

## **Chapter 2**

### **Existing Voting Systems**

#### **2.1 Introduction**

An overview of the diverse electoral systems used in local, national, or super-national elections around the world is already given. In this chapter existing methods for selecting single and multiple winners will be discussed with necessary examples. Eventually, we will elaborate on some of the better known strengths and weaknesses of various methods from both the theoretical and practical points of view.

An electoral system, or simply a voting method, defines the rules by which the choices or preferences of voters are collected, tallied, aggregated, and collectively interpreted to obtain the results of an election<sup>[22, 23]</sup>. There are many electoral systems. A voter may be allowed to vote for one or multiple candidates, one or multiple predefined lists of candidates, or state their preference among candidates or predefined lists of candidates. Accordingly, tallying may involve a simple count of the number of votes for each candidate or list, or a relatively more complex procedure of multiple rounds of counting and transferring ballots between candidates or lists. Eventually, the outcome of the tallying and aggregation procedures is interpreted to determine which candidate wins which seat. Designing end-to-end verifiable e-voting schemes is challenging. Indeed, most such schemes are initially designed to support relatively unsophisticated voting methods in which ballot structure and tallying rules are straightforward. However, extending such a scheme to support more complex voting methods may not be trivial. Issues such as efficiently encoding preferential ballots with a large number of candidates and preserving voter privacy when transferring ballots during multiple rounds of counting can introduce considerable design challenges. Such challenges are evidenced for instance by the compromises made in the design of the state-of-the-art e-vote system used for recent Victorian elections<sup>[24]</sup>. There have been a few works attempting to address these challenges (see, e.g.,<sup>[25]</sup> and the references within), nevertheless achieving practical end-to-end verifiable schemes supporting complex voting methods remains an area of research with many open questions. A good understanding of how different voting methods work is a prerequisite for tackling such open questions. In this chapter we aim to provide an introduction to the diverse voting methods used around the world.

#### **2.2 Types of Existing voting systems**

A country's electoral system is the method used to calculate the number of elected positions in government that individuals and parties are awarded after elections. In other words, it is the way that votes are translated into seats in parliament or in other areas of government (such as

the presidency). There are many different types of electoral systems in use around the world, and even within individual countries, different electoral systems may be found in different regions and at different levels of government (e.g., for elections to school boards, city councils, state legislatures, governorships, etc.). Some types of voting system are discussed below.

### **2.2.1 Ballot Paper System**

Ballot paper (or election paper) is a form which voters fill out in order to exercise their right to vote. Ballot papers list the candidates running for an election and the voter can mark their preferences accordingly. Ballot papers can be considered official documents.

In order to ensure the election is legally valid, the creation and distribution of ballot papers must fulfill certain requirements. For instance, all voters must receive identical ballot papers (print, size, color etc.). Moreover, the boxes displaying each candidate have to be the same font and size<sup>[26]</sup>. The methods of this voting system are as follows:

- In a jurisdiction using a paper system, voters choose by marking a ballot or, as in the case of Israel and France, picking one pre-marked ballot from among many. In most jurisdictions the ballots are preprinted with names of candidates and the text of the referendums. The Philippines (until 2007) and Japan are an exception. There, voters must write the names of their candidates on the ballot. Election officials manually count the ballots after the polls close and may be recounted in the event of a dispute.
- In a jurisdiction using an optical scan voting system, voters choose by filling an oval or by completing an arrow on the printed ballot next to their chosen candidate or referendum position. Voters with disabilities may be provided with electronic ballot marking devices. Optical scan technology has also been used by many standardized tests. Tabulating machines count the ballots either after the polls close or as the voters feed the ballots into the machine, in which case the results are not known until after the polls close. Officials often will manually count any ballots that cannot be read or with a write-in candidate and may recount the ballots in the event of a dispute.
- In a jurisdiction using a punched card system, voters choose by removing or "punching out" a perforated chad from the ballot next each choice, sometimes with tools as simple as a pin, but usually with a ballot marking device such as the Votomatic. The ballot may be preprinted with candidates and referendums, or may be a generic ballot placed under a printed list of candidates and referendums. Tabulating machines count ballots after the polls close. Officials may manually count the ballots in the event of a dispute. Punched card voting systems are being replaced by other voting systems because of a high rate of inaccuracy related to the incomplete removal of the perforated chad and the inaccessibility to voters with disabilities<sup>[26]</sup>.
- In a jurisdiction using a mechanical voting system, often called a "voting machine", voters choose by pulling a lever next to their choice. There is a printed list of candidates,

