The Use of Information and Communication Technologies in Electoral Procedures: Comments on Electronic Voting Security

Magdalena Musiał-Karg

Abstract—The expansion of telecommunication and progress of electronic media constitute important elements of our times. The recent worldwide convergence of information and communication technologies (ICT) and dynamic development of the mass media is leading to noticeable changes in the functioning of contemporary states and societies. Currently, modern technologies play more and more important roles and filter down to almost every field of contemporary human life. It results in the growth of online interactions that can be observed by the inconceivable increase in the number of people with home PCs and Internet access. The proof of it is undoubtedly the emergence and use of concepts such as e-society, e-banking, e-services, e-government, e-government, e-participation and e-democracy. The newly coined word e-democracy evidences that modern technologies have also been widely used in politics. Without any doubt in most countries all actors of political market (politicians, political parties, servants in political/public sector, media) use modern forms of communication with the society. Most of these modern technologies progress the processes of getting and sending information to the citizens, communication with the electorate, and also – which seems to be the biggest advantage – electoral procedures. Thanks to implementation of ICT the interaction between politicians and electorate are improved. The main goal of this text is to analyze *electronic voting* (*e-voting*) as one of the important forms of *electronic democracy* in terms of security aspects. The author of this paper aimed at answering the questions of security of electronic voting as an additional form of participation in elections and referenda.

Keywords—Electronic democracy, electronic participation, electronic voting, security of e-voting, ICT.

I. INTRODUCTION

INFORMATION technologies play a crucial role in the modern world, pervading nearly every aspect of social life in most states. Additionally, modern ICT have advanced, and continue to do so to such an extent that they have attracted the considerable attention of scholars and become a popular subject of academic studies. The social outcomes of the information revolution, related to the development of what has come to be called the information society, are increasingly considered and discussed by many academics.

The access to information (which is definitely greater and faster than several decades, or even a dozen years ago, due to ICT) is becoming increasingly significant in society, business

Magdalena Musiał-Karg (Prof. Dr.) works at the Faculty of Political Science and Journalism of Adam Mickiewicz University, Poland (e-mail: magda.musial@interia.pl).

and politics. This may be evidenced, for instance, by the emergence of such terms as e-society, e-banking, e-services, e-government, e-administration and, last but not least, e-democracy [2].

The information revolution, made possible by information technologies, facilitates easy replication and transmission of knowledge (at relatively lower cost) that would be unimaginable for societies that grew in the culture inseparably combining information with its carrier (be it paper or film) [3]. Additionally, the application of new tools in communication (following the application of ICT) and other fields of social life are increasingly addressed by scholars, journalists, politicians and observers. One of the areas discussed is certainly politics, as confirmed by the analyses of democracy, among other things, in relation to the new reality of electronic media. Thus, the notion of e-democracy has come to be used to describe one new way of communicating with citizens [4].

Note that against the backdrop of the extensively debated present crisis of representative democracy, which is related, among other things, to deteriorating civil engagement in the decision-making processes concerning the state, first and foremost, observers of social and political life are asking how to solve this problem and improve the state of contemporary democracy.

E-participation (next to e-Democracy) is a crucial term in discussion on development of decision-making processes in modern countries. It is defined as the use of ICT for enabling and strengthening citizen participation in the process of making democratic decisions. Over the last decade there has been a gradual awareness of the need to consider the innovative application of ICTs for participation allowing citizens to contribute to democratic debate. Without any doubt, alternative forms of citizens' participation – including electronic consultations, electronic popular initiative, electronic voting – give the electorate an opportunity not only to increase its activity in the political space, but also to influence the decisions taken. The experiences of many European countries (Estonia, Switzerland, Norway, United Kingdom) indicate that employing additional tools of civic participation minimizes the distance between politicians and voters, which in turn – in the context of the crisis of democracy – is an important argument for undertaking studies on this research subject.

Given the advancement of new technologies, a tendency is becoming apparent to combine politics with the development of ICT. There are more and more reports from many European

and other states about initiatives to launch common forms of e-voting.

