Project 2 - Report

Voting System Re-design

IN II - 111



P.C.Herold, 156330008
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Prof. Ravi Poovaiah
Guide

IDC - School of Design
Indian Institute of Technology, Bombay

Approval Sheet

The Interaction Design Project II entitled “Voting System Re-design” by Herold Pazhunnana Charles, Roll Number - 156330008 is approved, in partial fulfillment of the Master in Design Degree in Interaction Design at IDC School of Design, Indian Institute of Technology, Bombay.

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Herold Pazhunnana Charles
156330008

IDC School of Design,
Indian Institute of Technology Bombay

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Abstract

The Indian voting system, upholding the largest democracy in the world, gives every single citizen of our country the right to choose their own leader. But with population in billions, the prime task of collecting the vote becomes a huge effort, which has been handled over the years by different kinds of voting systems with each having their own set of problems too. The goal of this project is to explore the problems and need gaps in the current Indian voting system and propose improvements to design a new voting system. The solution of the project was focused on a single section of the newly proposed voting system, namely the ballot unit interface. A touch-screen device of 15-inch display in portrait mode was used to design and develop the interface for the ballot unit, using which people could cast their vote in a mock election. The votes get recorded in the device and it could also declare the results in the end. The improvements were realized more toward the usability and acces-sibility of the ballot unit by evaluating three sets of design options in comparison, to arrive at the results.

Table of Contents

1. **Introduction** **1**

2. **Primary Research** **2**
   - 2.1. Preparation 2
   - 2.2. Contextual Enquiry 3
   - 2.3. Affinity Mapping 4
   - 2.4. Insights 6

3. **Secondary Research** **7**
   - 3.1. Structure of Indian government 8
   - 3.2. Types of electoral systems in world 9
   - 3.3. Electoral systems in India 13
   - 3.4. Key inferences from the study of electoral systems 14
   - 3.5. Voting system technology in world 15
   - 3.6. Current voting system in India 20

4. **Understanding Problems in current system** **24**

5. **Ideation** **27**
   - 5.1. Key directions for Ideation 27
   - 5.2. Initial design ideas & feedback 28
   - 5.3. Redefined brief and ideation 33
   - 5.4. Final proposal for the voting system 42

6. **Ballot unit interface design** **51**
   - 6.1. High fidelity mock-up screens 51
   - 6.2. Final design and working prototype for ballot unit 55

7. **Evaluation** **61**
   - 7.1. Evaluation Protocol 61
   - 7.2. Profile of people used for evaluation 62
   - 7.3. Results 64

8. **Feedback and insights** **67**

9. **Conclusion and future work** **68**

10. **References** **69**

1. Introduction

The voting system is a huge part of the democracy which gives the people of a free country an opportunity to choose their leader by vote. As the people in each geography are varied, so are the electoral systems that got developed in each of these places. The electoral system forms the source guide for shaping the voting system of a specific country, through which a country decides whether they need a presidential system or a parliamentary system, a single member constituency or a multi-member constituency, a single member plurality or a rank based voting etc. Now with respect to the world's largest democracy namely India, the per-requisite for this project would be to understand the different electoral systems around the world and then realize that electoral system according to which Indian voting system got into shape.

The Indian election process has seen the voting system change from paper ballots to electronic voting machines. With passing time and new technological innovations, upgrades for the existing system are to be considered. Currently a new system called "VVPAT – voter verified paper audit trail" was introduced during 2013 assembly elections stating different problems in the previous system. But like the issues prevalent in other voting systems around the world, this new system also is constantly challenged with different problems concerning tamparability, usability, accessibility, ergonomics and reliability. Hence this project seeks to analyze the existing system and gather insights for improving the system a step further.

Motivation

History has shown us the ways of this world where equality of rights for the people was a distant idea in the era of kings and monarchs, until the idea of democracy took shape. Hence the voting system being the backbone of a democracy needs to be constantly questioned, improved and corrected for errors to reinforce the faith of people on democracy.

The Electronic voting machine(EVM) used in the Indian voting system was designed by the faculty of IDC namely Prof. Ravi Poovaiah and Prof. A G Rao and was successfully deployed in large scale inside India and also for other countries, which made me curious to understand the design process of this huge project. This motivated me to start this project, which also has indirect impact on various factors of Indian democracy, shaped by the diversity of language, caste and religion.

Process

The voting system in India is huge in itself and to study the details is a major task. In an effort to do so, the Indian voting system was studied by witnessing and conducting contextual interviews in the general assembly election of Tamilnadu government as part of the primary research. This was followed by a secondary research on the structure of Indian government, types of electoral systems around the world & India and the voting systems around the world & India to derive the problems and key inferences for ideation. Several ideas were proposed and feedbacks were taken to finalize one voting system. To start evaluating the system one by one, a component of the system was chosen to be designed in detail which was the ballot unit interface. It was evaluated by conducting mock elections among the people around Mumbai and project was concluded with the improvements and future scope for the project.

2. Primary research

The Tamil Nadu legislative assembly election, which was held on 16-May-2016 was the major election to be scheduled during the project period. To conduct a primary research, polling station in Kalpakkam which comes under 'Cheyyur' constituency in Kancheepuram district was chosen as the location, since I also had the eligibility to vote there. The objective was to witness the elections live and understand the process involved in conducting an election. To achieve this, necessary permissions were taken and the stakeholders of the election system were observed and interviewed.

2.1. Preparation

Before casting the vote and observing the election process, these were the list of things that were kept in mind-

1. How did you check whether you have your name in voting list or not.
2. Did you get green slip?
3. Have you visited the election commission website?
4. Have you applied voter ID online? Have u changed details online?
5. Are you first time voter or have experience.. In ballot and EVM system.
6. Have you heard of any other voting system other than these?
7. Ask education, age, occupation profile of people.
8. Number of polling booth in the campus and number of EVM machine.
9. Is ladies queue available.
10. Is disabled n old people queue available.
11. How do blind cast their vote.
12. Note time taken to cast vote from start of queue till the point of exit from polling booth.
13. Time taken from entering the booth for verification and ink mark till going near EVM.
14. Time taken to just cast vote in EVM.
15. Check for paper audit VVPAT system and polling officer's distance from the EVM.
16. Order of viewing the candidate in the ballot displayed on EVM - symbol, name and photo.
17. Audio and visual feedbacks to be noted. Like beep sound, light or paper prints etc.
18. Does pressing the button on EVM give adequate tactile feedback.
19. If there was any problem or delay in control unit side with polling officer, how they resolve and how much time does it take?
20. Is font size of text on the ballot sheet readable and the photo recognizable.
21. If you don't know whom to vote does the order of arrangement matter to you?
22. Does placing a candidate in first, but far from reach of hand matter in choice making?
23. Factor which make you leave voting in middle of the process ?
24. Factors which make you not come to vote at all.
25. Have you put vote wrongly and tried changing it.

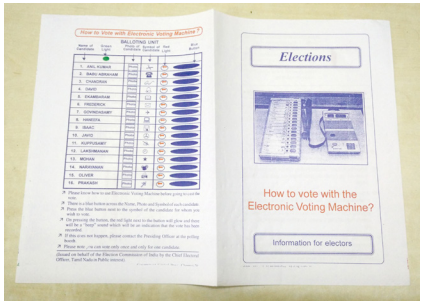


Fig 1 : "How to vote with EVM" pamphlet distributed in polling stations.

26. Pressing two buttons simultaneously?
27. How was previous ballet system? With respect to feedback. Was it lengthy process? Or confusing?
28. Has rain affected voting.
29. How to vote if person out of station, is power of attorney available.
30. Have you complained to polling officer on wrong vote? and was it resolved.
31. Why should we come to common place to vote can't we do it like bank transactions with Mobile?
32. How much security does a standalone system provide comparing the connected real time system.
33. What is standard vote n break timings?
34. Have u helped blind or disabled to vote?
35. Do popular guys cross the queue to vote?
36. Have u come across the flying squad checking for frauds?
37. Was table height appropriate on which the EVM was placed? and was it adequately covered?
38. How many people inside a single polling booth at a time?
39. What ID proof did u show? Is voter ID required or passport or Aadhaar card enough?
40. If one has no finger or is disabled, what is the protocol to put ink. Where to put?

Minutes of my Voting :

1. Start in queue 11:11 am.
2. No separate queue for ladies.
3. 23 in front of me.
4. Polling office sitting next to ballot box 1m range.
5. 7 polling booth in vicinity 3 more in back.
6. 2 polling officers and 1 identity officer present.
7. The identity officers checks the green slip given or asks for ID proofs to verify my identity.
8. Photo Aadhaar card or ration card needed if name not in the list due to address change.
9. In my case the serial number noted from Internet was shifted in the polling officer's voter list.
10. 5 polling agents for checking my validity with voters list and 1 for CCTV security camera.
11. Inked by polling officer on left index finger.
12. A counting slip with printed number torn by the officer and put inside a box.
13. Polling officer presses the ballot button in control unit to proceed and vote on the ballot unit.
14. 1 supporting staff for helping disabled voters vote.
15. Tactile button with click sound.
16. Red color light glows and beep sound for 4 to 5 seconds.
17. Time out 11:35 am and time taken for verification is 45 sec and a total of 1 min.
18. NSS or NCC volunteers outside each booth.
19. By 6 pm, the control box is put inside the case and sealed using candle and metal seal by the returning officer and is carried away with security.

2.2. Contextual enquiry

The interviews were conducted by the method of contextual enquiry where questions were asked in response to their replies. The profile of people varied from voters who had cast vote, the party workers who were involved in distributing green slip, Identity officers who lets voters know booth number and serial number in voter's list, to polling officers and agents who conduct the mock election and the polling.

Profile of people interviewed :

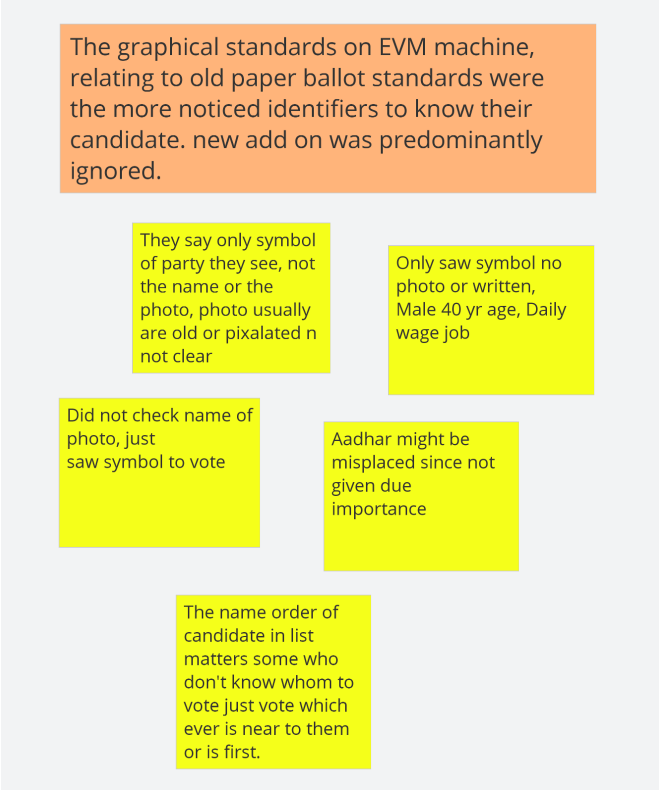
Total count - 18

Profile	**Count**
Voters	3
Party workers	2
Identification Officers	6
Polling Officers	2
Polling Agents	2
Visually Challenged	3

2.3. Affinity Mapping

The user statements and observations were grouped and the technique of affinity mapping was carried out, where similar user statements and observations were combined from bottom to top approach to gather broader insights from the interviews.

Following are the user statements, key observations and their affinity map-






Finding their names in the voter's list was a big task. Identity authentication is still on paper predominantly.
Polling agent, 34 age male Central government employee,
Voter name not in list is problem of people they should come n collect like when Aadhar was made compulsory.
Address problems occurs when two constituency get split n address gets changed, or in place like Kalpakkam with quarters, they survey whether they r there or not to distribute the slip, if not there or if dead they might strike off the name from list or keep the slip with them n do actions based on election commission's direction
Voter name in list only the location in the list not updated.. Hence many voter return without voting.
Biggest problem to find voter name in list or identity
People who voted for 15 years couldn't find name in voter list.
Helped a lady put vote without voter I'd with other id proof.
Old guys without name on list abuse that its opposite party 'sadhi' and they don't know why the name is not in list.. Some are due to address change.
In his family, one family had voter ids with the same photo of girl for all the family members
Got voter I'd info from party booths
People were welcoming biometric authentication and also gave ideas to make application for voter list identification
They don't know about any other system. When asked whether biometric may, one said it will n other the opposite, without explanation.
Mentioned real problem is to decrease the money distribution by parties with the help of election commission
Invited the biometric system for identity authentication
Welcomed app to verify and search for the voter list
The employees have a special voting few day before in paper ballot postal vote so that they can take care of the election work.
They voted by postal voting by posting their option in an envelope.
The voting process was fast once inside the polling booth. Took only less than 2 min
Fast moving only took 40 secs
Took only one minute to vote
Male 40 yr age, Daily wage job, No education Easy to vote in EVM
Feedback after voting with sound and light were adequate.
Accessibility for disabled and blind not supported fully.
He didn't know how blind cast vote, said party can bring blind voters together n cast vote for their party
Don't know how blinds vote.
Mostly blind won't come, if they come some family members assist of the officer assigned help them put the vote.
Features in internet for election services not explored even by educated.
Never accessed internet for checking voter list
Female age 30 Degree holder working, Never bothered to check internet
He says he has no doubt with the audio feedback and says if its wrong he has the power to freeze the elections and since its checked before morning its fail proof. No need for paper audit trails he says.
Feedback of light n sound more than necessary
They said photo not clear due to burqa and old photo and require color photographs
Just saw symbol not photo.. He asked to put audio headset feedback of voted candidate
50 age polytechnic, Beep sound and light more than enough as feedback.. Paper audit not required
No doubt sound feedback enough

2.4. Insights

Following were the insights gathered from the affinity mapping done based on the interviews and observations made as part of the primary research.

1. Finding the names in the voter's list was a big task. Identity authentication is still on paper predominantly.

2. The security was improved in this election by using the Swiss cheese model, where the number of slices where increased for an error to occur. There were several physical security protocols along with the digital security checks for handling the safety and security of the process.

3. Improved transparency and spreading the control to more people improved the security and reduced bogus votes, since each party agent did not allow the other party to put bogus votes.

4. A section of voters were not sure whether they were voting to the correct person or not and were not able to understand the exact steps involved in the recording and counting of votes.

5. Most voters were comfortable with existing EVM, since they were comparing it to paper ballot system. Many didn't know about VVPAT system and thought it was unnecessary.

6. The voters primarily looked at the party symbol, rather than the name or serial number which was also because the photo of the candidates were black & white and unclear.

7. The blind voters avoided going to vote and raised concern over the inefficiency of the system to be able to vote independently without the help from a support staff.

8. People were generally welcoming changes in the system and also started suggesting ideas for improvements.

9. New improvements and facilities made by the elections commission through Internet and the digital space has not yet reached the people adequately to make use them.

3. Secondary research

The secondary research was predominantly to explore and understand the following by reading books, papers, articles, blog and videos from internet to diverge and take in the domain knowledge for re-designing the voting system of India.

Structure of Indian Government - The classification of the regions and hierarchy of the India government is studied.

Types of electoral systems in world - The mechanics of electoral system is explored in detail with broad classification.

Electoral systems in India - The two types of electoral system used for seat allocation into houses of representatives is studied.

Key inferences from the study of electoral systems - Key directions taken on choosing the appropriate electoral system for India .

Voting system technology in world - The vote collecting and counting technologies used around the world is analyzed.