parties and referendums next to the levers indicating which lever is assigned to which choice. When the voter pulls a lever, it turns a connected gear in the machine, which turns a counter wheel. Each counter wheel shows a number, which is the number of votes cast using that lever. After the polls close, election officials check the wheels' positions and record the totals. No physical ballot is used in this system, except when the voter chooses to write-in a candidate. Other systems are replacing mechanical voting systems because they are inaccessible to disabled voters, do not have a physical ballot and are getting old <sup>[26]</sup>.

- In a jurisdiction using an electronic direct record voting system (DRE), voters choose by pushing a button next to a printed list of candidates and referendums, or by touching the candidate or referendums box on a touch screen interface. As the voter makes a selection, the DRE creates an electronic ballot stored by in the memory components of the system. After the polls close, the system counts the votes and reports the totals to the election officials. Many DREs include a communication device to transmit vote totals to a central tabulator. The touch screen systems remind people of an automated teller machine (ATM) and often are described as such.
- Bonser is a method allowing the voter more than two choices for a proposition. Choices of red, yellow and green can indicate disapproval, requirement for more clarity and approval, for example <sup>[26]</sup>.

### **2.2.2 Plurality Electoral System**

Also called “first-past-the-post” or “winner-take-all” systems, plurality systems simply award a seat to the individual candidate who receives the most votes in an election. The candidate need not get a majority (50% +) of the vote to win; so long as he has a larger number of votes than all other candidates, he is declared the winner. Plurality systems normally depend on single-member constituencies, and allow voters to indicate only one vote on their ballot (by pulling a single lever, punching a hole in the ballot, making an X, etc.) Plurality electoral systems also tend to encourage the growth of relatively stable political systems dominated by two major parties (a phenomenon known as “Duverger’s Law”).

Such an electoral system, though, clearly does not represent the interests of all (or even most) voters. In fact, since a candidate need have only a plurality of votes to be elected, most voters may actually have voted against the winner (although their votes are split among several candidates).

Elections for the House and Senate in the United States and for the House of Commons in the United Kingdom use the plurality system. The US presidential election is also generally considered a plurality system, but the existence of the Electoral College actually makes it a strange hybrid of plurality and majority systems <sup>[28]</sup>.

### 2.2.3 Postal Voting System

Postal voting is voting in an election whereby ballot papers are distributed to electors or returned by post, in contrast to electors voting in person at a polling station or electronically via an electronic voting system. Historically, postal votes must be distributed and placed in return mail before the scheduled Election Day, it is sometimes referred to as a form of early voting. It can also be used as an absentee ballot. However, in recent times the model in the US has morphed, in municipalities that use postal voting exclusively, to be one of ballots being mailed out to voters, but the return method taking on alternatives of return by mail or dropping off the ballot in person via secure drop boxes and/or voting centers.

Postal voting refers only to the means by which the ballots are submitted, not to the method by which the votes are counted. Election officials may count the votes by processing the mailed-in ballots through electronic voting machines, or may count the votes manually.

To enable as many voters as possible to participate, postal voting can assist people who may not be able to attend a polling station in person, for example because of a physical disability, absence from the locality or some other reason. Postal voting is generally available to voters upon application, sometimes with restrictions. If no reason for a request is required, it may be called postal vote on demand. Postal voting may be an option for voters in some jurisdictions, while in some elections there may be all-postal voting.