This paper is an attempt at answering the question of security when implementing the systems of e-voting as an additional form of participation in elections and referenda. In addition to theoretical considerations concerning e-voting, the paper addresses the most important rationale behind the implementation of e-voting. A theoretical basis for these considerations are the concepts of electronic democracy (as a new paradigm of democratic governance in modern states), and concepts of ICT-assisted voting (as the most important tool of e-democracy).

II. THE APPLICATION OF ICT IN THE PROCESSES ON THE POLITICAL MARKET

Using the latest technologies in exercising democratic power is obviously a certain novelty from the point of view of political institutions, parties, politicians and the media on the one hand and the electorate on the other. One has to realize that, despite a number of technical difficulties that emerge in the process of ICT implementation in different fields of life (including politics), this is an irreversible change even though the above-mentioned limitations of technical or psychological

nature are likely to extend this revolution over many years [17], [18].

Electronic voting (e-voting) is one of the alternative forms of voting and constitutes one of the tools of e-democracy [12]. The simplest definition of e-voting approaches it as "voting by electronic means" [7]. Electronic technologies employed in voting processes are primarily the Internet, telephones, television and digital platforms.

On January 10, 2007, the Internet Society Poland (ISOC) adopted the *Statement on e-voting in general elections* [27], where it indicated that voting based on electronic methods is a broad notion, and telecommunication and information technologies are applicable in the electoral system in the following ways:

- in the process of collecting, processing and presenting the results submitted by electoral commissions where votes are cast traditionally – on ballot papers;
- in the process of vote collecting and counting; and,
- in remote voting via the Internet.

The use of telecommunication and information tools in the process of vote collecting and counting conducted in the remote Internet counting is termed e-voting.
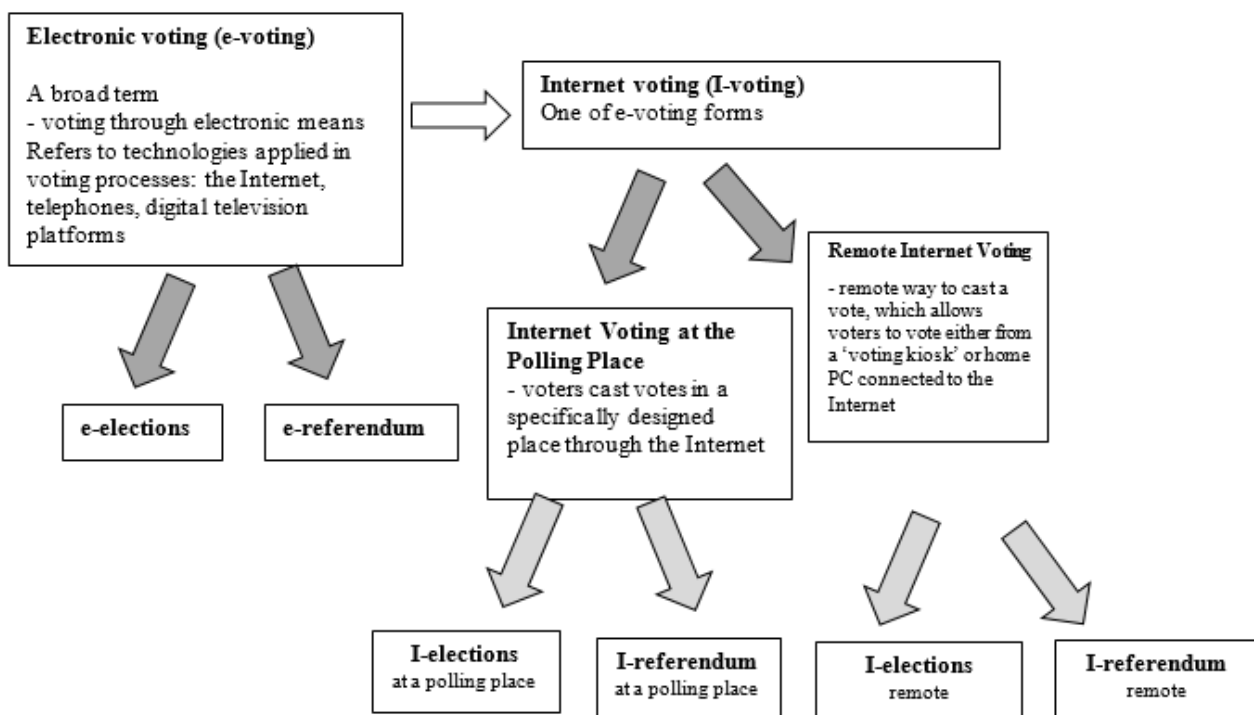