Fig 2 : Secondary research sticky notes



3.1. Structure of Indian government

The Indian government is of three levels and in each level there are three role as follows: [8], [9], [15].

1. Central Government -

a. Legislature : Making laws ..... Parliament (Lok Sabha + Rajya Sabha) - Contains MP's
b. Executive : Implementing laws ..... Prime Minister and his/her council of ministers
c. Judiciary : Interpreting laws ..... Supreme court

Parliament - Has two houses
- Lok Sabha (Lower House) : 552 members
Elected from 543 parliamentary constituencies
- Rajya Sabha (Upper House) : 250 members
Indirectly elected from each states legislative assembly

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2. State Government -

a. Legislature : Making laws ..... Vidhan Sabha(Legislative Assembly) - Consists MLA's
b. Executive : Implementing laws ..... Chief Minister and his/her council of ministers
c. Judiciary : Interpreting laws ..... High Court

Legislative assembly - example Tamilnadu
- 235 Assembly constituencies

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3. Local Government -

a. Legislature : Making laws ..... Municipal Council consist of Councillors/corporators
b. Executive : Implementing laws ..... Municipal Commissioner and his team
c. Judiciary : Interpreting laws ..... District courts

Local Municipal corporation - example Chennai
- 200 wards in Chennai municipal corporation

Hence you belong to three places at the same time -

1. Local Government : Wards ..... Represented by counsillors
2. State Government : Assembly constituency ..... Represented by MLA
3. Central Government : Parliamentary constituency ..... Represented by MP

3.2. Types of electoral systems in world

The types of electoral systems in world were largely studied from these two reference books -

[1] The Politics of the Electoral systems
- Michael Gallagher , Paul Mitchell

[2] IDEA(Institute for Democracy and electoral assistance)
- Handbook of electoral system design.

The electoral system is broadly classified into two with respect to the number of constituencies -

1. Single seat constituencies
2. Multi member constituencies

Each are further classified as follows-

1. Single seat constituencies

a. Single member plurality(SMP) or First-Past-the-Post(FPTP) system
b. Alternate Vote(AV) or instant runoff system
c. Two-round system(TRS) or double ballot/runoff system

2. Multi member constituencies

a. Proportional representation - Single Transferable vote (PR-STV)
b. PR-List system
c. Mixed System
d. Single Non-transferable vote (SNTV)
e.Borda Count system

Terms to understand, to assess the electoral systems -

1. ***Dis-proportionality ratio*** = Percentage of votes received by a party / Percentage of Seats received by the party

In more accurate terms its calculated by the formula of Least Square Index. Least square index = $((Si - Vi)^2/2)$, where (Si-Vi) is the difference between percentage share of seats and percentage share of votes.

2. ***District Magnitude*** = Number of members elected per constituency.

The major two electoral system that are implemented in India are explained in detail as follows-

1.a. Single member plurality(SMP) or First-Past-the-Post(FPTP) system

- Voters cast vote to one candidate and seat is awarded to the candidate with plurality of votes/more votes than others, whether or not it amounts to majority of all votes.

  Example Countries using this system - **India**, UK, Canada

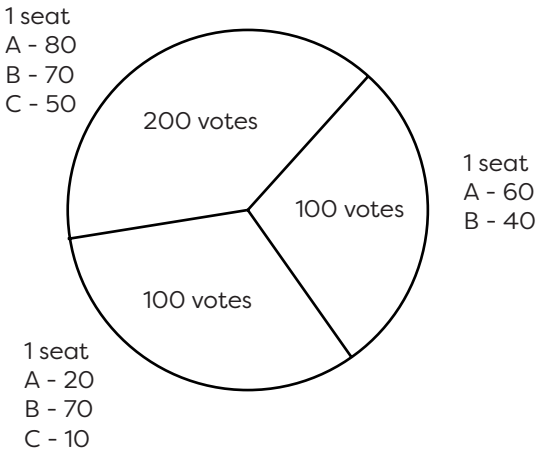
Advantages -

1. Strong geographic representation
2. Accountability
3. Simple to understand
4. Clear choice for voters
5. Majority governments more likely in parliamentary systems
6. Excludes extremist parties

Disadvantages -

1. Excludes minority parties
2. Many wasted votes
3. Often need for by-elections
4. May lead to gerrymandering
5. Difficult to arrange remote/absentee voting

Disproportionality example :



1 seat in each constituency

Party	Votes won	Seats won
A	160	2
B	180	1
C	60	0

Hence here even though Party B won more votes than A, it gets less number of seats comparing A.

2.a. Proportional representation - Single Transferable vote (PR-STV)

- Voters need to rank candidates in order of choice.
- A candidate must reach Droop quota to get seat. Droop quota = No. of votes/(No. of seats + 1)
- The first stage of the count is to ascertain the total number of first-preference votes for each candidate. Any candidate who has more first preferences than the quota is immediately elected.
- If no-one has achieved the quota, the candidate with the lowest number of first preferences is eliminated, with his or her second preferences being redistributed to the candidates left in the race. At the same time, the surplus votes of elected candidates (i.e., those votes above the quota) are redistributed according to the second preferences on the ballot papers.

Example Countries using this system - Denmark, Netherlands, Austria, Belgium, **India**.

Advantages -

1. Proportionality
2. Inclusiveness
3. Minority representation
4. Few wasted votes
5. No (or less) need to draw boundaries
6. No need to hold by-elections
7. Restricts growth of single party regions

Disadvantages -

1. Weak geographic representation
2. Accountability issues
3. Weaker legislative support for president more likely in Presidential systems
4. Coalition or minority governments more likely in parliamentary systems
5. Much power given to political parties
6. Can lead to inclusion of extremist parties in legislature

Example :

No. of seats = **2** in this constituency
No. of votes = 1000
Droop quota = 1000/2+1 = **334**

Party	*1st round*	*2nd round*	*3rd round*
A	300 +18	316 +6	322
B	200 +150	**350** -16	**334**
C	330 +2	332 +10	**342**
D	170 -170		

Hence here even though it seemed A & C had won the two seats after counting the first preference votes, finally B & C win the seats after gaining majority crossing the Droops quota.

Rest of the electoral systems are as follows-

1.b. Alternate Vote(AV) or instant runoff system

- Voters rank order the candidates by writing 1,2,3 etc.
- If no candidate receives majority of votes, counting proceeds by elimination of lowest placed candidate and transferred according to second preferences marked.
- In another variant of this system, all the candidates below top two are eliminated by transferring their second preference votes. This is done to avoid the winner be not among top two preferences.

  Example Country using this system - Australia.

1.c. Two-round system(TRS) or double ballot/runoff system

- In first round if majority not reached, second round for top 2 candidates is done for presidential elections.
- Unlike Alternate vote system, this is like asking for the second preference votes again by making the voters come again to vote in the second round.

  Example Countries using this system - France, US.

2.b. PR-List system

- Each party presents a list of candidates.
- Vote to be cast for one of these lists or for one or more candidates on a list.
- Seats allocated among parties according to the following two formulas-
  1. Highest Average method using D'Hondt or Sainte-Lague's sequence.
  2. Largest Reminder method using Hare quota.

  Example Countries using this system - Israel, Spain.

2.c. Mixed System

- Members elected from single member constituencies and some from list system.
- Two votes for each voter with one to select a candidate in single member constituency and another to select a party list.
- The two types of mixed system with respect to implementation are Compensatory and Parallel systems.

  Example Countries using this system - Germany, Hungary, Italy, Japan,Russia.

2.d. Borda Count system

- The system is similar to the Alternate vote system, except that points are assigned to each preference like 5 to 1st , 3 to 2nd etc.
- The sum total of each preferences is made and the top majority candidates are declared winners.

  Example Country using this system - Nauru.

3.3. Electoral systems in India

Two types of electoral systems are used in India - [10], [11], [14]

1. First-Past-the-Post(SMP) with single seat constituency for Lok Sabha, Assembly and Local elections.

2. Proportional Representation - Single transferable vote (PR-STV) for Rajya Sabha elections.

First-Past-the-Post(SMP) system with single seat constituency -

1. Lok Sabha Elections (Central Government) -

- 543 Member of Parliament(MPs) are elected from each of the single member parlimentary constituencies.
- The Prime minister is selected among the party to represent the council of ministers and he/she forms the executive team by selecting the cabinet ministers from the elected MPs.
- Conducted every 5 years.

2. Legislative Assembly Elections (State Government) -

- 235 Member of Legislative Assembly(MLAs) are elected from each of the single member Assembly constituencies.
- The Chief minister is selected among the party to represent the council of ministers and he/she forms the executive team by selecting the cabinet ministers from the elected MLAs.
- Conducted every 5 years.

3. Municipal Corporation Elections (Local Government) -

- 200 Councilors are elected from each of the wards.
- The Mayor is selected among the councilors to represent them.
- Conducted every 5 years.

Rajya Sabha elections (Central Government) -

- Proportional Representation - Single transferable vote (PR-STV).
- Elections to Rajya sabha are conducted every 2 years and each member server a term of 6 years.
- The quota for each state is fixed as per Schedule 4 of the constitution.
- Elections to 1/3 rd of these seats occur every 2 years.
- Its members are elected by the Legislative Assembly of States and Union territories.

Lets Consider an example of Maharashtra :

- Maharashtra has 19 members in Rajya Sabha, out of which 6,6 and 7 members retire every 2 years, after completion of their 6 year term.
- Suppose in particular year 6 members are retiring. Few months before their term end elections will be announced by Election Commission.
  No. of seats = 6
  No. of votes(No. of MLAs in Maharashtra) = 288
  Droops Quota = 288/6+1 = 42

- Hence the winning quota is 42.
- So in counting which ever candidate gets 42 or more first preference votes, is declared elected.
- If in this process less than 6 candidates are elected then second preference votes come into play.
- If even after second preference votes 6 candidates are not elected then third preference votes are counted and so on till 6 candidates are elected.
- The election held to fill a vacancy arising otherwise than by retirement of a member on the expiration of his term of office is called 'Bye-election'.
- The reason behind constituting Rajya Sabha was to bring area specic knowledge to the governance by brining skilled and knowledgeable people in the upper house. However, Rajya Sabha has always been a back door for political parties to bring in leaders who have lost people's faith in Loksabha.
- Since the number of votes to win a seat by a party is known using formula and since the number of voters(MLAs) is less in number, the advantages of PR-STV in proportional representation is marginalized.

3.4. Key inferences from the study of electoral systems

- To study the electoral system in practise, went through the electoral process in three countires namely -

    1. India (FPTP, PR-STV)
    2. USA (FPTP, TRS)
    3. Denmark (PR-STV)

- The factors that come into picture in the electoral system other than the seat sharing and proportionality of political party are the representation of women and minorities, communal representation, election timing, compulsory voting and absentee/remote voting.

- Even though there is a general agreement that majority systems tend to restrict the range of legislative representation to produce two-party system and PR systems encourage to give a multi-party system, this convention is increasingly proven false after elections across the world. For example, FPTP has not facilitated the aggregation of the party system in established democracies such as Canada/India and PR has seen the election of dominant single-party regimes in Namibia, South Africa and elsewhere.

- Electoral system consequences depend upon factors such as : [1]

    a. How a society is structured in terms of ideological, religious, ethnic, racial, regional, linguistic, or class divisions;
    b. Whether the country is an established democracy, a transitional democracy, or a new democracy;
    c. Whether there is an established party system, whether parties are unformed, and how many “serious” parties there are;
    d. Whether a particular party’s supporters are geographically concentrated together, or dispersed over a wide area.

- Choice of any electoral system is, to some degree, dependent on the cost and administrative capacities of the country involved.

- The theories of electoral system also doesn’t take into consideration reservations as a measure of proportionality provider.

- As per the book “The Politics of the Electoral system”[1], the Indian government had considered incorporating PR systems in LokSabha elections but the ability of Indian system to adapt and establish a multi-party system with coalition government based on pre-election alliance removed the option.

- **Hence from the above findings, the goal of the project is directed towards designing a voting system for the current FPTP electoral system used in Lok sabha and legislative assembly elections.**

3.5. Voting system technology in world

Following are the types of voting systems used around the world over the period of time, listed from oldest to newer versions -

1. Paper Ballot system : *Used in India [15], [19]*

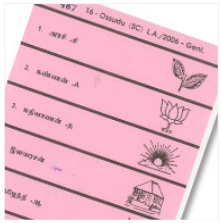
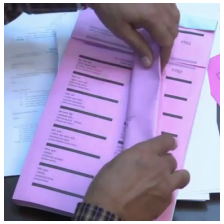




Fig 3, Fig 4, Fig 5: Paper Ballot, Ballot box, Manual counting.

- Vote cast on the ballot paper and put inside ballot box.
- Manually counted to access the majority.
- Labour intensive and time consuming process to cast vote and during counting process.
- Bogus vote cast very easily.

2. Postal vote system : *Used in India [15], [19]*



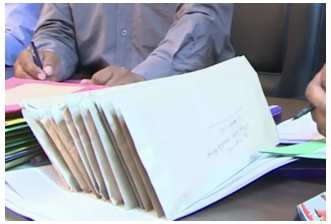
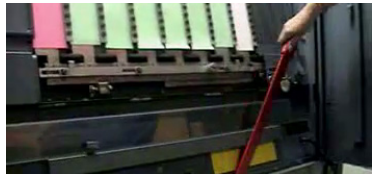


Fig 6, Fig 7, Fig 8: Ballot list, Counter foil sealed, Envelope for post.

- Staff deputed on election duty and service personnel are eligible for casting their vote through postal ballot in India.
- It is also used as an absentee ballot in other contries where people can opt on demand citing reason of unavailability during polling.
- Coercion and vote influencing is a major concern over this system as there is no supervision of polling officers while voting.

3. Lever voting machine : *[22], [23]*



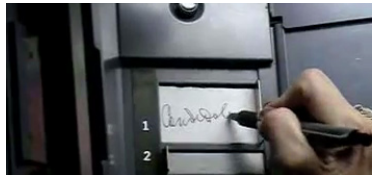


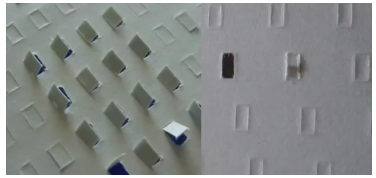


Fig 9, Fig 10, Fig 11, Fig 12, Fig13: Lever to confirm vote, Ballot list with knobs, Manual rolling counter, Mechanical wheels for counting, Paper strip to write candidate name for audit.

- Completely mechanical machine to cast vote, used before in US.
- Have error handling abilities such as, only one or specific numbers of knobs can be rotated to cast vote and rest will be mechanically locked.
- Paper audit facility provided, where one manually writes selected candidate's name.
- Very heavy machinery for logistics and difficult for illiterate to use.

4. Punch card system : *[20], [21]*





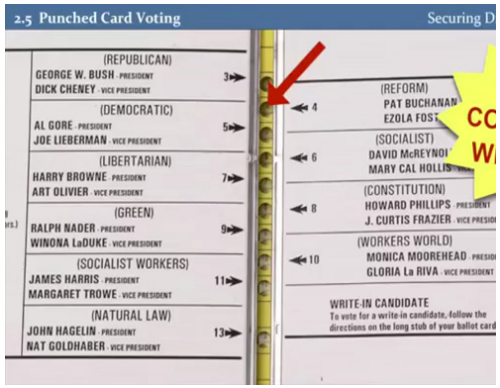




Fig 14, Fig 15, Fig 16, Fig 17: Punch device used to punch hole, Florida layout problem in ballot, partially punched chads, Punched chads.

- Voters punch holes in the cards with a punch device opposite their candidate or ballot issue choice.
- After voting, the voter may place the ballot in a ballot box, or the ballot may be fed into a computer vote tabulating device.
- Layouting of candidates list became a big issue once.
- The partially punched chads created confusion while counting the punched ballots.
- Chads had to be regularly cleaned from the box during election.