### 2.2.4 Electronic Voting System

There have been several studies on using computer technologies to improve elections <sup>[29, 30, 31 and 32]</sup>. These studies caution against the risks of moving too quickly to adopt electronic voting machines because of the software engineering challenges, insider threats, network vulnerabilities, and the challenges of auditing. Electronic voting machine is a simple machine that can be operated easily by both the polling personnel and the voters. Being a standalone machine without any network connectivity, nobody can interfere with its programming and manipulate the result. Keeping the erratic power supply position in many places in the country, the machines have been made to run on batteries. It has mainly two units: Control unit and Ballot unit. The Control Unit is the main unit which stores all data and controls the functioning of EVM. The program which controls the functioning of the control unit is burnt into a microchip on a “one time programmable basis”. Once burnt it cannot be read, copied out or altered. The EVMs use dynamic coding to enhance security of data transmitted from ballot unit to control unit. Although there has been cryptographic research on electronic voting <sup>[32]</sup>, and there are new approaches such as <sup>[33]</sup> currently the most viable solution for securing electronic voting machines is to introduce a “voter-verifiable audit trail” <sup>[34, 29]</sup>. A verifiable audit trail does not, by itself, address voter privacy concerns, ballot stuffing, or numerous other attacks on elections. Some vendors have claimed “security through obscurity” as a defense, despite the security community’s universally held belief in the inadequacy of obscurity to provide meaningful protection <sup>[33]</sup>.

Electronic voting also known as e-voting is a term encompassing several different types of voting, embracing both electronic means of casting a vote and electronic means of counting votes. Electronic voting technology can include punched cards, optical scan voting systems and specialized voting kiosks (including self-contained direct-recording electronic voting systems, or DRE). It can also involve transmission of ballots and votes via telephones, private computer networks, or the Internet. And, of course, EVM helps maintain total voting secrecy without the use of ballot papers. And, at the end of the polling, just press a button and there you have the results.

## **2.3 Aspects of E-Voting**

The technology can be able to solve a lot of problems associated with the traditional voting system. Before designing an e-voting system few aspects need to be overlooked.

### **2.3.1 Properties of EVM**

Researchers in the electronic voting field have already reached a consensus pack of following core properties that an electronic voting system should have <sup>[31]</sup>.

#### **Accuracy:**

- It is not possible for a vote to be altered.
- It is not possible for a validated vote to be eliminated from the final tally.
- It is not possible for an invalid vote to be counted in the final tally.

#### **Democracy:**

- It permits only eligible voters to vote.
- It ensures that eligible voters vote only once.

#### **Privacy:**

- Neither authorities nor anyone else can link any ballot to the voter who cast it.
- No voter can prove that he voted in a particular way.

#### **Verifiability:**

- Anyone can independently verify that all votes have been counted correctly.
- Any voter can verify their votes are counted for the candidate they wanted.

#### **Availability:**

- The system works properly as long as the poll stands.
- Any voter can have access to it from the beginning to the end of the poll.

### Resume Ability:

The system allows any voter who had interrupted his/her voting process to resume it or restart it while the poll stands <sup>[35]</sup>.

### 2.3.2 Taxonomy of voting devices

There are different forms of Electronic Voting Machines are used in across the world. The variations of EVM are as follows:

- **Paper-based electronic voting system:** Sometimes called a "document ballot voting system," paper-based voting systems originated as a system where votes are cast and counted by hand, using paper ballots. With the advent of electronic tabulation came systems where paper cards or sheets could be marked by hand, but counted electronically. Most recently, these systems can include an Electronic Ballot Marker (EBM), that allow voters to make their selections using an electronic input device, usually a touch screen system similar to a Direct-recording electronic (DRE). Systems including a ballot marking device can incorporate different forms of assistive technology.
- **Direct-recording electronic (DRE) voting system:** Electronic voting machine by Premier Election Solutions formerly Diebold Election Systems used in all Brazilian elections. A DRE voting machine in Figure 2.1 records votes by means of a ballot display provided with mechanical or electro-optical components that can be activated by the voter (typically buttons or a touch screen); that processes data with computer software; and that records voting data and ballot images in memory components. After the election it produces a tabulation of the voting data stored in a removable memory component and as printed copy. The system may also provide a means for transmitting individual ballots or vote totals to a central location for consolidating and reporting results from precincts at the central location. These systems use a precinct count method that tabulates ballots at the polling place. They typically tabulate ballots as they are cast and print the results after the close of polling.



Figure 2.1: DRE voting system <sup>[43]</sup>.