Fig. 1 Forms of electronic voting

Pursuant to the *Recommendation Rec (2004)11 of the Committee of Ministers to member states on legal, operational and technical standards for e-voting, adopted by the Committee of Ministers on 30 September 2004 at the 898th meeting of the Ministers' Deputies*, e-voting may be divided into two main categories: remote voting and voting in a kiosk.

Remote Electronic Voting is a type of voting using electronic media, allowing the voting act to be performed from any location. Such voting may involve voting via the Internet, short text messages, interactive digital television and touch screen telephones.

Voting from kiosks requires voters to approach their polling

station, or another location indicated by the electoral authorities, in order to register their votes [8]. Voters cast electronic votes, frequently by means of touch screens. Their votes are counted by separate devices, DRE (Direct Recording Electronic) machines and then sent to the central register of cast votes.

The literature on the subject usually indicates two types of e-voting: electronic voting (e-voting) and Internet voting (I-voting). E-voting encompasses a more extensive scope of meaning and also encompasses Internet voting. As was already mentioned, electronic voting refers also to the electoral technology applied in the process, such as digital television platforms, telephones and the Internet [19], [23].

Internet voting, in turn, is divided into two categories: Internet Voting at the Polling Place and Remote Internet Voting. In the former case, voters cast their votes in a specifically dedicated voting kiosk via the Internet. The later form means a remote method to cast votes, allowing voters to cast voters either from the 'voting kiosk' (this time located outside a polling station) or home PCs connected to the Internet. The data from either voting place are sent to central database through the Internet.
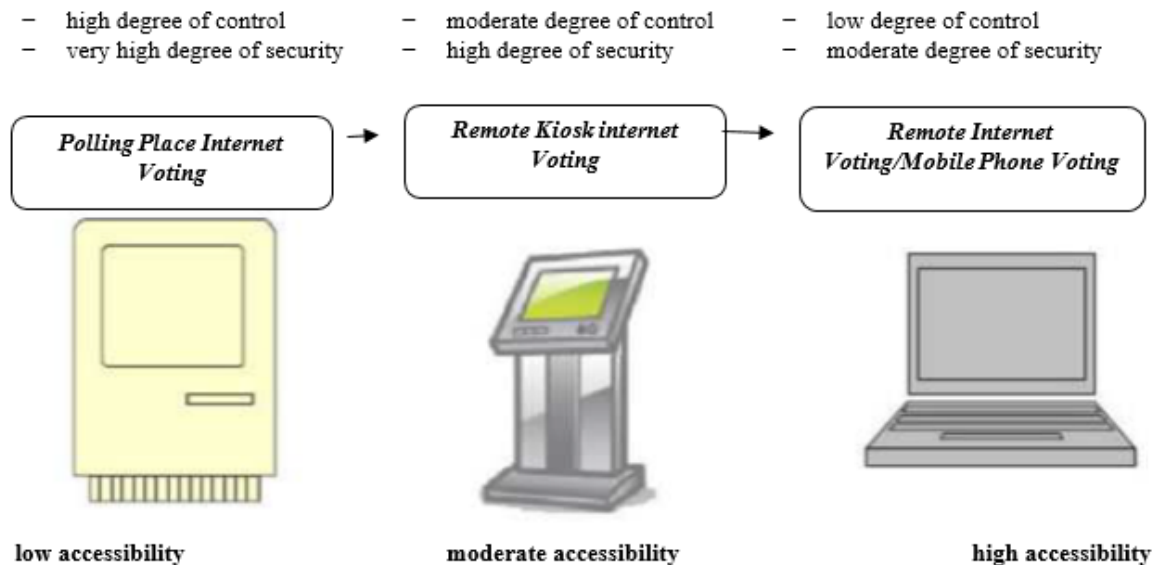

Fig. 2 Methods of Internet voting [1]

Fig. 2 illustrates selected properties (strengths and weaknesses) of the three Internet voting methods: Internet voting using voting machines installed in polling stations, voting kiosks placed outside polling stations and remote online voting (via computer or mobile phone).