5. Electronic voting machine : *Used in India [6], [24]*





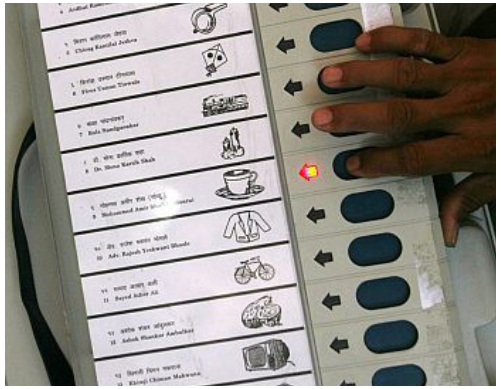




Fig 18, Fig 19, Fig 20, Fig 21: Indelible ink to register identity, push button electronic ballot unit, Counting of result from recording unit, Insider recording/control unit.

- Two piece system with Ballot unit and control unit.
- Purposely designed as stand-alone units because electronic transmission of results could lead to intrusion/hacks.
- Power – 6-8V alkaline battery, no risk of getting shock.
- Easier to transport, light weight and compact.
- Easier to cast vote for illiterate.
- Not possible to press more than once.
- Vote counting is faster.
- Bogus voting greatly reduced.
- Operating program etched permanently in silicon at the time of manufacturing.
- 10,000 tons of ballot paper saved and substantial reduction in counting staff and remuneration paid to them.

6. EVM with VVPAT(voter verifiable paper audit trail) : *Used in India [16]*



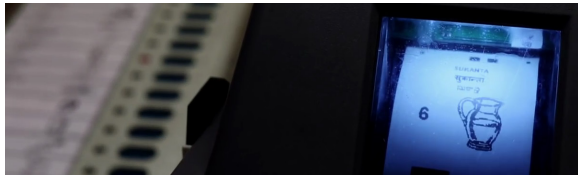
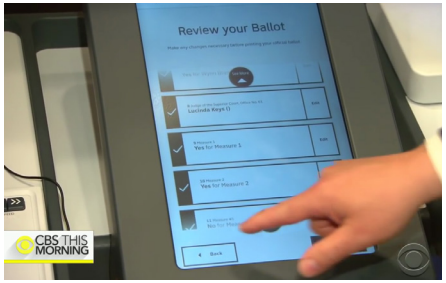
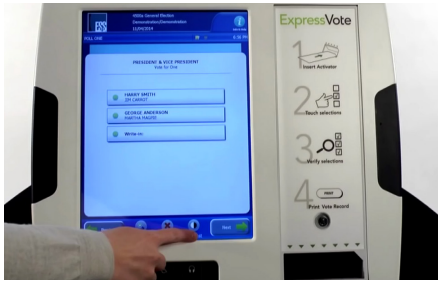



Fig 22, Fig 23, Fig 24, Fig 25: Paper roll to print on, VVPAT connected to EVM unit, Printed slip of the voted candidate, all the printed slips collected in the VVPAT unit.

- Prints vote in paper to show voter and collects it within the unit for future audit.
- Mainly used to detect possible electronic fraud or malfunction.
- Most do not verify their choices.
- Increased time required to vote due to usability problems – Variations in the graphical layout of the ballot and that of the printed paper making it inconsistent to relate.
- Manual VVPAT audit is labour intensive, expensive and not affordable to candidates.
- VVPAT tapes destroyed easily – blank tapes printed due to wrong insertion of paper roll.

7. Direct electronic recording(DRE) Touch screen voting system : *[26]*





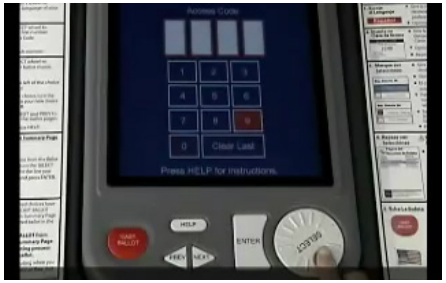
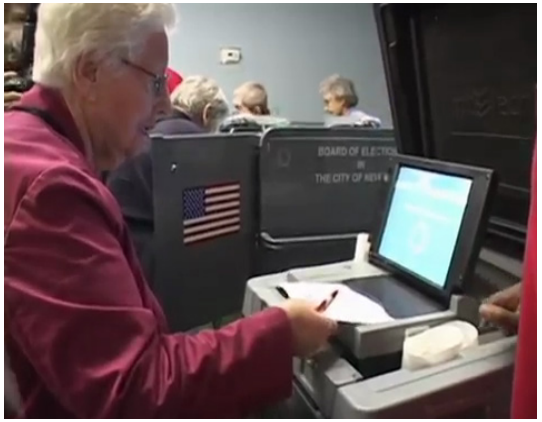




Fig 26, Fig 27, Fig 28, Fig 29, Fig 30 : Touch screen voting, Touch screen system with printed slip, Screen with tangible controls and ID card security to vote, sip&puff, rocker paddle for physically challenged voters.

- Different kinds of touch screen voting units are used in different places with some completely touch and some attached with tangible buttons for navigation and selection.
- Greater flexibility in terms of accommodating content of the ballot lists.
- The unit is integrated with error handling features like vote for specific number of candidates, undo selection, selection overview etc.
- Some of these systems have greater security handled with voter Id card insertion, but internet connectivity is a major concern opening up the possibility of hacking the system.
- Accessibility features like audio ballot, sip&puff, rocker paddles etc for challenged voters makes this system universal.

8. Optical scan voting system : *[27]*



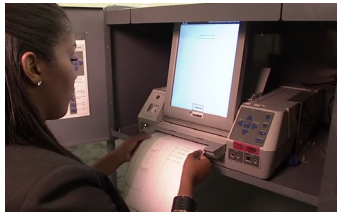




Fig 31, Fig 32, Fig 33 : Marked paper ballot fed to optical scanner, Empty ballot fed to marker unit, Marked ballot paper fed into optical scan counting unit.

- The optical scan voting allow the system to have both digital record and also a paper audit record simultaneously for counting.
- This is a mix of old paper ballot system integrated with technology to scan and count the votes fast.
- Manual labour for counting the marked paper ballots is greatly reduced.
- Some systems allows the voter to cast the vote by physical markers and then be fed into the optical scanner. Where as in other systems the empty ballot paper is first fed into a electronic marker and then the printed ballot is again fed to the optical scanner for counting.
- The machinery is heavy and big is size with respect to logistics and central counting is difficult.
- Security concern with respect to internet connected counting units prone to hackers.

9. Mobile/Remote voting system : *[25]*





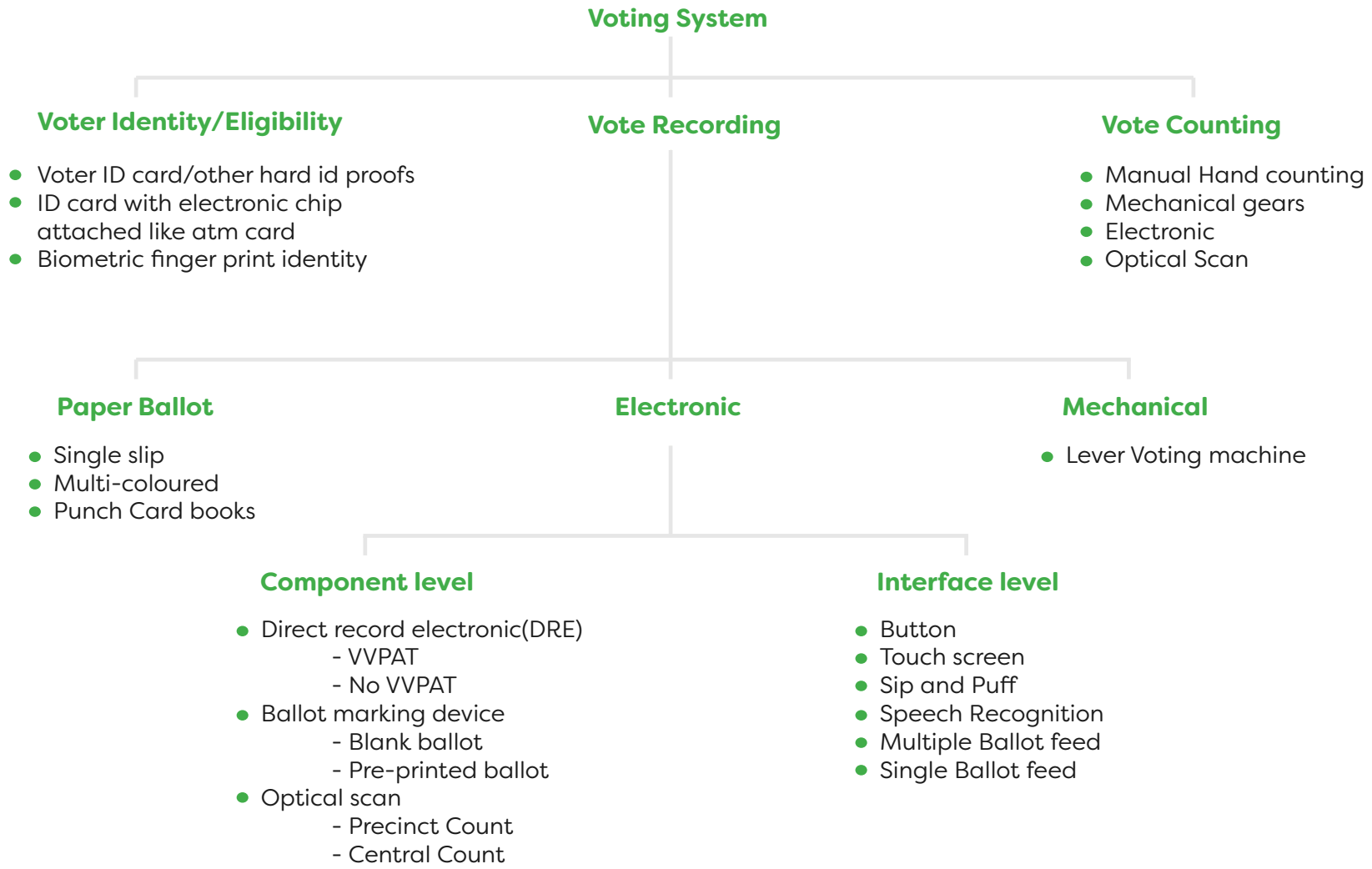


Fig 34, Fig 35, Fig 36 : Vote cast remotely using personal laptop, Voter ID inserted to dongle device for authentication, QR code process for additional security.

- This system is adopted only in the country Estonia.
- The voter can cast their votes remotely without any supervision from election authorities.
- Voter ID card is inserted to the laptop and through the portal for voting, a secure internet connection is made and the voting is additionally layered with a QR code scanning mechanism.
- The major concern is of coercion that can not be monitored and the chance of people trying to influence for a candidate while the voter casts their vote.
- The other concern is of the internet security and central counting server security which has a possibility of being hacked by external forces.

Voting system classification:

Based on all these voting systems, they can be classified into the following as an overview: *[7]*



3.6. Current Voting system in India

The current voting system in India without VVPAT can be divided into **8 stages,** which handles **security of the system by digital & physical protocols** - *[19]*

1 EVM Manufacture and Despatch

1. Manufactured at BEL and ECIL.
2. Bulk carrying case having 10 units with quality certificate enclosed and is maintained using register with serial number- emailed by BEL employee to Election Commission of India.
3. Case sent to respective districts with district collector as in-charge.

2 Storing EVM

1. EVM checking in warehouse and district collector locks with double locked door.
2. Entry into ware house - Log book entry for party men/representative for poll, training, voter awareness, maintenance, diagnostic test, physical verification.

Fig 37 :

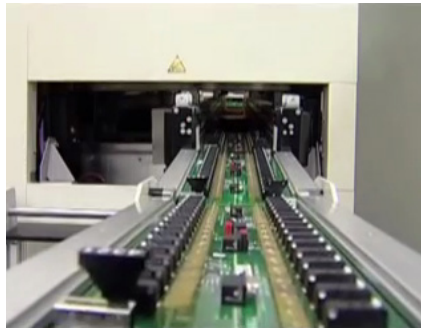


Fig 38 :



Fig 39 :



Fig 40 :



3 First Level Checking (FLC)

1. In a FLC hall, district collector, Bell/ ECIL employee and party agents do a mock election check.

2. Random basis EVM chosen by party agents to check.

3. Mock poll conducted with 1000+ votes as minimum.

4. Printout of details taken out to check - Report date, Report time, serial number of EVM, start time, end time, candidates votes and total polled votes.

5. For sealing - pink slip is used to wrap around the machine in a specific way and party agents sign on it after the verification is satisfactory. The pink slip is made by currency makers.

4 EVM Setting

1. EVM selected using randomization technique to be sent with each returning officer one week before the election.

2. Ballot paper is loaded into the EVM and the ballot unit is sealed using thread and paper with metal seal.

3. Pink paper slip is then wrapped around with party agents sign put on the slip as part of security protocol.

4. Battery placed and candidate setting made and that compartment is sealed.

5. Again after the sealing procedure, a mock election is conducted and all the EVMs are sealed again in warehouse store room.

Fig 41 :



Fig 42 :

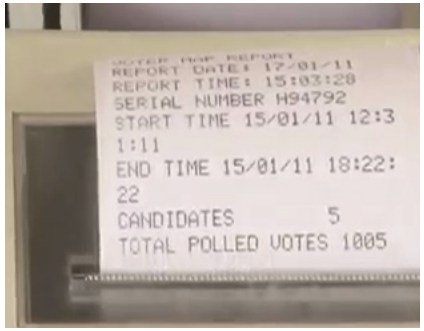


Fig 43 :

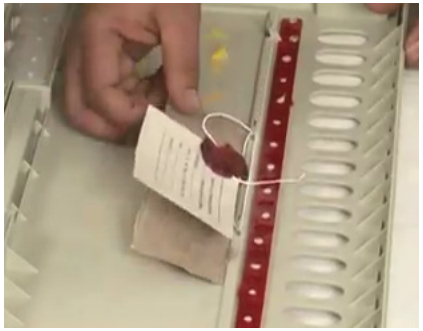


Fig 44 :



5 Mock Poll

1. Polling officer with party agent do mock poll on the morning of the election day or the previous day night.

2. The party agents vote for their candidates and the results are shown there for verification to the party agents.

3. The result is then cleared to zero and the result section is sealed in the control unit of the EVM.

4. The Party agents then put their sign on a slip as verification protocol which would be later verified during the counting process by these same party agents.

6 Polling

1. The voters get a green slip from the party workers or identification officers who are present near the polling station, which specifies the polling booth number and their serial number and page number in the voters list.

2. The voter's ID is verified by the identification officer in the polling booth and the name is read out loud for the party agents who are seated in the polling booth as party agents/observers to mark the voter on their voters list too. This acts as a redundancy mechanism to confirm the voters eligibility to vote. The observers have the power to stop the voter from voting, if their identity is not satisfactory.

3. The polling officer puts the indelible ink on the index finger to confirm their vote cast, which acts as a security to avoid double voters.

4. The polling officer presses the ballot button in control unit and ready light glows in both control unit and ballot unit for allowing the voter to vote.
5. Voter presses the blue button to cast their vote which gives a feedback of Red light glowing near the candidate selected and a long beep sound for 4/5 sec.

Fig 45 :



Fig 46 :

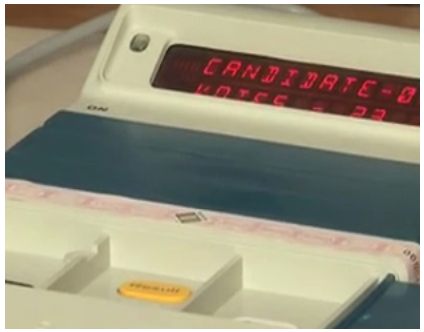


Fig 47 :



Fig 48 :



7 Poll closing

1. As the polling ends around 6 pm, the close button is pressed by the polling officer and no more votes can be cast into the EVM again.