- **Public network DRE voting system:** A public network DRE voting system is an election system that uses electronic ballots and transmits vote data from the polling place to another location over a public network. Vote data may be transmitted as individual ballots as they are cast, periodically as batches of ballots throughout the Election Day, or as one batch at the close of voting. This includes Internet voting as well as telephone voting. Public network DRE voting system can utilize either precinct count or central count method. The central count method tabulates ballots from multiple precincts at a central location.
- **Diebold AccuVote-TS:** The Diebold AccuVote machine is the system that tested <sup>[38]</sup>, and is in use in the State of Maryland. It uses a touch screen (Figure 2.2) with a card reader that the voter gets after being authenticated by polling officials. Indeed, the CVS source code repository for Diebold's AccuVote-TS DRE voting system recently appeared on the Internet <sup>[36]</sup>. This appearance, announced by Bev Harris and discussed in their book, Black Box Voting <sup>[29]</sup>, gives us a unique opportunity to analyze a widely used, paperless DRE system and evaluate the manufacture's security claims. Jones discusses the origins of this code in extensive details <sup>[37]</sup>. Diebold's voting systems are in use in 37 states, and they are the second largest and the fastest growing vendor of electronic voting machines. And also only inspected unencrypted source code, focusing on the AVTSCE, or AccuVote-TS version 4, tree in the CVS repository. This tree has entries dating from October 2000 and culminates in an April 2002 snapshot of version 4.3.1 of the AccuVote-TS system. From the comments in the CVS logs, the AccuVote-TS version 4-tree is an import of an earlier AccuTouch-CE tree. They did not have source code to Diebold's GEMS back-end election management system.



Figure 2.2: Diebold AccuVote-TS system (Left) and Hart Inter Civic Slate system (Right) <sup>[43]</sup>.

- **SureVote:** The SureVote Company provides a system that offers higher protection against malfunction or fraud. At voting time, users authenticate themselves and their right to vote using a numeric personal identification code and a numeric ballot code <sup>[39]</sup>. They then can enter a four-digit “vote code” for each race. An error message is presented if the entered code is invalid for that race. If the code is valid, the vote is sent to multiple vote storage servers scattered across the country. Each server sends back a numeric response, which is combined by the client into another four-digit code, the “sure code”.
  
- **VoteHere Platinum:** VoteHere Platinum <sup>[37]</sup> uses a completely software-based touch screen interface. It can be run on any personal computer with a touch screen monitor. However, this also means that the buttons or any of the benefits that Hardware buttons provide. In addition, it introduces new risks that the computer the software is running on may have been tampered with the Vote Here system presents one race on the screen at a time; the voter presses the “next” and “back” buttons at the top of the screen to navigate between races.
  
- **Biometric EVM:** Biometrics refers to an automated system that can identify an individual by measuring their physical and behavioral uniqueness or patterns, and comparing it to those on record. In other words, instead of requesting personal identification cards, magnetic cards, keys or passwords, biometrics can identify fingerprints, face, iris, palm prints, signature, DNA, or retinas of an individual for easy and convenient verification. With the boom in Internet-based business and the increased need for accurate verification when accessing accounts, biometrics is the simplest and most convenient the solution. Biometrics can also provide you with convenience and security, by enabling a machine to verify the individual by itself and to respond to the individual’s requests.

The objectives of biometric recognition are user convenience (e.g., money withdrawal without ATM card or PIN), better security (e.g., difficult to forge access), and higher efficiency (e.g., lower overhead for computer password maintenance). The tremendous success of fingerprint based recognition technology in law enforcement applications, decreasing cost of fingerprint sensing devices, increasing availability of inexpensive computing power, and growing identity fraud/theft have all ushered in an era of fingerprint based person recognition applications in commercial, civilian, and financial domains. So the EVM has to be improved based on the current technologies viz, biometric system.

Some previous work use fingerprint for the purpose of voter identification or authentication. As the fingerprint of every individual is unique, it helps in maximizing the accuracy. A database is created containing the fingerprint of all the voters in the



constituency. Illegal votes and repetition of votes is checked for in this system. Hence if this system is employed the elections would be fair and free from rigging.

A fingerprint identification system should be used which can: 1) store the fingerprint of a person at some given time. 2) Should recognize whether the prints match or not at some other instant of time. 3) It should be touch sensitive; thumb prints are stored when a person places his thumb on a particular area & they are recognized at a later instant.

The mechanism of working is: Centers for recording thumb prints must be installed two months before voting. Here persons register their prints. During the actual voting, the voter first places his thumb on the touch sensitive region. If the print matches he is allowed to vote. In case the print is not stored before, a single beep is given, so the person cannot vote or if the same person votes again, the system should give a double beep, so that the security can be alerted. The system is programmed to recognize a print twice, but to give a beep for more than once <sup>[39]</sup>. The comparison of Paper voting, Diebold and Biometric EVM are shown in the Table 2.1.

