1	1	0	0	1	0
A4	0	0	1	0	0	1	0	0	0	0	0	1
A5	0	0	1	0	0	1	1	1	0	1	0	0
A6	0	0	1	0	0	0	0	1	1	0	1	0
	C3						C4					
	A1	A2	A3	A4	A5	A6	A1	A2	A3	A4	A5	A6
A1	0	1	1	0	0	1	0	1	0	0	0	1
A2	0	0	1	0	0	0	0	0	0	1	0	0
A3	0	0	0	1	1	1	0	1	0	0	0	1
A4	1	0	0	0	0	1	0	0	1	0	0	1
A5	1	0	0	1	0	0	0	0	1	1	0	0
A6	0	1	0	0	1	0	0	1	1	0	1	0

Table 3. The criteria-based evaluation of the candidate A_3

	C1						C2					
	A1	A2	A3	A4	A5	A6	A1	A2	A3	A4	A5	A6
A1	0	1	0	1	0	0	0	1	1	0	1	0
A2	0	0	1	0	0	1	0	0	1	0	0	1
A3	1	0	0	1	1	0	0	0	0	1	1	0
A4	0	1	0	0	0	0	1	1	0	0	0	0
A5	0	0	0	1	0	1	0	1	0	1	0	1
A6	0	0	1	1	0	0	1	0	0	1	0	0
	C3						C4					
	A1	A2	A3	A4	A5	A6	A1	A2	A3	A4	A5	A6
A1	0	1	0	1	0	0	0	0	0	0	0	1
A2	0	0	1	0	1	0	1	0	1	1	0	0
A3	1	0	0	1	0	1	0	0	0	0	1	1
A4	0	0	0	0	1	1	0	0	1	0	0	1
A5	1	0	1	0	0	0	0	0	0	1	0	0
A6	1	1	0	0	1	0	0	1	0	0	1	0

Table 4. The criteria-based evaluation of the candidate A_4

	C1						C2					
	A1	A2	A3	A4	A5	A6	A1	A2	A3	A4	A5	A6
A1	0	0	0	0	1	1	0	1	1	0	1	0
A2	1	0	0	0	0	0	0	0	0	0	1	1
A3	1	1	0	0	1	0	0	1	0	1	0	0
A4	1	0	1	0	0	1	1	1	0	0	1	0
A5	0	0	0	1	0	1	0	0	0	0	0	1
A6	0	0	1	0	0	0	0	0	0	1	0	0
	C3						C4					
	A1	A2	A3	A4	A5	A6	A1	A2	A3	A4	A5	A6
A1	0	0	0	0	0	0	0	0	1	1	1	0
A2	1	0	1	0	1	0	0	0	0	0	1	0
A3	1	0	0	0	1	1	0	1	0	1	0	1
A4	1	1	1	0	0	1	0	0	1	0	0	1
A5	1	0	0	1	0	0	0	0	1	1	0	0
A6	1	1	0	0	1	0	1	1	0	0	1	0

Table 5. The criteria-based evaluation of the candidate A_5

	C1						C2					
	A1	A2	A3	A4	A5	A6	A1	A2	A3	A4	A5	A6
A1	0	1	0	0	0	1	0	1	0	0	1	1
A2	0	0	0	0	1	0	0	0	1	0	1	1
A3	1	1	0	1	0	1	1	0	0	1	1	1
A4	1	1	0	0	1	1	1	1	0	0	0	0
A5	1	0	0	0	0	0	0	0	0	1	0	1
A6	0	1	0	0	1	0	0	0	0	1	0	0
	C3						C4					
	A1	A2	A3	A4	A5	A6	A1	A2	A3	A4	A5	A6
A1	0	1	0	0	0	0	0	0	1	0	0	1
A2	0	0	0	0	1	0	1	0	0	0	0	0
A3	1	1	0	0	0	0	0	1	0	1	0	0
A4	0	1	1	0	0	1	1	1	0	0	0	1
A5	0	0	1	1	0	0	0	0	1	1	0	0
A6	0	1	1	0	1	0	0	1	1	0	1	0

Table 6. The criteria-based evaluation of the candidate A_6

	C1						C2					
	A1	A2	A3	A4	A5	A6	A1	A2	A3	A4	A5	A6
A1	0	1	0	1	0	0	0	0	0	1	0	1
A2	0	0	0	0	1	0	1	0	1	0	0	0
A3	1	1	0	1	0	1	1	0	0	0	0	0
A4	0	1	0	0	0	1	0	0	0	0	0	0
A5	1	0	1	1	0	1	1	0	1	0	0	1
A6	1	0	0	0	0	0	0	1	0	0	0	0
	C3						C4					
	A1	A2	A3	A4	A5	A6	A1	A2	A3	A4	A5	A6
A1	0	0	1	1	0	1	0	1	0	0	1	1
A2	1	0	0	0	1	0	0	0	0	0	1	0
A3	0	1	0	0	0	1	0	1	0	0	0	1
A4	0	1	1	0	0	1	0	1	1	0	0	1
A5	0	0	1	1	0	0	0	0	1	1	0	0
A6	0	1	0	0	1	0	0	1	0	0	1	0