2. The polling officer puts the control unit inside its case and is sealed with stamp and party agents sign on slip.

3. Till counting date, the cases are transferred to the warehouse of district collector and the door is sealed.

8 Counting & Result

1. Before counting, the party agents check their sign on the pink and green slip for verification and then the seal is broken to start the counting.

2. Result button is pressed and the count for each candidate and total count are noted down on paper in the presence of the respective party agents assigned for that particular EVM.

3. The results from each of these EVMs are manually added and the result is collaborated and declared.

4. EVM closed inside the casing and is sealed inside the warehouse for the next election.

Fig 49 :

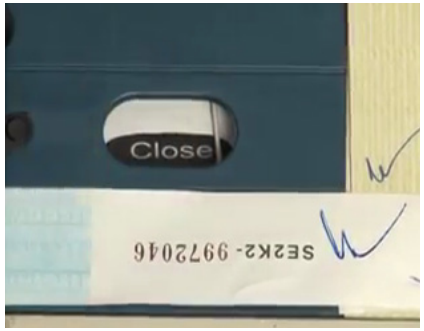


Fig 51 :



Fig 52 :



Fig 53 :



4. Understanding problems in current system

The problems in the current Indian voting system with EVM and VVPAT is looked upon through the broad classification of voter eligibility, vote recording and vote counting process of a voting system. To guide this problem identification, two evaluation criterion is employed below to judge the voting system and narrow down the problems.

The **first evaluation criterion** consolidated from different research works as requirements for a voting system *[2], [3], [4]* is broadly classified into the following 3 sections -

1. Security

- **Eligibility** - Only authorized voters should be able to vote. Identify voters and detect an impersonation attempt.
- **Privacy** - Protect voter privacy, concealing the relation between voter and his/her cast vote.
- **Integrity** - provide measures to prevent and/or detect any attempt to change the voter's intent once the vote has been cast.
- **Voter verifiability(Cast as Intended)** - Voter must have the possibility to check that his/her vote has been accurately recorded.
- **Voter verifiability(Counted as Cast)** - Voters must have the possibility to verify the inclusion of his/her vote in the final tally.
- **Prevention of Intermediate Results** - prevent the disclosure of intermediate results before the election is closed.
- **Ballot Box Accuracy** - Protection of the ballot box against the addition of bogus ballots or the elimination of valid ballots is needed.
- **Coercion and Vote Buying Resistance** - The voting channel must mitigate the voluntary impersonation, in which eligible voters cooperate with the coercer or buyer to access the voting system.
- **Channel Reliability** - Balance the availability of channel to detect delays in an appropriate time-frame (e.g. the detection of a denial of service) and the availability to react to them (e.g. use a contingency channel to cast the vote).

2. Usability

- **Prevention of Voting Errors** - Voting channel has to prevent involuntary voting errors by voters when casting their votes.
- **Ease of Use** - Prevent disenfranchisement and facilitate the participation of voters.
- **Accessibility** - Disabled voters have to be allowed to vote with total privacy without the need of assistance from third parties.

3. Election Management

- **Election Setup** - This requirement regulates the time to set-up the election and to provide voters with the voting materials.

- **Voting Period Election Management** - This management measures the effort required by election managers to follow- up the participation during the voting process, provide support to voters, and react if any issue arose during the election.

- **Counting Process** - This criterion evaluates the effort (resources and time) needed to count the votes at the end of the election.

- **Auditing of the Election Results** - Voting channels must provide means for facilitating the audit of the election to ensure its correct execution.

The following matrix on the right side gives an overview of the typical strengths and weaknesses that different e-voting solutions tend to have, compared to paper-based equivalents published in the research by IDEA(International Institute for Democracy and Electoral Assistance) [12]. This is the second evaluation criterion used to assess the current Indian voting system and identify the problems.

Problems :

1. Security problems

- Difficulty in authenticating the eligibility of voter, as omission of their name from the voters list due to address change or updated serial number in the list make it difficult to identify the voter in the list. This prevails as the process is predominantly paper driven. Hence searching becomes difficult.

- Voter privacy is not taken care in the system for blind voters as it's a mandate for an external party namely the polling officer to help them cast their vote in the ballot unit.

Electoral issues, compared to paper voting	Internet voting	DRE without VVPAT	DRE with VVPAT	PCOS	Electronic ballot printers
Faster count and tabulation	Strength	Strength	Strength	Strength	Strength
More accurate results	Strength	Strength	Strength	Strength	Strength
Management of complicated electoral systems	Strength	Strength	Strength	Strength	Strength
Improved presentation of complicated ballot papers	Mixed	Mixed	Mixed	Weakness	Mixed
Increased convenience for voters	Strength	Mixed	Mixed	Weakness	Mixed
Increased participation and turnout	Strength	Neutral	Neutral	Neutral	Neutral
Addressing needs of a mobile society	Strength	Mixed	Mixed	Neutral	Mixed
Cost savings	Mixed	Weakness	Weakness	Weakness	Weakness
Prevention of fraud in polling station	Neutral	Strength	Strength	Strength	Strength
Greater accessibility	Mixed	Mixed	Mixed	Weakness	Mixed
Multi-language support	Strength	Strength	Strength	Weakness	Strength
Avoidance of spoilt ballot papers	Strength	Strength	Strength	Strength	Strength
Flexibility for changes, handling of deadlines	Strength	Strength	Strength	Weakness	Strength
Prevention of family voting	Strength	Neutral	Neutral	Neutral	Neutral
Lack of transparency	Weakness	Weakness	Mixed	Mixed	Mixed
Only experts can fully understand the voting technology	Weakness	Weakness	Mixed	Mixed	Mixed
Secrecy of the vote	Weakness	Mixed	Mixed	Mixed	Mixed
Risk of manipulation by outsiders	Weakness	Mixed	Mixed	Mixed	Mixed
Risk of manipulation by insiders	Weakness	Weakness	Weakness	Weakness	Weakness
Costs of introduction and maintenance	Strength	Weakness	Weakness	Weakness	Weakness
Infrastructure/environmental requirements	Mixed	Weakness	Weakness	Weakness	Weakness
Lack of e-voting standards	Weakness	Weakness	Weakness	Weakness	Weakness
Meaningful recount	Weakness	Weakness	Strength	Strength	Strength
Vendor-dependence	Weakness	Weakness	Weakness	Weakness	Weakness
Increased IT security requirements	Weakness	Weakness	Weakness	Weakness	Weakness

Fig 54 : IDEA policy paper December 2011 [3]

- Even though the signature to be put by party agents on the pink slip after the mock polls acts as a physical layer of security, the protocol to authenticate the validity of the pink slip while counting is very weak, as those signatures could be forged to an extent that they may be unrecognizable to the party agents themselves.

- During the First Level Checking(FLC) stage of the voting process, even though 1000 mock votes are put by the party agents and the results are printed for verification, the possibility that the embedded program could have been written to administer favored votes after 1100+ votes cannot be verified, unless a full round of polling with maximum voters is conducted.

- Even though VVPAT system provides the option to verify the vote, it happens in a two step process, where voter first cast their vote and then they look into another device to check on the printed slip. From a pilot study conducted by election commission, it was found that most people do not check the VVPAT display, since it was not compulsory. This could allow a faulty machine to run smoothly within the voting process.

- VVPAT could also print while no voter is observing the paper trail, a form of ballot stuffing. Even if additional votes were discovered through matching to the voters list, it would be impossible to identify legitimate ballots from fraudulent ballots.

- Voters doesn't have the possibility to verify the inclusion of his/her vote in the final tally.

- Since the EVM and VVPAT production is controlled by a single manufacturer, and due to the secrecy of the program embedded into the hardware, redundancy of the machine cannot be compared while conducting the mock poll drills by the election commission.

2. Usability problems

- The ballot paper stuck on the ballot unit could be tampered by adjusting the height or start position, leaving the voter to cast vote to the wrong candidate. Ballot paper list order needs to be more secure.

- The printed slip from the VVPAT machine has a different format and graphical layout when compared with the ballot, which might lead to confusion for the voter to verify them.

- Disabled voters are not allowed to vote with total privacy without the need of assistance from third parties.

3. Management problems

- No adequate information displayed or written in the pamphlet distributed, for the voters to react, when an EVM feedback light doesn't glow or if VVPAT doesn't print properly.

- Time taken to verify voter eligibility in the voters list is more, since the process is predominantly on paper.

- Aggregation of the result from each control unit is done manually on paper during the counting process, which could lead to human errors or malpractice.

- Auditing the VVPAT slips is a labour intensive process and hence cannot be done for all the EVMs after election.

- There are possibilities that VVPAT tapes could either be destroyed, left blank due to improper loading of the thermal paper, or even go missing as there are various opportunities for a human error to occur while setting it up.

5. Ideation

5.1. Opportunities & Key directions

- Use of relevant technologies to enhance the authorization process of voter's eligibility. This should make the election officials work fast and easily search the identity of voters from the list.

- Need for a single step process to cast vote and verify them simultaneously. This is to avoid the problem of people not checking the external VVPAT display introduced as a second step in the voting process for verification.

- To facilitate the participation of blind and disabled voters, the system needs to facilitate options through which they can cast their vote independently without anyone's supervision or assistance.

- Need for a mechanism at the counting station to authenticate the pink slips used by the party agents to put their signature as part of the physical verification protocol.

- Opportunity to make the First level checking(FLC) protocol more redundant as the mock poll is not extensively conducted, taking into account the possibilities of deploying a vulnerable EVM without testing the maximum limits of that machine.

- Designing an interface which could make the voters verify the inclusion of his/her vote in the final tally.

- Designing a system to better secure the ballot paper stuck on to the ballot unit, to avoid forging and manipulation.

- Designing a fault redressal system for voters when the system goes wrong. It should guide them with the necessary steps to address the problem like when the VVPAT prints the slip wrongly.

- Possibilities to improve the reliability of system by having multiple layers of authentication so that we can cross check the validity of result from multiple sources.

- Using multiple levels of check points like the Swiss cheese model, where the number of slices could be increased for an error to occur. This could help improve the security and reliability of the system.

- Consider the option to decentralize the system to bring more transparency, by including more man power to check upon one another.

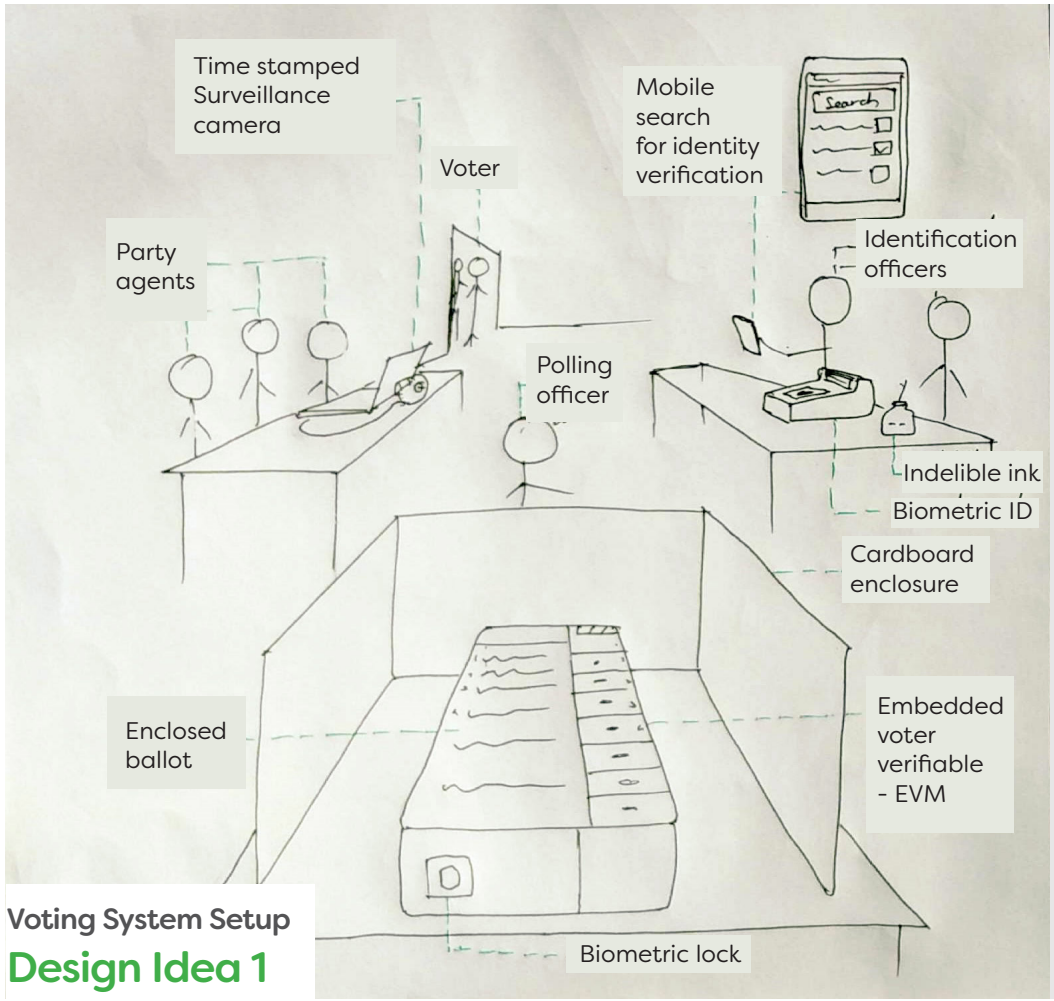
- Always assess the advantages of the existing system and technology. Upgrade them with new technologies only if it could bring significant improvements to the system functionally and economically.

- Consider to separate the interface part from the core recording components of the voting system, to improve the accessibility features for the specially challenged voters.

- Address the needs of a mobile society, with focus on the remote voting features without giving chances for coercion or forceful/incentive voting.

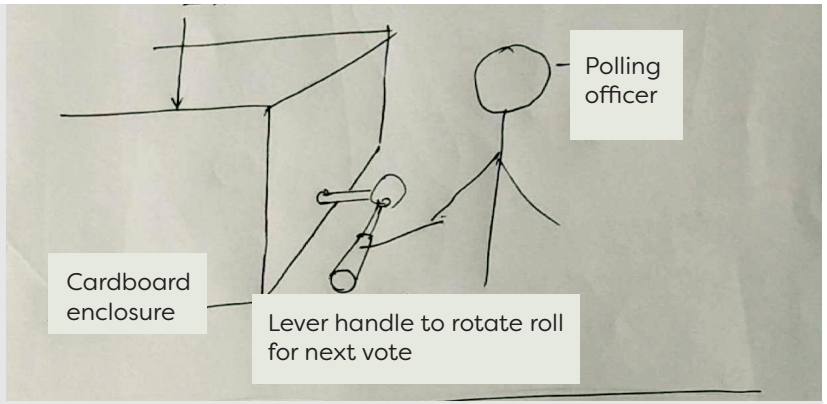
5.2. Initial design ideas & feedback

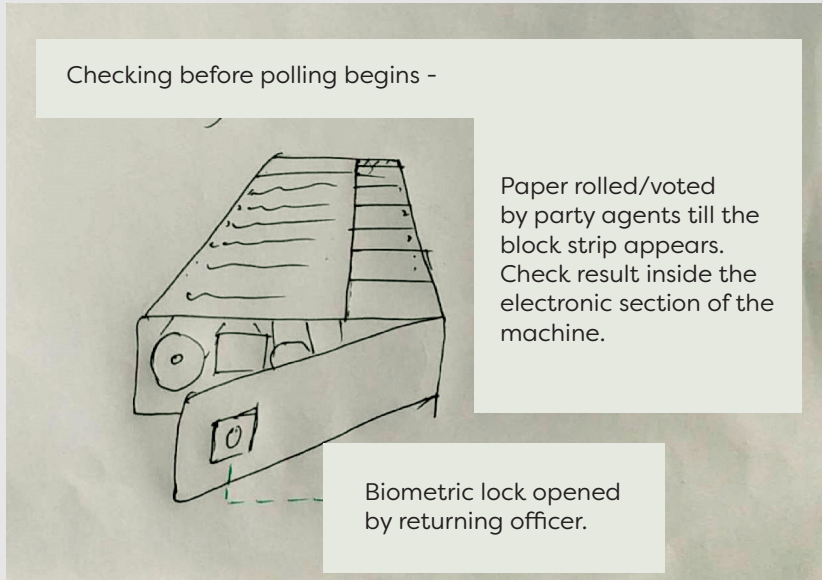
With a main focus of trying to combine the two step process of having to cast the vote and then check the VVPAT printout for verification, the below system was envisioned, were **the voter will punch the vote button and simultaneously verify his/her vote on paper** and gets better feedback with respect to cast as intended factor is concerned. Other features like easier voter identification and accessibility were looked upon in this system.