The first method of Internet voting – in polling stations – ensures a high degree of control and considerable security level but, compared to the remaining two types of Internet voting, is less accessible for voters (in order to cast their votes, voters are required to go to specific places where voting takes place). In the case of remote voting from voting kiosks, the degree of control is moderate (lower than at polling stations), the degree of security is high, and voting kiosks are additionally slightly more accessible to average voters. Note that this voting method may generate more technical problems when compared to the first type of Internet voting.

Remote Internet voting by means of computers or mobile phones seems to be less susceptible to various kinds of technical problems (at least on account of the small number of users – voting through computers and phones is likely to be performed by their respective owners). From the point of view of voters, who can vote from any location at any time, this voting mode is significantly more accessible than the former

two. It is worth mentioning that remote Internet voting ensures a significantly lower degree of control, therefore making this method impossible of guaranteeing a very high security level and providing security ranging from low to moderate [1].

Distinguishing between representative and direct democracy, two types of electronic voting can be identified: electronic elections (e-elections) and electronic referendum (e-referendum). In terms of technology, the latter manner of voting seems less complicated to implement, mainly because there are typically only two possible responses ("Yes" and "No") in a referendum. In the case of elections, however, ballots tend to be more complex and extensive in terms of their content than those in referenda.

E-elections may be defined as the election of representatives for public posts and offices using modern ICT. An e-referendum is a general vote on a defined subject where voters do not cast their votes in the traditional way, using ballot boxes, but employ modern telecommunication and information technologies, such as the Internet, digital telephones and voting machines. An e-referendum is typically offered as an alternative voting method in otherwise traditional referenda.

Depending on the technologies employed in the voting

procedure, a referendum can have a broader character of an e-referendum (voting by means of voting machines, interactive television, short text messages or an Internet electoral portal). When talking about Internet-aided referenda, however, their range is narrower, and they are referred to as I-referenda. As demonstrated in the diagram, an I-referendum may be remote if it is based on remote Internet voting, or it may be conducted in a polling station where voting machines have an Internet connection (which facilitates vote counting and sending votes to the central electoral commission).

As concerns the issue of e-voting security, the topic of how e-voting is organized needs to be discussed. The process of e-voting can be divided into six key stages.

The first stage – registration of voters – consists in defining the voters who are eligible to decide through the electronic voting system, and providing them with the authentication data which is required to sign in to the e-voting system.

The second stage aims at verifying whether the person signing in actually has the right to access the system and the right to vote. In the third stage, the eligible voter casts a vote, and the e-voting system registers it.

I. Voter registration
II. Authentication
III. Voting and vote
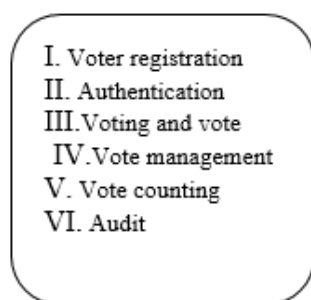IV. Vote management
V. Vote counting
VI. Audit

Fig. 3 Stages of e-voting [15]

In the next stage, all votes are appropriately sorted and prepared for counting. The counting phase involves deciphering the votes, followed by their final counting and tabulation. The auditing stage aims at verifying whether the votes cast are taken into consideration in the final results and the turnout count [15].

The diagram offers only a very brief and general presentation of the selected stages of e-voting that appear to be the most important. Note that additional, intermediary stages are also distinguished which are disregarded here, since this paper is not concerned with the analysis of e-voting systems in technical terms. Nevertheless, at least some stages of e-voting are worth mentioning, such as registration of candidate lists, developing a register of voters eligible for e-voting, data recording and system archiving.

The importance of each indicated stage of e-voting is crucial from the perspective of the credibility of the entire system. Thus, each stage of e-voting should guarantee the secure and correct operation of the whole e-voting system [15].

III. E-VOTING AND SECURITY ISSUES – ARGUMENTS 'FOR' AND 'AGAINST' E-VOTING

The considerations on the introduction of e-voting lead to an analysis of the motives and potential benefits for the three most important groups, according to Robert Krimmer, of 'beneficiaries' of the tool: the voters, public administration and politicians [13].