- **Vote Here Platinum:** Vote Here Platinum <sup>[38]</sup> uses a completely software-based touch screen interface. It can be run on any personal computer with a touch screen monitor. However, this also means that the buttons or any of the benefits that Hardware buttons provide. In addition, it introduces new risks that the computer the software is running on may have been tampered with the Vote Here system presents one race on the screen at a time; the voter presses the “next” and “back” buttons at the top of the screen to navigate between races.

Table 2.1: Comparison of Paper voting, Diebold and Biometric EVM

S. No	Differs in	Ballot Paper	EVM	Diebold	Biometric EVM
1	Device Type	Papers and boxes	Embedded system with Assembly code	Embedded system with Windows CE, and C++ code	Embedded system with Assembly code
2	Visual Output	Stamp on paper	Single LED against each candidate's name	Color Touch screen, with GUI Software	Single LED against each candidate's name
3	Operating System/Software	No Operating System	None, the Assemble code to register number of votes is all it has. Hence it is simple automation of voting, no complexities	Windows CE and C++ code stored on the Internal Memory and PCMCIA cards, bulky, unnecessary additions.	None, the Assemble code to register number of votes is all it has. Hence it is simple automation of voting, no complexities
4	Records/Audits	Manual counting to be done by officials, lengthy, time consuming process, Inaccurate due to human errors	The Voting unit doesn't store anything, the control unit records the number of votes cast for each candidate against his serial number. No record to link person-to-vote	Internal ribbon printer. And PCMCIS storage for records and audit trails. Additionally the GEMS server also stores the votes and audits. Again unnecessary addition, work can be accomplished by simple counter.	The Voting unit doesn't store anything, the control unit records the number of votes cast for each candidate against his serial number.
5	Control and Operation	Manual Operation	Automatic operation, The control unit accumulates the votes; it is a device with flash storage and seven segment LED display. The ballot unit has a button to issue a ballot for a voter	Complex automatic operation. Two GEMS servers one primary and a backup, for every polling station, that connects to the voting units to "Load the ballots" and then voting units work independently	Automatic operation, The control unit accumulates the votes; it is a device with flash storage and seven segment LED display. The ballot unit has a button to issue a ballot for a voter
6	Security Issues	No security provided by the system, neither during polling nor during voting	During polling, a facility is provided to seal the machine in case of booth capturing. No further voting can be done afterwards	GEMS server has access through Supervisory Smart cards, and PINS, some users have login and password access. But these server connections can be easily tapped and can be used for tempering with the data or procedure.	During polling, the voters' biometric trait is checked between the control and ballot unit. Once both measures are matched then only allow the person to cast a vote. And also once polling gets over, a facility is provided to seal the machine in case of booth capturing. No further voting can be done afterwards
7	Ballot Issue	Ballot paper is issued by Electoral officer on which voter could cast his vote	Ballot is issued by Electoral officer by pressing a button on the control unit. It allows the voter to press any button on the ballot unit to cast is vote	Voter access smart card is issued in an envelope for a terminal. Voter can put it in the assigned terminal and cast his/her vote. This smart card system rarely uses encryption and hence it is not difficult to duplicate these cards and pose false identity.	Ballot is issued by Electoral officer by pressing a button on the control unit. Once the person pressed his/her biometric trait compared with the stored information which is in the memory card, it allows the voter to press any button on the ballot unit to cast his vote

## 2.4 Comparison among the Countries of Electronic Voting System

The last few years have brought a renewed focus on to the technology used in the voting process. The current voting system has many security holes, and it is difficult to prove even

simple security properties about them. The comparison between EVM and computerized EVM. A voting system that can be proven correct has many concerns. There are some reasons for a government to use electronic systems are to increase elections activities and to reduce the elections expenses. Still there is some scope of work in electronic voting system because there is no way of identification by the electronic voting system whether the user is authentic or not and securing electronic voting machine from miscreants.

## **2.5 EVM System around the world**

### **2.5.1 Types of Electronic Voting in World Elections**

There are three main types of electronic voting systems that have been used in elections around the world.