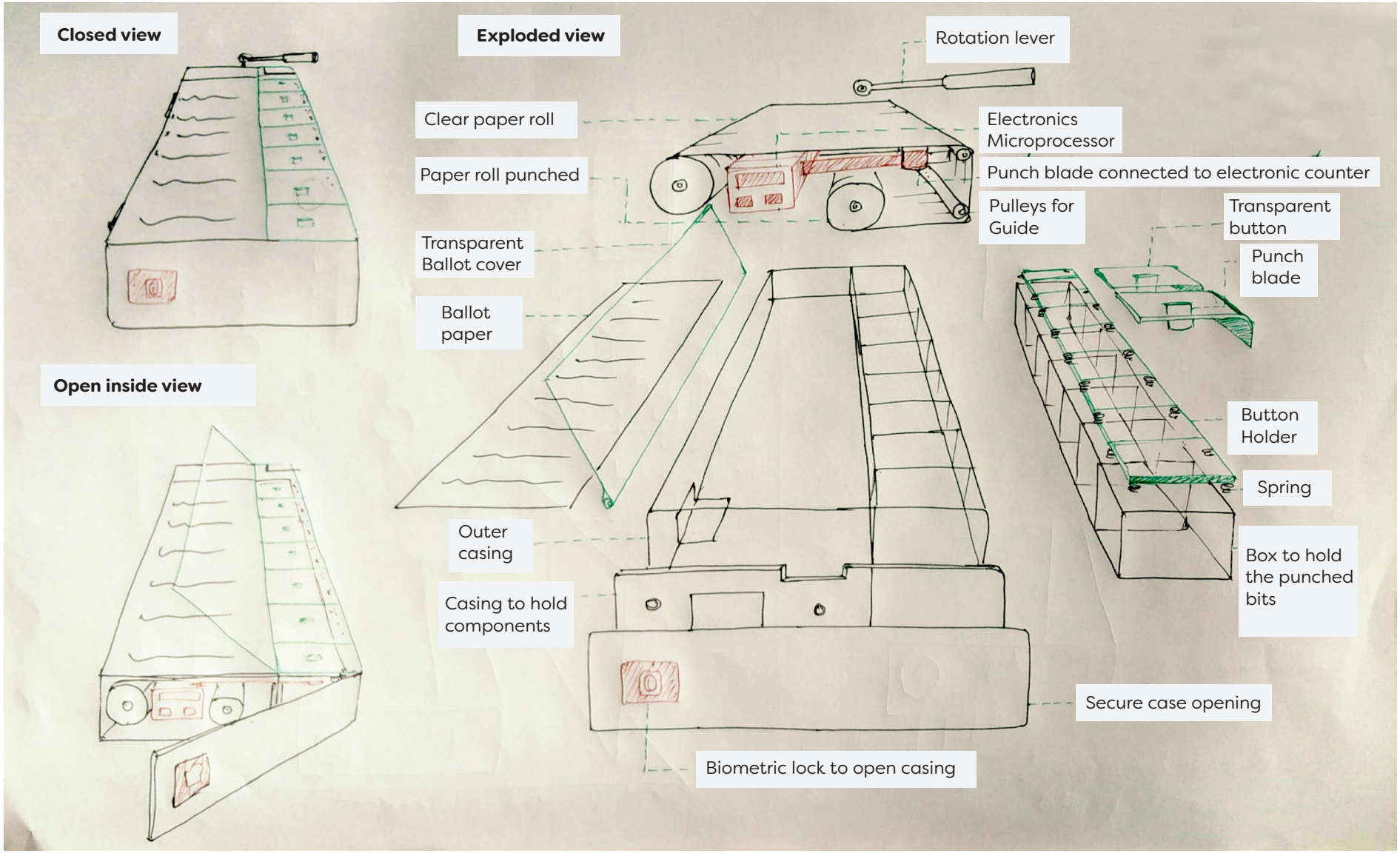
Voting System Setup

Design Idea 1



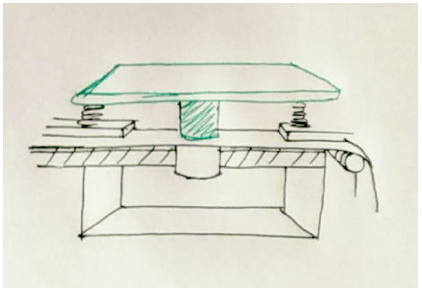


Embedded voter verifiable EVM - Vote recording mechanism



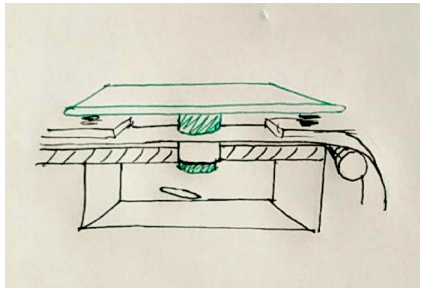
Embedded voter verifiable EVM - Vote recording mechanism

Punching mechanism



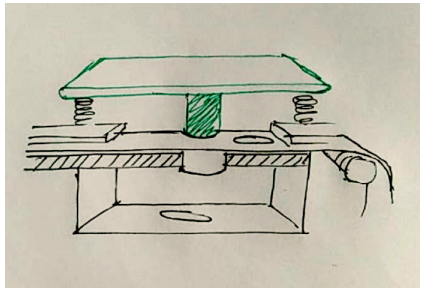
Step 1

Plain paper in place below puncher.



Step 2

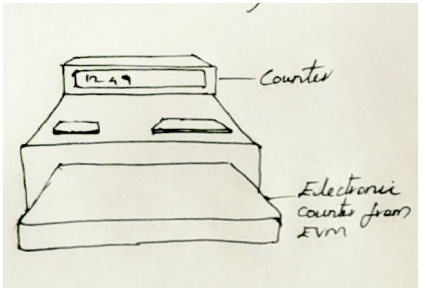
Push the button down to punch hole in paper and the punch bits fall inside box.



Step 3

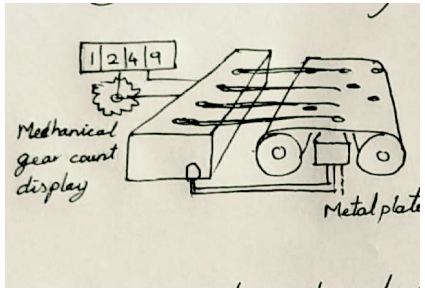
Rotate paper using lever to make the plain paper area to come again under the puncher.

Counting Mechanism



Electronic counting

Plug the electronic component into counting machine to get result.



Punch roll counting

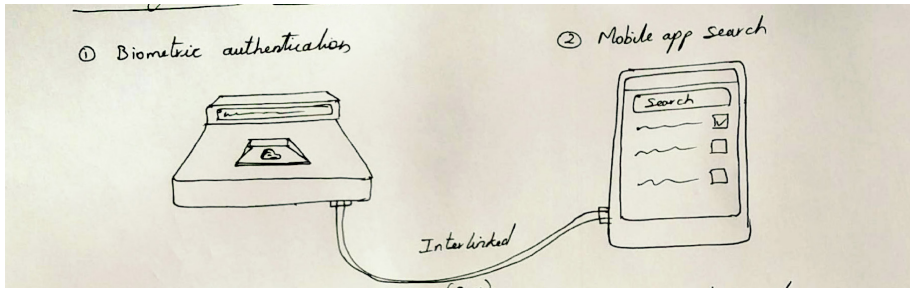
Mechanical counter where the extended arm completes circuit when comes in contact with metal and counts with gear me-

-chanism to roll the display counter as in lever system.

In both the mechanisms, at random intervals count a known value (say 1000 in memory) to check validity of counting machine.

Counting done live under public broadcasting with party agents supervision.

Identification Mechanism



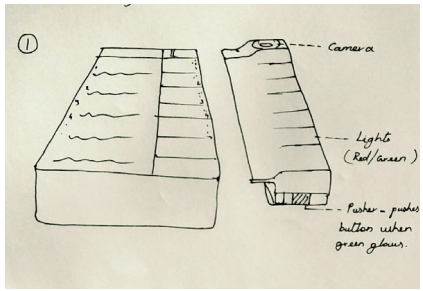
Biometric authentication

- Each biometric machine populated with voter details of one constituency.
- Aadhaar card to be shown, which has photo ID to put biometric authentication.

Mobile app search

- Customized mobile with security lock for searching voters in single constituency.
- Once tick marked, cannot vote again.
- Should show standard ID proof for voting if Aadhaar card not available.
- Online certificate in government digital locker app as ID proof.

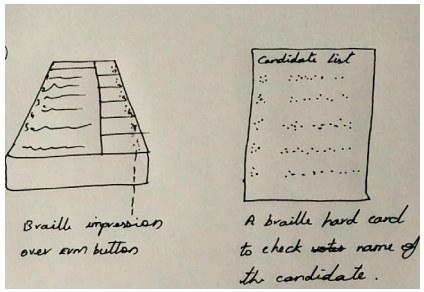
Accessibility Mechanism



Physically challenged

- For people with motor disabilities, move eye ball to move the selection option which glows in red colour.

- Blink eye twice to select candidates.



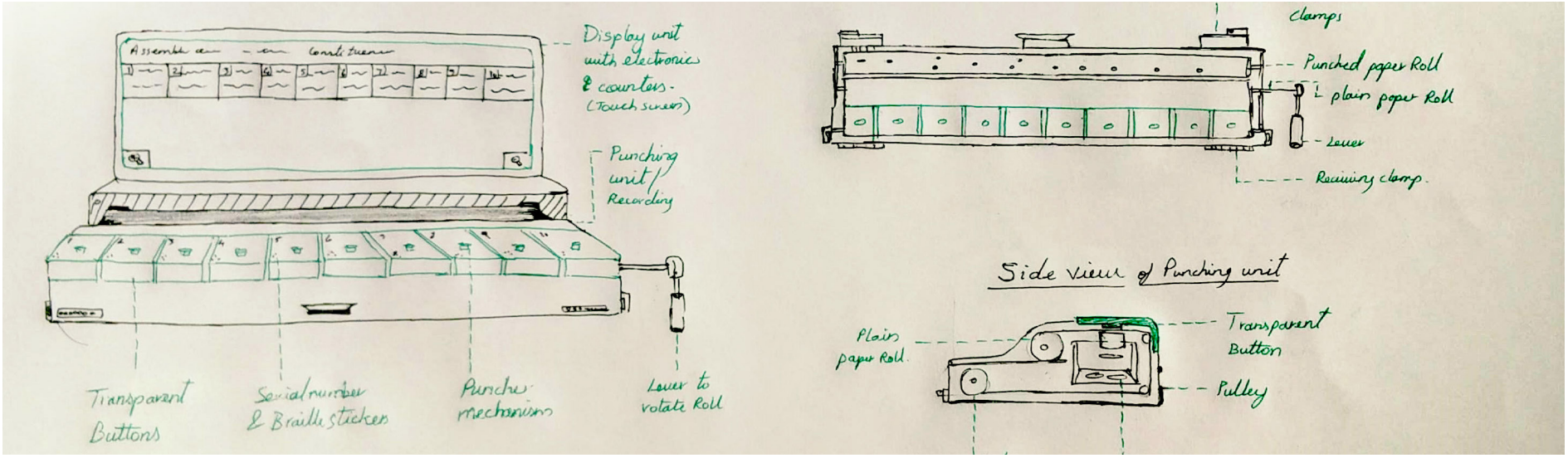
Visually challenged

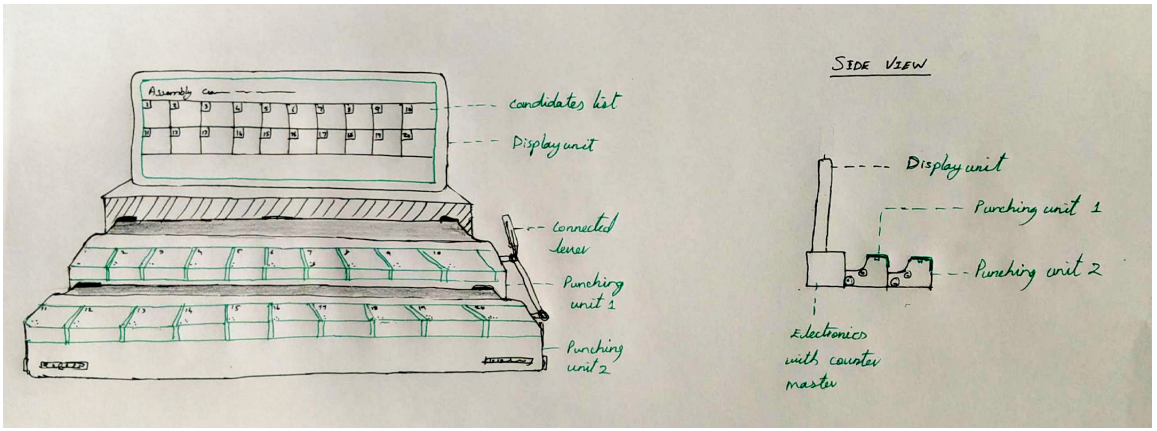
- A card is provided to touch and read the candidates and party name in braille with number sequence.

- Following the number, one can punch the button with the hand, as the braille marks are given at right edge of the machine for referencing.

Design Idea 2 : **Modular punch machine**

The modular punching unit is to be attached to machine display based on number of candidates in list.
Horizontal arrangement of candidate list is to give equal distance between punch button and voter's hand.





When the number of candidates is more than 10, the punching unit is attached with another similar unit to vote for the rest.

One can connect to the punching unit by stacking horizontally as per the candidates list. The name of candidates are shown in the display with exact mapping with number stickers on each button.

5.3. Feedback and redefined brief

- In the idea1 the plain punch paper onto which the vote is pressed and punched may not be relatable to the candidate name list over the ballot unit. At least numbers must be printed on the paper roll on which the punching is made.

- Even though the two step process of first voting and then looking at the printed slip is avoided, the paper wastage could be a important factor to look into comparing the VVPAT system.

- The necessity of voter verifiability through paper audit trail all together was questioned.

- The voter not able to correct the error that one might make while voting. No second chance given to correct the vote.

- The touch display technology which has a vast mobile phone penetration into all levels of people in India is not exploited as a possibility for the solution. Since the future is moving towards touch screen technologies, and since the cost of these technologies are reducing heavily day by day, those area could also be explored.

- The battery powers are greatly improving due to technological innovations and taking that as a constraint on not to consider touch display devices need to be reconsidered.

- The inclination in the solution towards mechanical systems were questioned. The assumption that mechanical systems could be more reliable and understandable for the voters when compared to electronic systems are not validated.