From the voters' perspective, the greatest advantage of e-voting is improved mobility. The e-voting system allows voters to cast votes at any place and any time (within a time frame specified by law) – even if they are away from their place of residence. Additionally, modern technologies increase the convenience of voting – voters no longer need to leave their homes in order to reach a polling station. E-voting (particularly Internet voting) is also advantageous for disabled people, who often find it difficult to get to a polling station. Thanks to e-voting, people with recognized disabilities no longer need to make efforts in order, for instance, to ensure transportation to a polling station. Thanks to the Internet, they can give their vote at home or whenever they are, with no need to reach the polling station.

From the perspective of public administration or electoral institutions (electoral commission), one may say that electronic voting is a tool that improves the procedure of counting of votes during the popular votings. What is emphasized here, first and foremost, is that the probability of mistakes made by election clerks is eliminated. Additionally, the implementation of an electronic register of voters may eliminate occasional instances of a single voter casting multiple votes. In countries where e-voting (e.g. the RIV system) has not yet been introduced, a central electronic register of voters may be the first stage in implementing I-voting [25].

E-voting based on a central electronic register of voters may contribute to reduced costs related to the organization of elections and referenda. This argument can be substantiated by the fact that e-voting does not require large numbers of election clerks to be involved, who are indispensable in the case of traditional elections taking place at ballot boxes. As far as the costs of implementing e-voting are concerned, it was already mentioned that the development, preparation and implementation of the electronic voting system imply relatively high costs to be borne over a short period of time. The advocates of e-voting claim, however, that its costs will be significantly lower in the long run.

Politicians notice numerous advantages of e-voting systems as well. They concern, among other things, changing the image of particular politicians or political parties. Those who support technological progress and introduction of technical innovations aimed at making various procedures simpler for citizens are often regarded as more open, friendly and innovative. In this way, political parties are able to operate so as to expand the electorate, for instance with the youngest voters. Apart from that, politicians are well aware that e-voting systems translate into quicker access to information about election winners and, consequently, into chances to make a coalition in a quicker way, and so on. Additionally,

politicians know that e-voting can increase voter turnout, which may impact the distribution of seats in a parliament. Greater turnout may improve a result of one party, simultaneously harming the other parties [13].

To sum up, it is worth noticing that the implementation of ICT in voting procedures results in overcoming the difficulties related to polling stations being remote from voters, and in facilitating the work of public administrations and politicians who seem to know that e-voting may contribute to their electoral capital. Therefore it is common to hear that the application of new methods for exercising democratic power (particularly during a polling process) is indeed a revolution.

The introduction of new forms of democratic procedures has triggered off a discussion about the weaknesses of e-voting. Although modern technologies are commonly applied in business, commerce, administration and science, some politicians, experts and scholars are still cautious when it comes to the implementation of information and telecommunication technologies in polling processes. This is confirmed, among other things, by the fact that many states expressed their anxieties about e-voting possibly leading to mass electoral frauds. Such uncertainties resulted from the analyses in the so-called *Zetter Report* (Kim Zetter is a journalist of the "Wired" magazine), who, following the 2006 elections, filed a motion to the American electoral commission requesting information about specific problems which occurred during the elections. Zetter has identified over 150 instances of specific problems having been reported within the Sarasota County in Florida alone. The *Zetter Report* "includes very detailed information about e.g. serial numbers of specific voting computers, names of members of electoral commissions, problem description and – what is significant – the number of votes lost due to a failure. The analysis implies that failures of voting computers were common and resulted in the loss of votes and registration of invalid votes" [which clearly affected the election result – M.M.-K.]. Apart from the typical 'computer' problems, voters reported numerous other issues, raising concerns about the fairness of voting: a voter voted for candidate A, yet the computer presented candidate B in the summary screen; regardless of the vote cast, only candidate A was shown in the summary screen; the summary screen reported the vote as invalid (no candidate selected) while the voter claimed to have chosen candidate A or B" [10].