Table 7. The final opinion of the candidates based on the four criteria

	C1						C2					
	A1	A2	A3	A4	A5	A6	A1	A2	A3	A4	A5	A6
A1	2	2	2	2	2	2	3	3	3	3	3	2
A2	2	2	2	1	1	1	3	1	2	2	3	2
A3	2	1	3	3	4	4	3	3	2	2	4	1
A4	2	2	1	3	4	2	2	1	2	3	2	0
A5	3	2	2	2	1	4	3	3	3	1	2	3
A6	0	1	2	1	2	1	1	3	2	1	1	1
	C3						C4					
	A1	A2	A3	A4	A5	A6	A1	A2	A3	A4	A5	A6
A1	1	3	2	0	1	3	2	2	1	3	2	1
A2	4	1	2	3	1	2	2	1	3	1	1	4
A3	2	3	3	3	2	2	2	2	2	3	2	2
A4	4	2	2	4	3	3	1	2	2	2	3	4
A5	1	2	2	2	2	2	2	2	1	2	2	1
A6	3	2	3	3	3	2	3	3	2	3	3	3

Based on the formula (4), the overall opinion of the candidate A_k on all the candidates is calculated based on the criterion C_l, and is given in Table 8.

Table 8. The criteria-based opinion of each candidate (the final opinion)

O_1	11	10	12	12	14	14
O_2	15	14	14	12	15	9
O_3	15	13	14	15	12	14
O_4	12	12	11	14	13	13

The ranking of the candidate A_i is calculated based on the formula (5), respectively based on the criterion C_l and presented in Table 9.

Table 9. The ranking of the candidates based on each criterion

R1	Rank	R2	Rank	R3	Rank	R4	Rank
12	4	17	1	10	6	13	2
9	5	13	4	13	4	9	6
17	1	15	2	15	3	13	2
14	2	10	5	18	1	13	2
14	2	15	2	11	5	11	5
7	6	9	6	16	2	16	1

Using the positional ranking approach, the resultant rank in Table 10 was calculated by means of the formula 6. For example, the rank of the alternative A_1 is calculated as follows:

$$\text{Resultant rank } (A_1) = \sum_{s=1}^{6} \frac{(6-s+1)r_s}{6} = \frac{(6-1+1)\cdot 1}{6} + \frac{(6-2+1)\cdot 1}{6} + \frac{(6-3+1)\cdot 0}{6} + \\ + \frac{(6-4+1)\cdot 1}{6} + \frac{(6-5+1)\cdot 0}{6} + \frac{(6-6+1)\cdot 1}{6} = 2.500$$

Table 10. The resultant rank of the candidates

Candidate	Resultant rank	Rank No
A1	2.500	3
A2	1.500	6
A3	3.333	1
A4	3.000	2
A5	2.333	4
A6	2.167	5

As described in Table 10, the candidates are ranked in accordance with the A_3, A_4, A_1, A_5, A_6 and A_2 sequence. As the result shows in this case, the candidate A_3 has more appropriate competencies needed for the appointment to the position, according to the multi-criteria evaluation of the candidates.

The ranking results can be improved by employing the importance of criteria and the fuzzy hybrid approach for the purpose of computing the weights of the criteria (Lin 2010; Chang et al. 2013; Sakthivel et al. 2015). In practice, a different evaluation scale for the multi-criteria selection of candidates in the e-voting process can be used in the proposed model. The tools that enable the selection of a candidate with more relevant competencies within the framework of certain criteria among the candidates can be created by implementing the proposed model.

5. Conclusion

The paper investigates the approaches, tools, and mechanisms pertaining to the formation of e-democracy as the last stage of the development of e-government. The research results show that e-voting is gradually gaining greater importance and becoming one of the main components of e-democracy. The selection of qualified personnel at the government level and their appointment to responsible positions are important issues in economic and political processes. The candidates who are the best for the vacancy are selected for a particular position. It is worth noting that the effective functioning of the government directly depends on human resources, and the participation of qualified personnel with competencies in governance is an issue of national importance. From this point of view, the selection of candidates with appropriate competencies, the appointment of elected candidates to administrative positions as a result of e-voting, and the criteria and factors to be considered in the selection process are referred to as topical issues. The paper considers the application of the MCDM model in candidate selection in e-voting.

The approach proposed in the paper is based on candidate evaluation given each candidate's attitude towards another candidate. The rank of the candidates is calculated based on the MCDM model and the candidates are selected based on the positional ranking approach. The proposed approach enables us to select a candidate with more relevant competencies within the framework of the selected criteria. In the numerical experiment, a total of the six candidates selected based on the four criteria (education, work experience, age, and professional competencies) are evaluated and the candidates are ranked according to the resultant ranking method. The proposed model allows for the selection of the candidate with the competencies based on the criteria set out in the e-voting process and the making of more effective decisions as well.

Note that, alongside the rapid development of technologies and the enhancement of the implementation of the same in political processes, there is a need for a detailed analysis of the existing practice and for conducting studies oriented towards supporting citizen participation in political processes by applying these technologies. The development of e-voting methods will allow for the creation of a new e-democracy maturity model by facilitating the direct participation of citizens in democratic processes. Future studies will examine the application of the fuzzy hybrid approach to candidate selection by taking the importance of criteria into consideration.

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