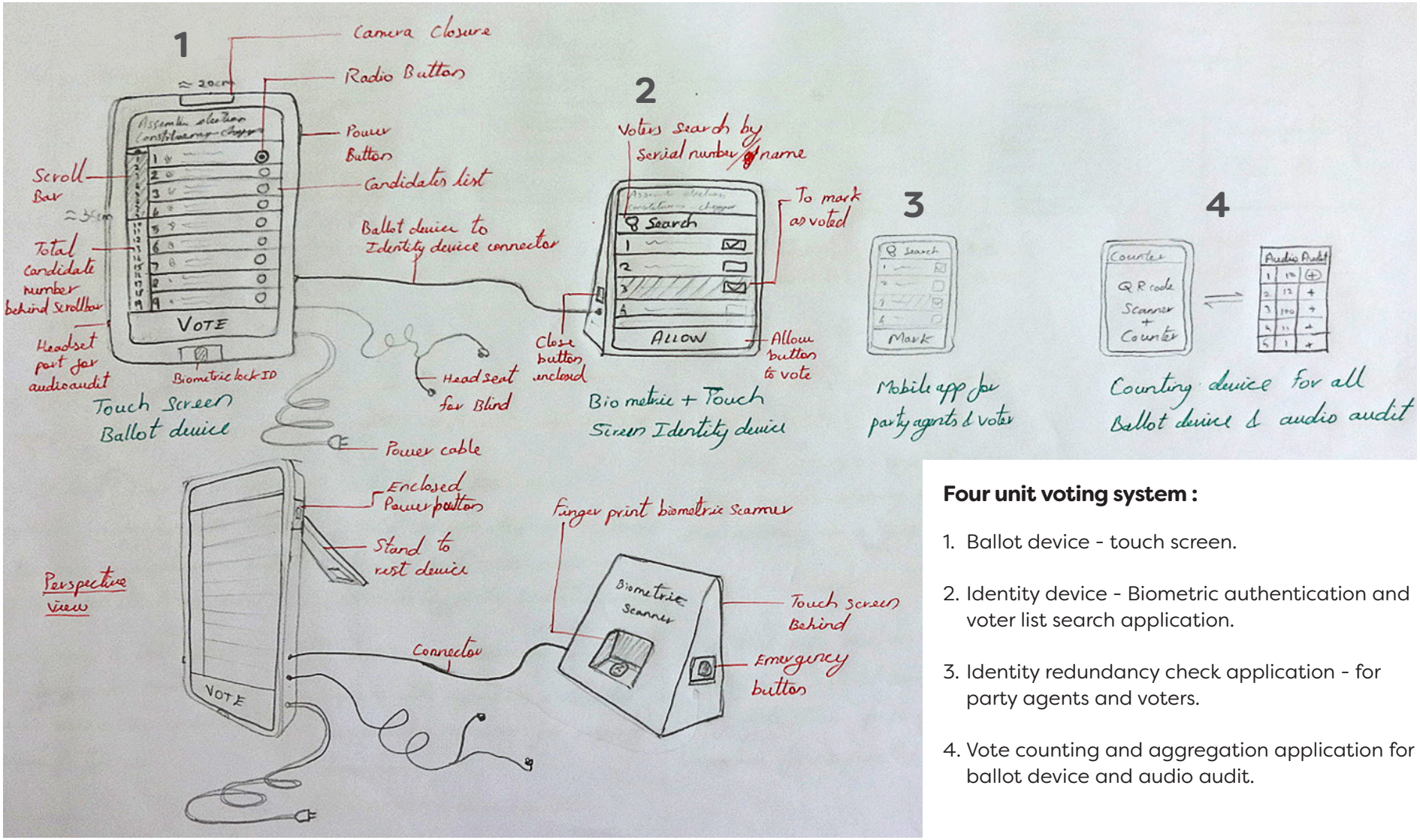
Redefined brief for ideation :

- Realized that there is an election prerequisite that the system should not provide means to trace back the order in which people cast their vote. This is ensured so that any lost candidate don't take revenge on any section of voters if they come to know the order in which people went to polling booth. Hence this makes the initial design idea of paper roll mechanism invalid as it keeps track of the punch holes in order.

- Also realized that I had taken presumptions that we need an alternate mechanical system to make audit which would be much more reliable and secure and did not consider a completely electronic system even as an option.

- Hence the ideation was proceeded by incorporating not only mechanical but also relevant electronic and touch screen technologies.

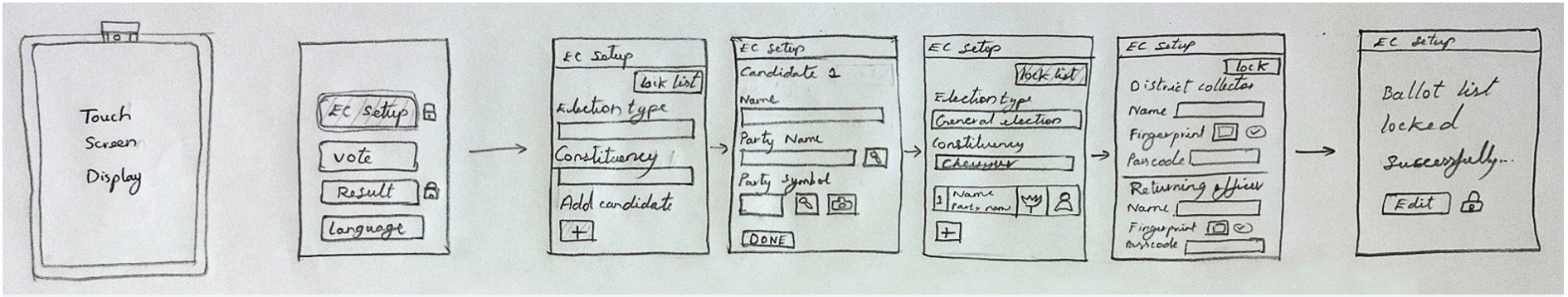
Design Idea 3 : Touch screen DRE voting with audio audit mechanism



Four unit voting system :

1. Ballot device - touch screen.
2. Identity device - Biometric authentication and voter list search application.
3. Identity redundancy check application - for party agents and voters.
4. Vote counting and aggregation application for ballot device and audio audit.

1. Touch screen ballot device - EVM setup -whys and hows ??



Election commission EC setup pressed

Add candidate '+' pressed

Done pressed and candidate list updated

Lock list pressed

Two level lock with biometric & password

Why fully sealed ballot device with no access port ?

- So that there is no access point for hackers to alter the code or elections even if they get them in hand.

- Only way to touch electronics is to break them, which will render the machine invalid for use.

How to access the electronics to enter candidates list or ballot ?

- Entered by two ways -
  1. Touch screen display keyboard to type and enter name of candidate, party and constituency.
  2. Camera scanner application to capture the symbols and auto cropped by software for required dimension.

Why camera has close casing ?

- So that once the machine is setup with ballot list, it could be closed during the election, else voters might feel they are being watched.

Why each candidate details entered one by one ?

- So that enough concentration is given by the typing officials, rather than entering in a table of fields with all information at once.

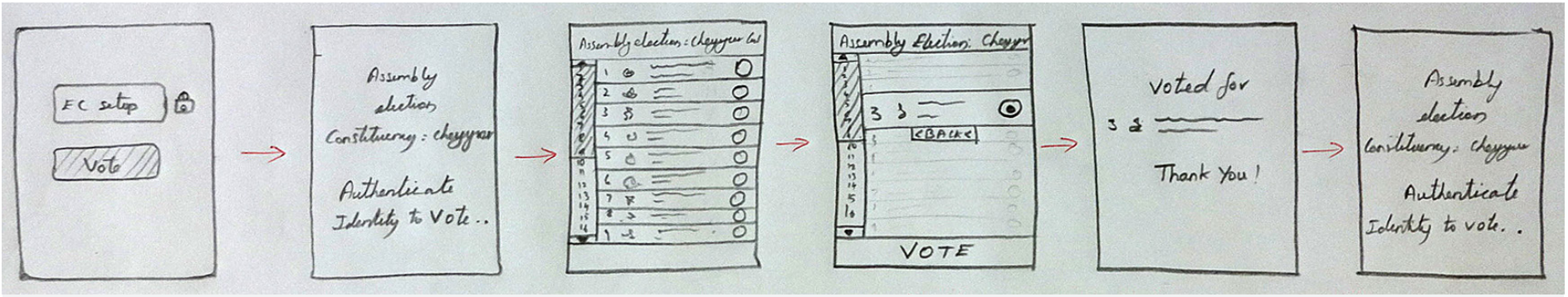
Why is EC setup button locked ?

- So that only election officials namely the district commissioner can enter into this page with their biometric finger print and password.

Why two level lock system provided to lock candidates list ?

- So that two officers in two levels of hierarchy namely the district commissioner and returning officer of a particular ward/zone is involved in confirmation for better accountability and security. The responsibility is dispersed without having solo control or power.

2. Touch screen ballot device - Vote screen - whys and hows ??



Vote option selected by polling officer

After biometric/ID authentication ballot shown

When 3 is selected, it pops out with vote button

Feedback of voted candidate

Back to ID authenticate screen

Why authenticate screen shown first ?

- So that one can vote only after authentication and authentication system is linked to ballot unit to just trigger the ballot list to be shown.

Why can't a hacker access the ballot through the port and into the system ?

- Because the ballot unit is made of three parts
  1. Ballot selection unit.
  2. Counting / recording unit.
  3. Audit audio unit.

  And we know exactly how many type of ballot are to be fetched and for all other input error handling can be done easily and hackers don't have access past this ballot selection unit. Ballot selection means - Ballot for normal, visually and physically challenged voters.

Why is voting made a two step confirmation process ?

- Because voters need to be given a chance to confirm their selection by popping it out, so that they can verify, which might have gone wrong due to similar symbol of party occurring simultaneously in the list.

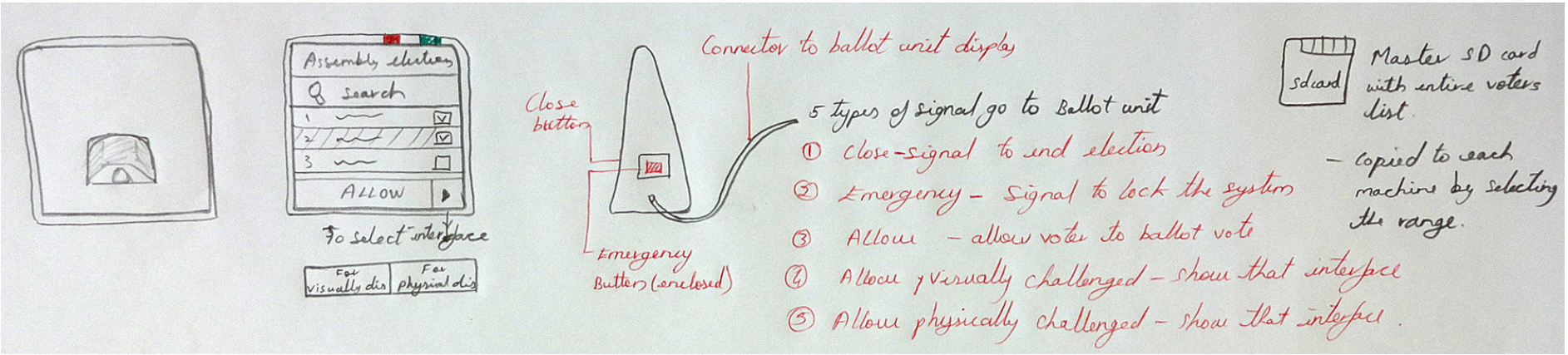
Why is a big scroll bar kept in left and only 9 candidates shown first on screen ?

- So that voters can know there are more candidates in list to scroll down and only 9 view because its an incomplete sequence. If 10 were displayed psychologically it gives a feel of completeness. But 9 can make voter feel still more candidates are there.

Why a separate confirmation or acknowledgment screen ?

- This is for voter to know that they voted as intended and have satisfaction that their contribution is valid.

3. Voter eligibility/ identification unit - whys and hows ??



Why two parts for authentication ?

- One voter with Aadhaar card can directly use biometric authentication to speed up process. For those who don't have them, the screen based system is used by polling officer to identify the voter and allow to vote.

How the search feature speed up the process of identification ?

- Search based on the serial number given from the website or application of election commission, can be used to locate the user or else name could be typed directly to get the voter details and if found allow the voter to proceed.

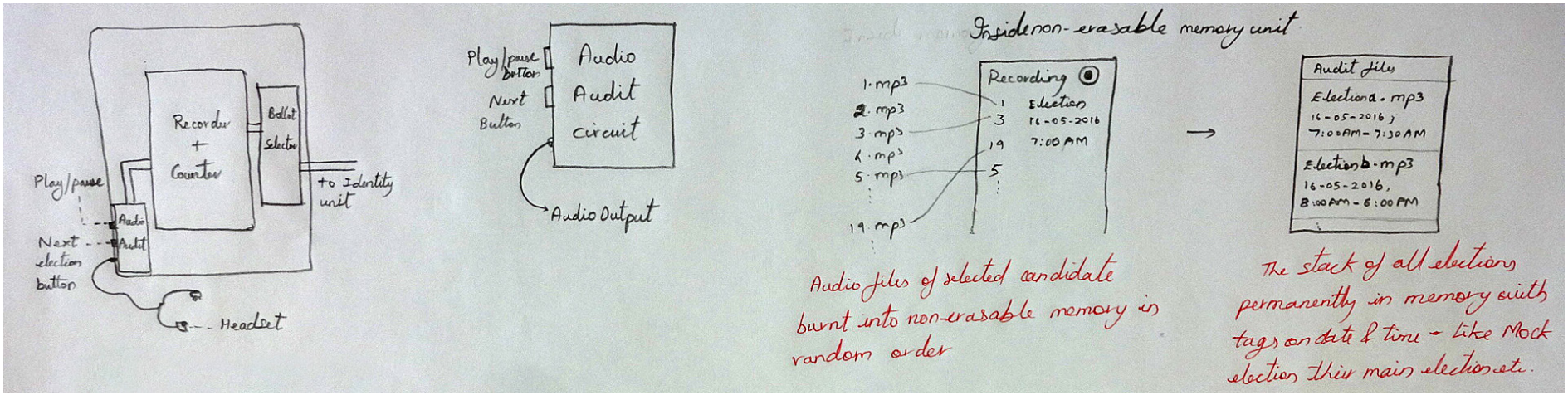
Why is the arrow mark as more option provided as hidden option?

- The voters who are visually or physically challenged are rare to come, hence the "allow" interface for default is shown in big.

How is the voters list fed into the device ?

- To enter voters list into the machine, the memory card with entire list of voters which is publicly available is inserted into the device and unlocked by enabling the port using biometric or password lock system secured by the district commissioner and zonal officer of respective area. Once populated, they are locked again, which is indicated by a 'green' tick light outside the device.

4. Audio audit mechanism - whys and hows ??



How does audio audit work ?

- When voter confirms their vote, an audio file of the corresponding candidate's serial number is burnt into the non-volatile, non-erasable, read only memory, so that in future we can cross verify the count by hearing the count one by one on playing it back.

Why is it non-erasable and sealed in the ballot device itself ?

- Its non-erasable so that no one can alter the result and the audio is burnt so that one can have proof which is not just electronic display but also an audible representation. And sealed because, if given as modular separate unit, fraudsters can replace them with similar tweaked one.