Another problem is related to the transparency of the election process [5]. The e-voting method is sometimes called a "black box" due to the fact that voters, candidates and even officials do not really know how the voting machines operate; only a small group of specialists (system administrator) and other experts have an understanding of the technical aspects of voting and the manner of vote counting. It should be mentioned here that such doubts are, to a large extent, based on the experience of Great Britain, among others, where a report on the British pilot electronic voting conducted in England, Wales and Scotland until 2000 was published on January 29, 2007 [7]. The electoral commission in its report defined the risks associated with e-voting as "considerable and unacceptable" [14] and recommended ceasing of the pilot projects until developing a coherent strategy specifying the potential benefits of such voting [16]. An additional, crucial argument against e-voting is the concern that it may divide society into two parts: those who have access to the Internet and those who do not use it – mainly because of lack of access. This, in turn, may result in a "digital gap" (digital divide) emerging and becoming a serious problem which will translate into increased social disparities in many geographical regions [22].

Another essential problem concerns the identification of voters. On the one hand, a password and electronic signature should be considered helpful at the stage of voting. On the other hand, one needs to be aware that they may not necessarily be used by the voter to whom they have been assigned. Moreover, electronic voting systems are susceptible to many technical problems. ICT-based polling may be susceptible to attacks (e.g. from personal computers) which may eventually lead to significant disruption of the voting process. Thus, the servers, systems, computers and voting kiosks should be sufficiently protected to prevent any hacks and infections with computer viruses.

The issue of security features within electronic voting systems is addressed by Michał Rajkowski, who emphasizes a dozen or so such important elements of his selection:

- privacy – the cast vote has to remain confidential allowing voters to express their will without fear of being intimidated;
- accuracy – election results have to accurately reflect the choice made by voters;
- receipt-freeness – denotes a voter's inability to receive/create a 'receipt' which indicates his or her voting preference; this feature aims at preventing trading of votes;
- eligibility – only eligible voters have the right to vote, any votes cast by non-eligible voters are not taken into consideration;
- un-reusability – each eligible voter is entitled to cast only one correct vote, which guarantees that each voter has the same (partial) influence on the final;
- result of polling;
- fairness – no partial election results are presented before the polling is officially closed;
- robustness – the system remains secure, even in the case of any disruptions/faults (of a limited scope) regardless of their source (voter, system administrator or external factors);
- completeness – all correctly cast votes have to be correctly counted;
- soundness – resistance to errors/disruptions – an example is the system protection which disallows a dishonest voter from disrupting the voting process;
- inalterability – once a vote has been cast by the voter, neither the voter nor anyone else (both from within the system and outside it) is able to change it;
- personal verifiability – it must be possible to verify if the voting result is correct and whether an unauthorized

person could have an impact on it during the elections; the voter must have the possibility to verify whether the vote has been properly cast;
- universal verifiability – similar to the above, with the only difference that everyone can verify the correctness of elections;
- dispute-freeness – the fact that voting participants (voters/administration) act in accordance with the voting protocol may be publicly confirmed (at any phase of elections) by any person (within and outside the system);
- incoercibility – it must be impossible to coerce an eligible voter into casting a vote against his or her will or convictions [24].

As regards the weaknesses of e-voting and various devices applied in voting, note that the following difficulties may appear when using voting machines (voting computers):
- Firstly, the "undefined security level of voting computers (…) mainly based on general application operating systems (e.g. *Microsoft Windows*) and specialist software that is not subject, however, to independent security certification as per recognized standards (*Common Criteria*), which does not guarantee fairness of voting [10]"
- Secondly, problems with getting voting computers started and their stability, which, given the strictly scheduled duration of polling, may result in a considerable part of electors being unable to cast votes (such problems occurred, among others, during the American elections in 2006);
- Thirdly, the elevated purchasing costs of voting machines (which is a crucial argument particularly at the onset of e-voting implementation). In comparison with the traditional method of voting (on a ballot paper in a polling station), the costs of such e-voting are very high [9], [11] As emphasized by Piotr Krawczyk, these costs are particularly burdensome when it is "necessary to buy several computers per commission and at a low level of depreciation (used every few years, including the cost of storage during this period)" [10].