- Optical scanning
- Direct recording
- Vote over internet

The oldest, and most common, is optical scan voting. Direct recording electronic (DRE) voting machines are newer and less common, and voting over the internet is the rarest of all. Some countries use one type of voting nationwide, and others use different types in different areas. For instance, Brazil uses DRE voting machines throughout the country, while individual precincts in the United States use a variety of DRE voting machines, optical scan machines, and even manually-counted paper ballots <sup>[41]</sup>.

### **2.5.2 Optical Scan Voting Machines in World Elections**

Optical scan voting machines use paper ballots that are marked by the voter and then scanned for electronic tabulation. This process is very similar to traditional voting, but it allows ballots to be counted and results made available in a much shorter time frame.

Since optical scan technology has been around for so long, it has been used in many countries throughout the world. Some countries have adopted optical scan technology across the board, some have abandoned it, and others use it primarily for absentee votes.

### **2.5.3 Direct Recording Electronic Voting Machines and Internet Voting**

Direct recording electronic voting machines don't use paper ballots. They record votes electronically, and store them electronically, without the voter interacting with any physical

ballot. These machines can use touch screen interfaces, dial controls, and push-buttons. Brazil and India are countries that have implemented DRE voting machines nationwide.

Some DRE machines use a single master ballot that is inserted into the machine in some way to show voters which buttons to push to vote for which candidates and measures. Other machines use the same types of screens found in computers, tablets, and smart phones to display the ballots.

While there are no physical ballots used with DRE voting machines, some are designed to create a paper trail. These machines will typically print a ballot receipt for each voter to confirm. The receipts are then retained for verification and recount purposes.

Internet voting is the rarest form of electronic voting, and it allows voters to register their votes over the internet. These systems can use physical polling places or allow voters to use their own devices in their own homes. Estonia has implemented this type of voting nationwide, while other countries allow it in more limited circumstances <sup>[41]</sup>.

- **Countries that use electronic voting nationwide:** Brazil, Estonia, India, Venezuela
- **Countries that use electronic voting in some areas:** Canada, United States, Peru, Argentina
- **Countries where electronic voting has been tested:** Bhutan, United Kingdom, Italy, Norway, Kazakhstan, Australia, Nepal, Philippines, Australia, Guatemala, Costa Rica, Ecuador, Russia, Mongolia, Nepal, Bangladesh, Indonesia, Finland, Somalia (Somaliland), Switzerland <sup>[41]</sup>.
- **Countries where electronic voting has been discontinued:** Belgium, France, Netherlands, Germany, Paraguay, Japan

#### 2.5.4 Electronic Voting system in some country

- **Electronic Voting in Argentina:** Electronic voting was first implemented in Argentina on a limited basis in 2004. Additional election reform legislation was passed in 2016. Argentina purchased DRE voting machines from South Korea for its 2017 national election, but they were not used due to security concerns.
  - **Type of electronic voting:** DRE
  - **Availability:** In some areas

- **Electronic Voting in Brazil:** Brazil implemented DRE voting machines on a limited basis in 1996. The use of DRE voting machines was expanded throughout the country in 2000 and electronic voting is used at all levels nationwide. Paper ballots and voter-verifiable paper trail systems were eliminated entirely in 2018 <sup>[41]</sup>.
  - **Type of electronic voting:** DRE
  - **Availability:** Nationwide
  
- **Electronic Voting in Canada:** Federal elections in Canada are all carried out via paper ballots. Some municipalities use optical scan and DRE voting machines, and internet voting has been made available in a limited number of precincts. Electronic voting is only used at the municipal level, never at the Federal level <sup>[41]</sup>.
  - **Type of electronic voting:** Optical scan, DRE, internet
  - **Availability:** On the municipal level
  
- **Electronic Voting in Estonia:** Estonia first implemented internet voting at the local level in 2005. Internet voting was expanded to the national level in 2007. Traditional polling places are still available, but about one-third of all votes in any given election are cast via the internet. Estonian citizens living abroad are also able to use internet voting <sup>[41]</sup>.
  - **Type of electronic voting:** Internet
  - **Availability:** Nationwide
  
- **Electronic Voting in India:** Electronic voting machines were first used in India in 1982, but they were not adopted into widespread use until much later. Partial adoption of DRE voting machines occurred in 1999, electronic voting was adopted nationwide in 2002. India uses portable push-button DRE voting machines that run on battery power. They also use battery-powered voter-verifiable paper trail hardware. Internet voting has also been made available on a limited basis <sup>[41]</sup>.
  - **Type of electronic voting:** DRE, limited internet
  - **Availability:** Nationwide
  