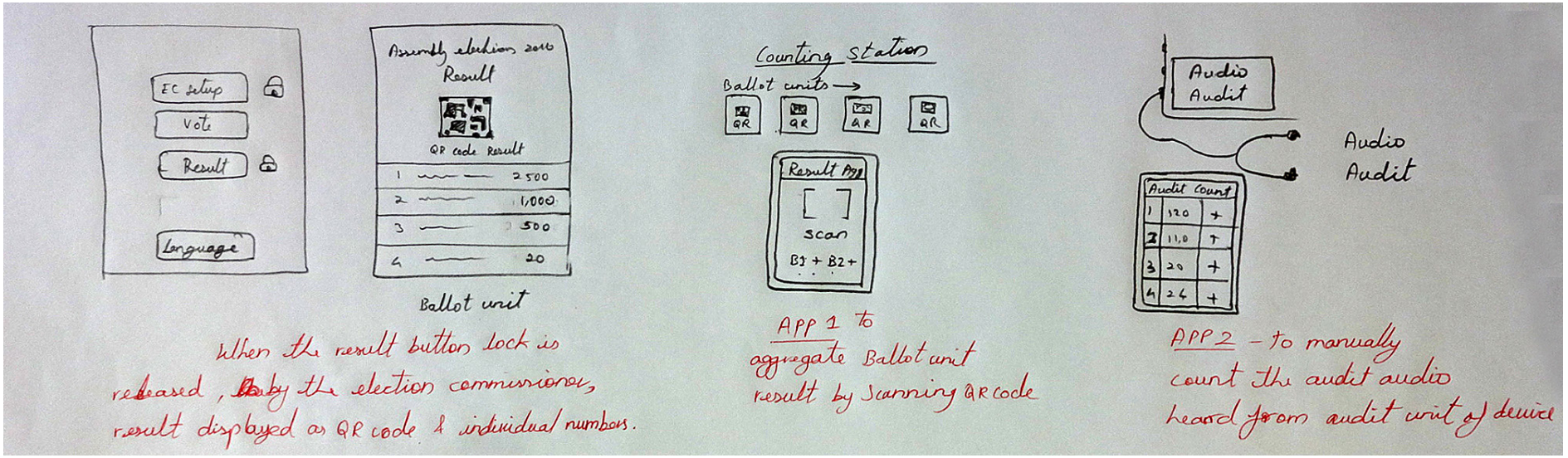
Why audio files are recorded in memory in random order ?

- Because while playback, one cannot find out the order of vote cast by voters. For example, if we know the order, then candidate who has contact with the auditor can note that the group who voted last, voted for him or others, so that he could take revenge on a particular group. To avoid this recording itself is made random.

Why there is next button and why all elections for (50years say) recorded in same memory disc?

- So that there is no possibility for replacing the unit between elections and used as same process for both mock election and the main election to avoid doubt that both might follow different process. The next button is provided to go to next election recording set based on the audio tags.

5. Vote counting device - whys and hows ??



Why QR code is used as output mechanism to show result, rather than access and transfer by connecting cable ?

- Accessing result through port is vulnerable to entry of malicious code into the system. Hence nothing can go into this system while scanning an image.

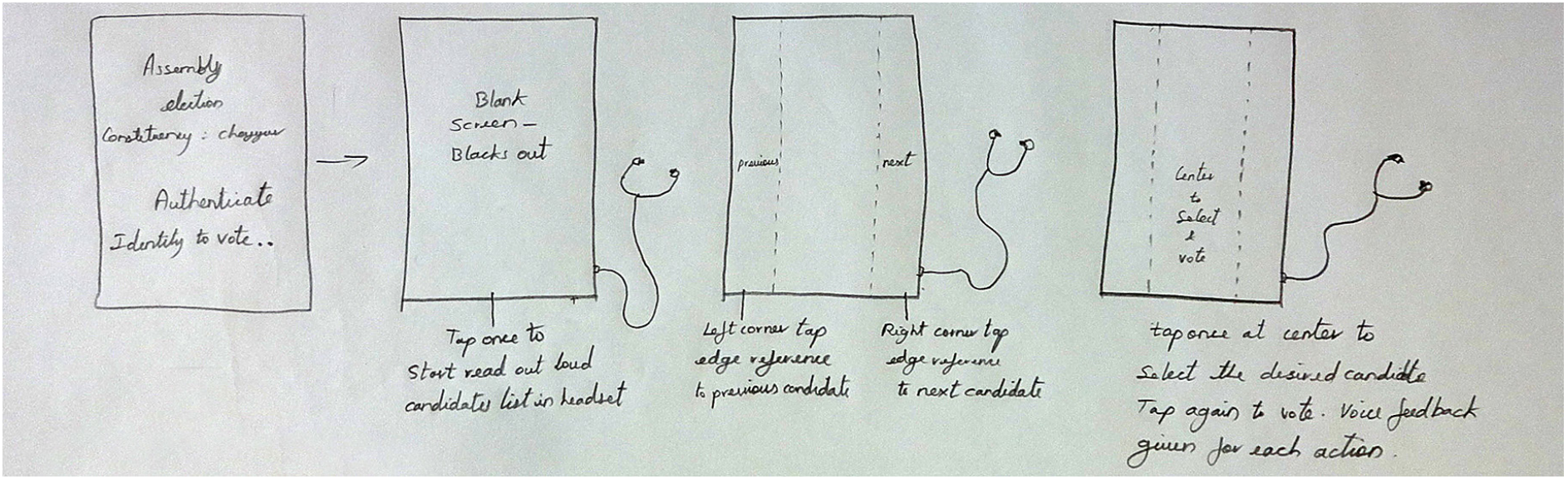
Why a mobile counting device used to scan QR code ?

- So that all the results from all ballot devices can be aggregated and the result can be shown at once after the whole counting, rather than releasing intermediate results.

Why audio audit require mobile app to count ?

- It could be counted using a pen and paper too, but to avoid distraction errors and easier usage an application is provided, but this is optional.

6. Accessibility for visually challenged - whys and hows ??



Why the display screen blacks out, when a blind is opted to vote ?

- So that they need not worry about checking whether anyone is standing near them and can cast their secret ballot alone.

Why is the next and previous button area given in the corner of the screen ?

- So that blind can get a physical reference from the edges of the device and go to next and previous candidate with feedback given as audio by headset.

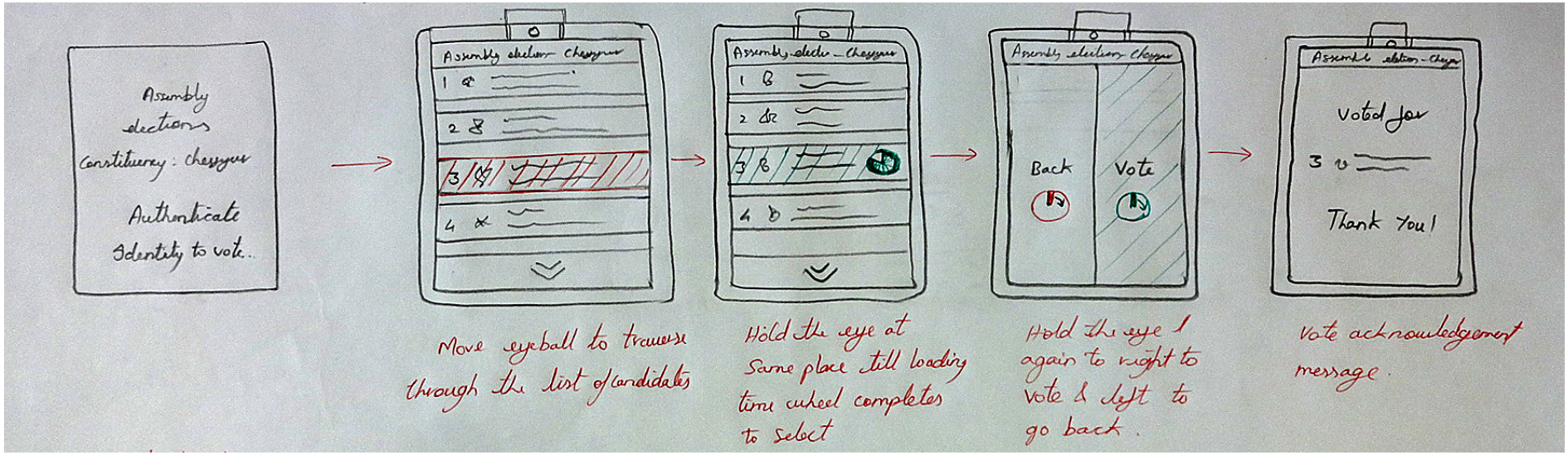
Why there is double confirm to select the candidate once and then vote by tapping again at center ?

- So that the candidate has an option to change, if they selected the wrong candidate at first due to careless physical contact with display screen.

Why is braille system not incorporated ?

- Because only 2% of blind population know to read braille and this could be the alternate mechanism to apply using their knowledge from world.

7. Accessibility for physically challenged - whys and hows ??



Why is the candidate names given gap with big arrow mark to traverse down ?

- So that the physically challenged are given enough margin for error and large area for them to focus on.

Why is time load mode of selection better than blink and select ?

- The number of blinks to set for a selection to happen is varied because, blink speed of people vary widely, hence time based select would be apt to select.

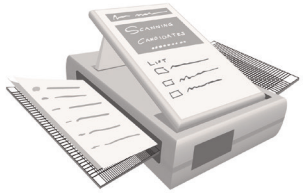
Why is the back/vote confirmation screen provided instead of completing the voting process in one step ?

- When technology is new, people take time to adapt to them, which could make their actions more prone to mistakes. Hence to make them focus and choose the correct one, giving relaxation space for errors, made this screen necessary.

5.4. Final proposal for the voting system

After getting feedbacks from all the previous designs, this is the final design proposal for the voting system. An overview of the system is shown along with flow diagram in the start of this section. They are followed by a detailed presentation of the system in 4 sections.

The design consists of the physical product model with design decisions taken for the physical modes of interaction and digital mode (touch screen) interactions. The product is presented with a demo interface to showcase the functionalities of the product with in this system.



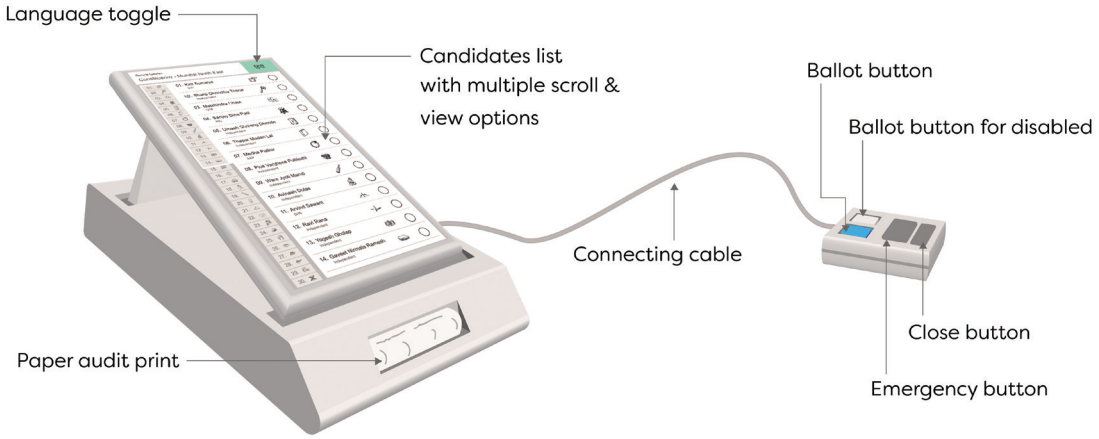
Ballot setting unit



ID authentication unit



Counting & Result unit



Touch screen Ballot unit

Control unit

Overview of the proposed voting system in sequence :

1. **Manufacture** of Ballot unit, control unit, scanning unit, audit unit, authentication unit and result aggregation unit.

2. **Dispatch** of units to the respective district collectors and **store** in the **secure warehouse**.

3. **First level checking** (FLC) of the machines in the presence of district collector, manufacturer's employees and party agents.

4. **Ballot unit setting** - uploading candidates list into ballot unit memory by connecting with **optical scanning unit**.

5. Securing the ballot unit with **physical security protocol**, where party agents put their sign on the pink slip.

6. The ballot unit, control unit and authentication unit **sent to respective polling booth** one day prior to the election.

7. **Mock poll** is conducted in the presence of returning officer and the party agent in the early morning of election.

8. **Pink slip** again sealed over the ballot unit with **sign of party agents** over the slip as part of security protocol.

9. **Election starts** when the returning officer **unlocks the ballot unit** by entering the password sent to all officers.

10. **Authentication unit** is used by the polling officers to authenticate the voters eligibility and then ink mark is put on finger.

11. **Party agents** use mobile app of authentication unit to check eligibility. **Voter actions are recorded** by Online web cam.

12. **Ballot button is pressed** on the control unit to show the ballot list in the touch screen display of the ballot unit.

13. **Ballot button for disabled** is pressed if the voter is blind or disabled to show the **respective interface** on touch display.

14. **Voter selects the candidate** from list and **confirms the selection** in the next screen to get the vote recorded feedback.

15. **Close button** of the control unit is pressed once the polling ends, which will **lock the ballot unit screen** and disable control unit.

16. The **ballot unit is sealed** and sent to the counting station by the polling officer.

17. Counting proceeds in the ballot unit by first **validating the pink slip** by party agents and proceeding to unlock the unit.

18. **Ballot unit unlocked** by counting officials with security code released by election commission just before counting.

19. **Result shown** both as a **QR code** and also individually with candidates name and the vote count by their side.

20. The **aggregation device** is used to scan the QR code results from all the ballot units to **consolidate the result**.

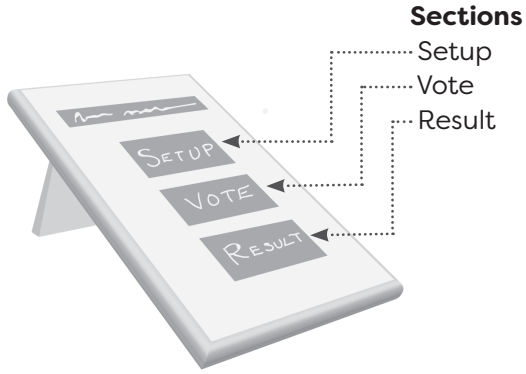
1 Ballot unit Setup - candidate list entry

This section details the touch screen ballot unit and the optical scanning unit used to populate the candidates list contesting for the election into the ballot unit and also shares the advantages and disadvantages of this solution.

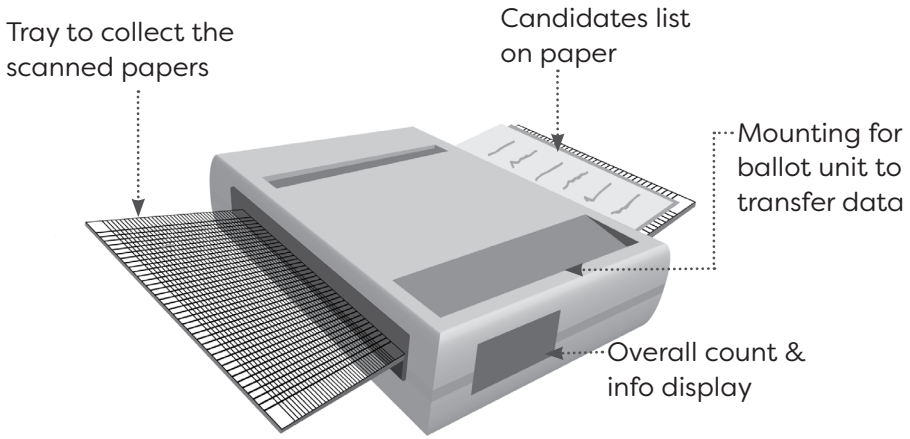
The touch screen ballot unit is the major product of this system which handles the interface to setup the ballot, the interface to vote and also the interface to record and count the vote. The home-screen interface displays the three sections of voting process which would be accessed during the setup, polling and result declaration period of the voting process. Each section is password protected. The setup section is protected by the election commission and are passed on to the respective district collector in a secure protocol. The district collector sets the password for the coded ballot units before handing it over to the returning officers, who would transfer them to the respective polling booths.