In the case of Internet voting, however, problems of a different nature become apparent. The following should be indicated, first and foremost:
- The need to guarantee the strong and unambiguous confirmation of identity, e.g. using a qualified signature. This would result in the considerably reduced availability of such an election procedure due to the scarce popularity of this manner of confirming identity, as well as due to a high cost of implementing such a solution;
- "lack of a guarantee to stay anonymous, which is contrary to the requirement for strong authentication (only the central system conducts vote anonymization, but remains beyond the control of the voter – unlike the unsigned ballot paper)" [10].

It is also worth mentioning that both voting on voting machines and online voting decrease the transparency and auditability of electoral procedure. This results from the fact that members of electoral commissions and stewards do not have a direct insight into the process of vote counting, which is held within the system constituting the "black box" in their opinion. In order to minimize those problems, it is often advocated to apply a combination of various e-voting systems that allow for the electronic counting of votes with a paper receipt of the vote (e.g. *Punchscan*) as well as systems which employ advanced cryptographic techniques. They are not, however, the solution to all the problems [10], [11].

TABLE I
WEAKNESSES OF ELECTRONIC VOTING [6]

Weaknesses of electronic voting
- lack of transparency;
- limited openness and understanding of the system among non-specialists;
- lack of agreed standards for e-voting systems;
- possibility of the secrecy of voting being contravened, particularly within systems that both authenticate the voters and handle the voting;
- the risk of manipulation by so-called 'insiders' (system administrators) who have broader access to the system, or by external hackers;
- increased purchase and maintenance costs of the e-voting system;
- higher security requirements concerning the protection of the voting system during and between elections, including transportation, storage and maintenance;
- decreased supervision of the electoral administration;
- curbed opportunities to re-count the votes;
- the need for additional campaigns to educate voters;
- possible conflict with currently applicable rules of law;
- possible distrust among the voters to participate in electronic elections resulting from the above-mentioned weaknesses

In the analysis of literature on e-voting, the most common weaknesses of e-voting can be indicated. The majority is presented in Table I.

The analysis of the motives for introducing electronic voting in many states of Europe and the world demonstrates that a majority of the arguments tend to recur in various discussions. The most common motives include increasing the mobility of voters, facilitating the voting of people abroad, increasing voter turnout by providing an additional voting platform, broadening the access to democratic procedures for elderly, sick and disabled citizens, decreased voting costs and publishing voting results in an independent and much quicker manner [26].

Taking into account only some of the arguments of e-voting's opponents, many states (despite great interest in this form of electoral participation) have abandoned e-voting implementation, claiming, for instance, that it is too risky to guarantee correctly held elections. Other states tend to disregard the advantages of electronic voting in comparison with the traditional form of casting votes, or they claim that the range of Internet infrastructure disallows their implementation of similar solutions.

IV. CONCLUSIONS

As far as the influence of new ICT on political life is concerned, it should be remembered that the application of ICT brings one of the most appreciated advantages: it removes barriers related to the actual remoteness between the voters and those who exercise power or represent them. That is why it is common to hear that the application of new methods for

exercising democratic power is indeed a significant change, especially in the electoral process.

E-voting has recently become increasingly popular in many states (e.g. Estonia [21], Switzerland [20], etc.) which is manifested in the growing number of pilot projects and initiatives related to e-voting. Despite the ongoing technical problems with ensuring the security of elections, among other things, multiple advantages (for various groups: voters, politicians, public administration) as well as positive experiences of many countries may constitute a considerable stimulus for implementing e-voting in Europe and elsewhere. However, when considering the implementation of e-voting, the government and officials should take into account the weaknesses of e-voting connected mostly with the security of the vote casting procedure, as well as the security of vote counting in elections and referenda. Thus, following the opinion of the Internet Society Poland, it is worth noticing that the "inviolable and necessary conditions which apply to any future changes to electoral procedures should include: anonymity, secrecy, impossibility to trade votes, correctness of the results and verifiability of the results for the voters" [27].

Despite the difficulties with e-voting that have been referred to above, the number of states interested in the implementation of this solution is constantly increasing. Good practices of Estonia and Switzerland (where e-voting systems have been introduced), among others, are likely to provide a model for states that plan to introduce this alternative manner of participation in elections. In the process of implementing e-voting systems, it should be remembered to take advantage both of the good and the difficult experiences, current state of knowledge and threats indicated by scholars within this scope.

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