- **Electronic Voting in Peru:** Peru implemented electronic voting machines for the first time in 2013, and it was expanded to cover about 14 percent of voters nationwide in the next few years. Touch screen DRE voting machines are used in Peru.
  - **Type of electronic voting:** DRE
  - **Type of DRE machines:** Touch screen
  - **Availability:** In some areas

- **Electronic Voting in United States:** The United States uses optical scan machines in every state, although they are sometimes only used for absentee ballots. Some states have DRE voting machines in every local precinct, and other states use a mixture of paper ballots and DRE voting machines. Voting over the internet, email, and fax is mostly limited to specific military personnel.
  - **Type of electronic voting:** Optical scan, DRE, limited internet and fax
  - **Availability:** On the state, county and precinct level.
  
- **Electronic Voting in Venezuela:** Venezuela implemented electronic voting in 1998. Touch screen DRE voting machines are used throughout the country, and they include the ability to print a voter-verifiable paper trail. Vote results are also transmitted electronically, rather than physically transporting the machines to a central location.
  - **Type of electronic voting:** DRE
  - **Type of DRE machines:** Touch screen
  - **Availability:** Nationwide

Electronic Voting Machine (EVM) has been used around 20 countries out of which 6 countries are still piloting it <sup>[43]</sup>. A graphical overview is shown in Figure 2.3.

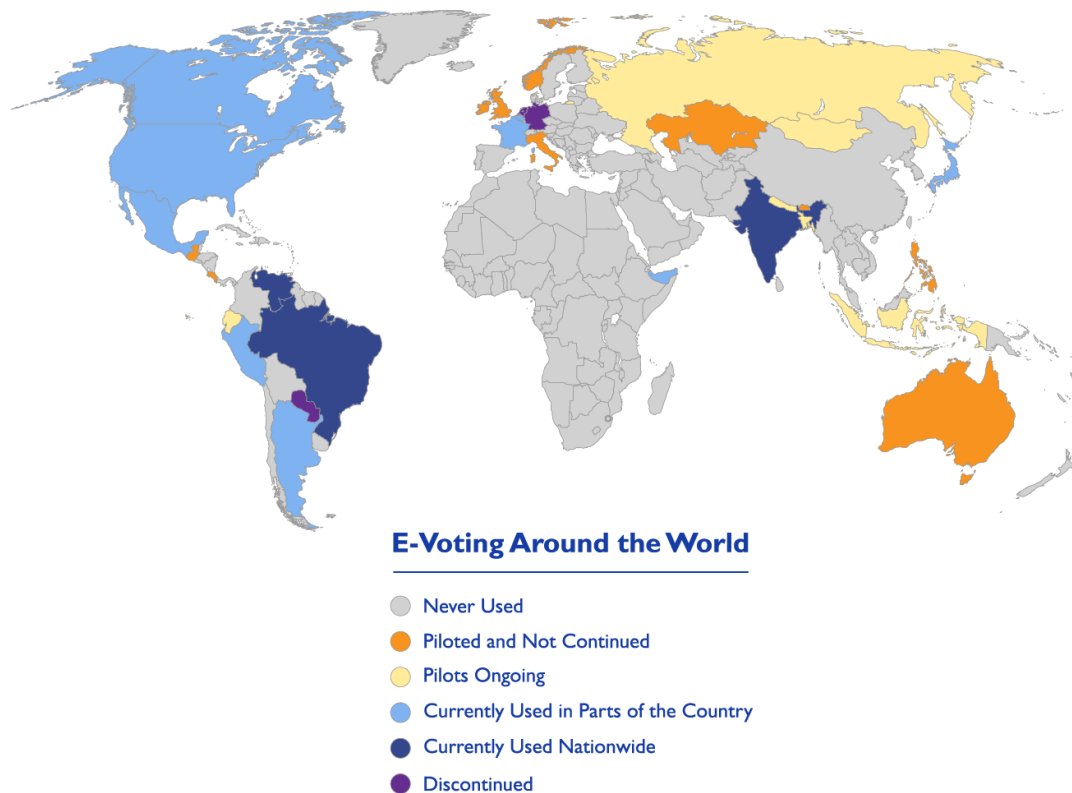


Figure 2.3: EVM System around the world <sup>[43]</sup>.

### 2.5.5 E-Voting in Bangladesh

Bangladesh has been struggling to take the advantage of using the electronic voting machine (EVM) for the last few years. It offers a number of advantages as well as serious disadvantages along with some challenges. Most of the people still do not know much about this device and the technology involved in it. Whenever the government tries to introduce it in any election, the oppositions come forward with strong criticisms for its negative implications. Bangladesh tried to utilize EVM at Officers' club Election (2007), Chittagong City Corporation Election (2010), Comilla City Corporation Election (2011), Narayanganj City Corporation Election (2011), some centers of Rangpur, Barisal, Sylhet, Rajshahi and Khulna City Corporation (2016) and only in six places in the national election (2018). That was the first time, when Bangladesh's parliamentary elections experienced the benefit of Electronic voting machines (EVMs) and voters of Dhaka-6 and 13, Chattogram-9, Rangpur-3, Khulna-2 and Satkhira-2 had the privilege of trying it out<sup>[44]</sup>. Hence gradually people have been becoming familiar with this device due to some government efforts. Mixed reactions have been coming out from the people who have experienced with this device, some of them positive and negative as well. An illustration of 2018's EVM is shown in Figure 2.4.

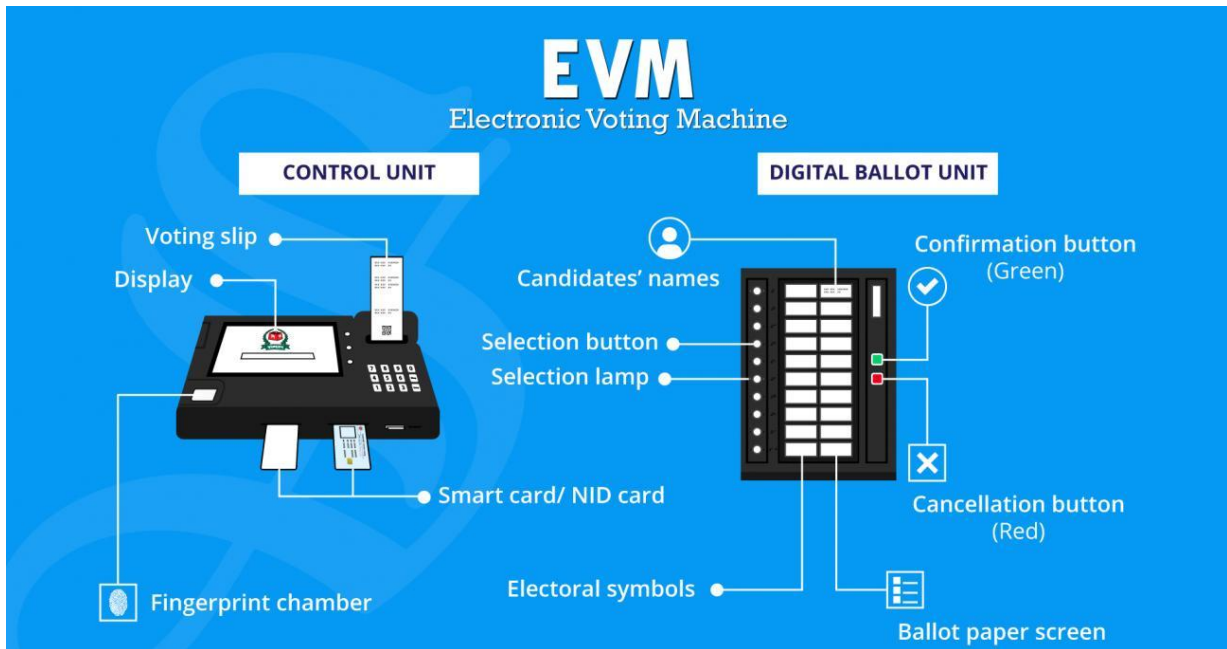


Figure 2.4: EVM system used for 2018 Bangladesh National Election<sup>[44]</sup>.

Although it was a pretty good device, hence it lacked the features of verifiability and receipt-freeness. In our model we will be focusing more on these two features.