The ballot unit is setup by placing it over the mount area of the optical scanning unit and a proprietary handshake protocol connects the ballot unit with the optical scanner unit. The optical scanning unit has an input tray to feed the candidates list printed on paper and an output tray to collect the scanned papers. It also has a display to show the overall count and information like the ballot unit serial number into which the candidates list is populated.

The ballot unit is placed over the optical scanning unit in a slant angle with a support angle at the back, so that the content of the touch screen display could be viewed better by the election officials while working on the candidates entry.



Touch screen ballot unit



Optical scanning unit

The reason for this mounting mechanism and optically scanning the candidates name was to avoid the possibility of having an input port in the ballot unit like a USB port, which could be a vulnerable access point for hackers to put in malicious code into the ballot unit and jeopardize the system.

Advantages :

- Since there are no ports in the ballot unit through which malicious program could be inserted, the security of the standalone touch screen display is more.

- The manufacture of the ballot unit and optical scanning unit is such that its entirely sealed without any screw mechanism to open and tamper.

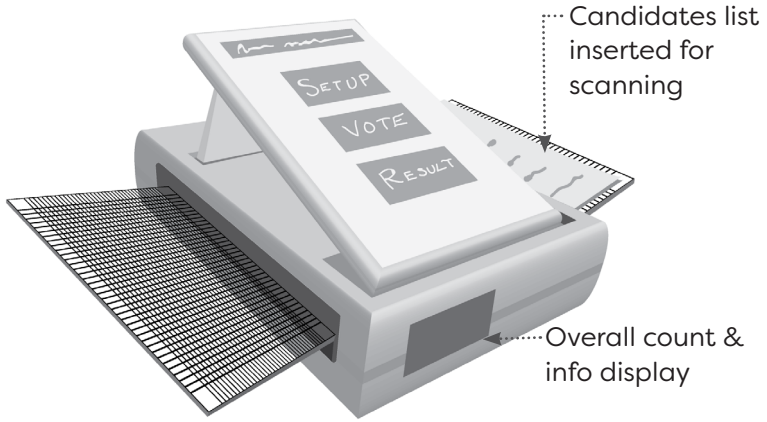
- The ballot unit doesn't have any wireless or blue-tooth capabilities to intrude its security.

- The printed papers of the candidates list can be reused by the party agents during the polling to communicate their candidates position in the ballot list to the voters.

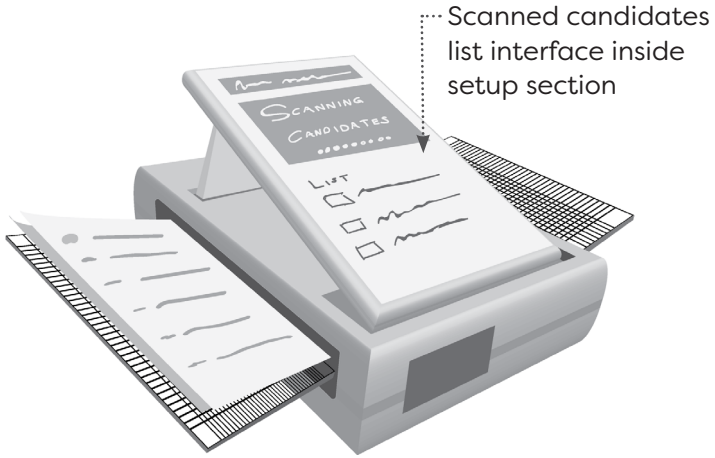
Disadvantages :

- The printed papers could go waste if there are not effectively used during the polling day.

- The optical scanning unit is bulky and adds more labour for the election officials. Smaller proprietary devices as an option to transfer the candidates list not explored.



Ballot unit attached over scanning unit

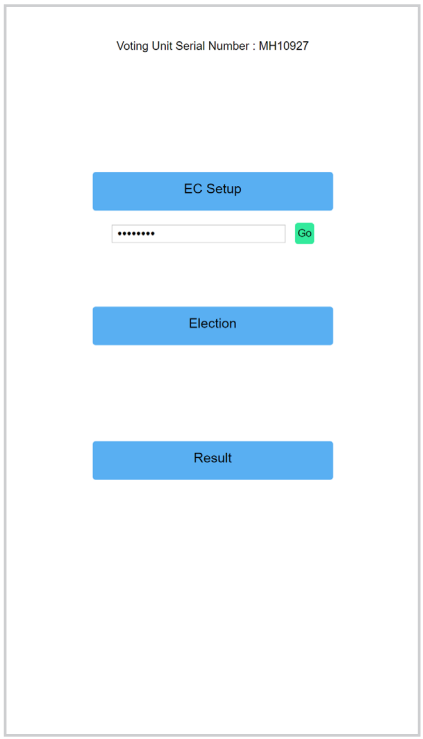


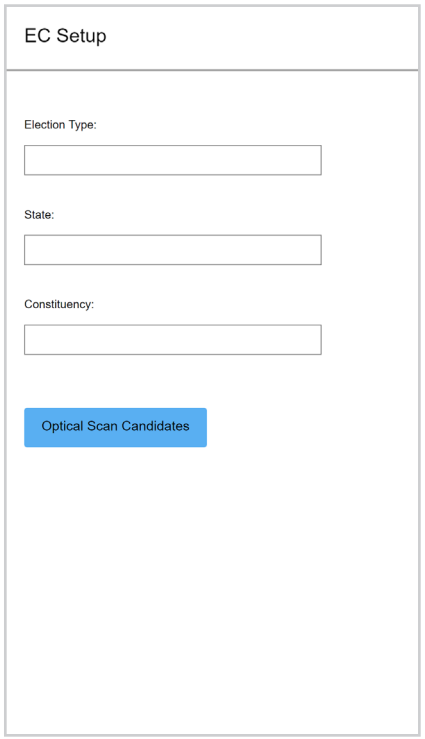
Ballot unit with scanned candidates list

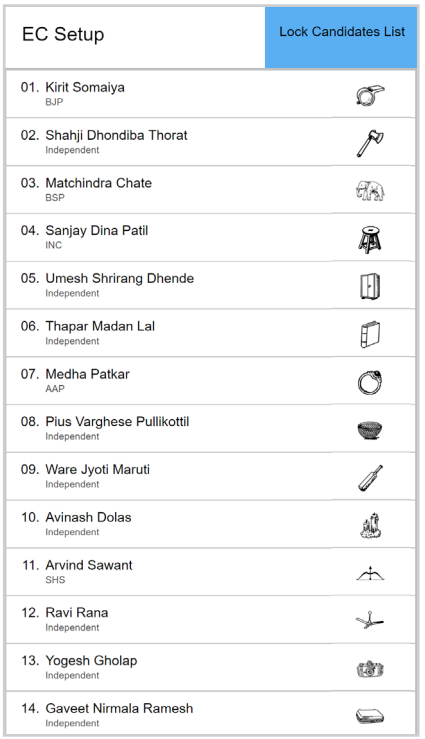
1. Home-screen with ballot unit serial number and 3 sections.

2. Inside the EC setup section.

3. After the optical scan of candidates list is complete.







The district collector enters into the EC(election commission) setup section by entering the password given by the election commission and with the help of manufacturer employees and in the presence of party agents, the fields are entered and the candidates list are optically scanned through the optical scanning unit. The scanned content consists of the serial number of the candidates, their name, their party symbol and also the party name. Once the scanning is complete, the candidates information is verified by the party agents with the printed paper and if faulty is reported to the collector for edit. Once the list is verified, the candidates list is lock inside the ballot unit by the collector and this cannot be changed till the results are declared. Similarly the ballot units assigned for all the constituencies of that particular district is loaded and locked by the collector and then a physical security procedure of pink slip is sealed around the device, on which all the assigned party agents for that constituency and booth number put their signature. Now the ballot unit is ready to be transfered to the respective polling booths through the returning officer.

2 Voter eligibility authorization setup

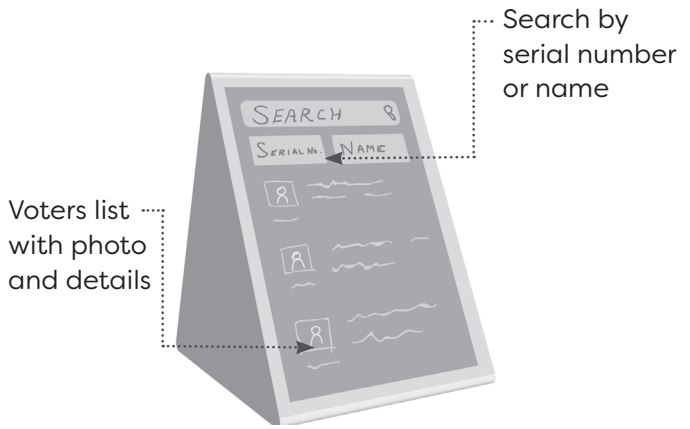
The authentication unit has two faces to interact. The front side of the unit is a touch screen display with the list of voters for that particular constituency. The list has details about the voter's photo, name, address, voter ID, Aadhaar ID and other ID details. This side is used by the polling officer inside the polling booth to verify the eligibility of the voters who come to vote. Once ID is verified, a check mark with confirm button is put on the voter's entry in the list to avoid double voting again. The display also increments the count of total number of voters who had cast vote. Simultaneously the party agents also double check the voter's photo ID with the printout taken during the setting up of authentication unit in the collector's office using the optical scanning unit. This process would be faster if the voter has an Aadhaar card, as he could scan his finger print right away on the authentication unit and proceed to vote.

The reason for keeping the authentication unit as standalone and not connect with the ballot unit is as follows. If they are connected, they could assume that since they look physically connected, the system could track who voted for which candidate, which counters the right for secret ballot to all the voters.

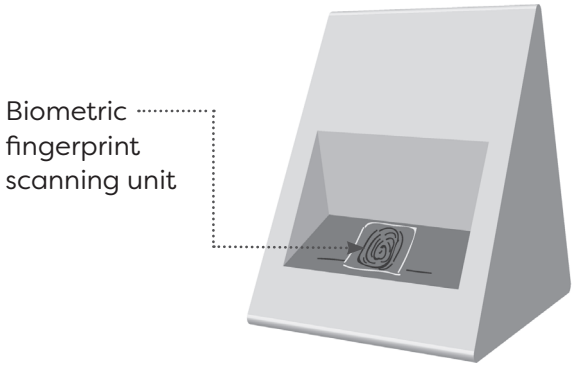
Advantages :

- Speed of the voter authentication process improves due to search feature and disenfranchisement of voters can be avoided.

- The party workers can also use the authentication unit's application in mobile phone to guide the voters with serial number and booth number assigned for the voter.



Front side of authentication unit facing polling officer

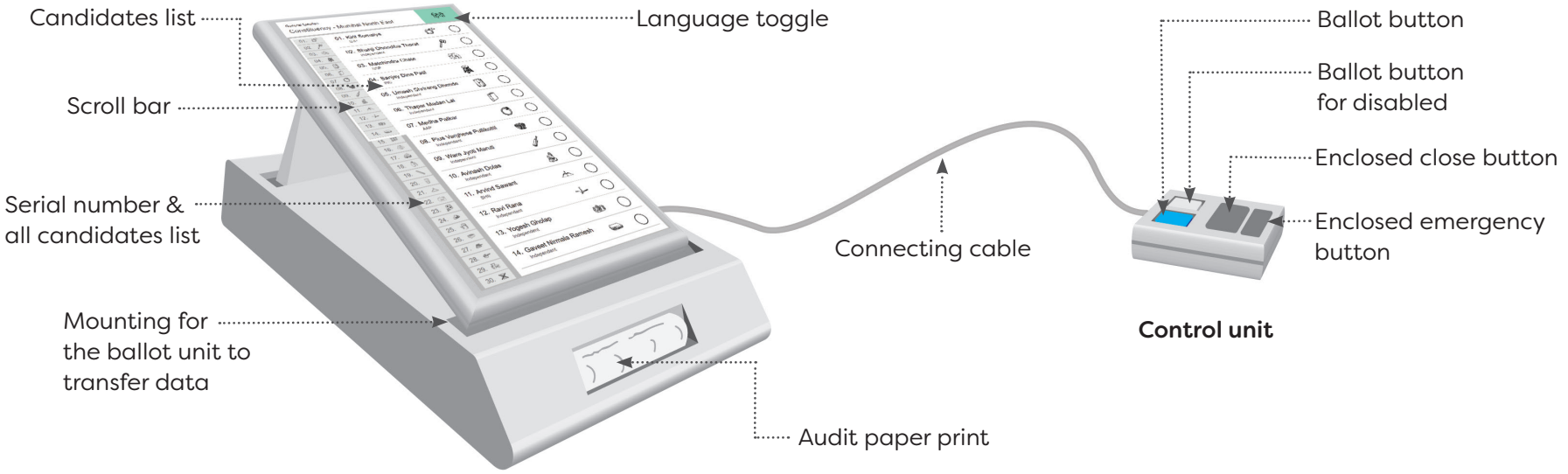


Back side of authentication unit facing voter

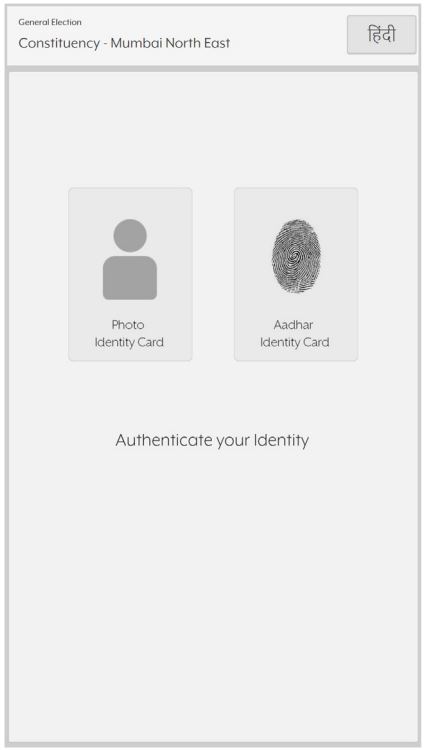
3 Polling setup to vote

The polling setup has three components namely the ballot unit, the audit unit and the control unit. The ballot unit is mounted onto the audit unit with the proprietary handshake protocol like the one with the optical scanning unit to transfer the data. The control unit is connected to the ballot unit using a proprietary cable. The control unit has four buttons on them as follows-

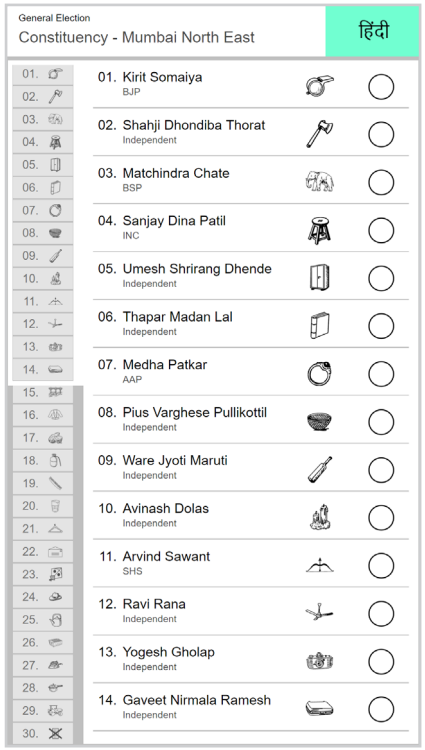
1. **Ballot button** to enable the interface for regular voters on the ballot unit touch screen interface after authentication.
2. **Ballot button for disabled** to enable the interface for blind/disabled voters on the ballot unit touch screen interface.
3. **Close button** to end the recording of votes into the ballot unit and restrict further entry till the result announcement.
4. **Emergency button** to pause the recording of votes in case of emergency like booth capture by criminals. This process could be resumed once the district collector unlocks the system.



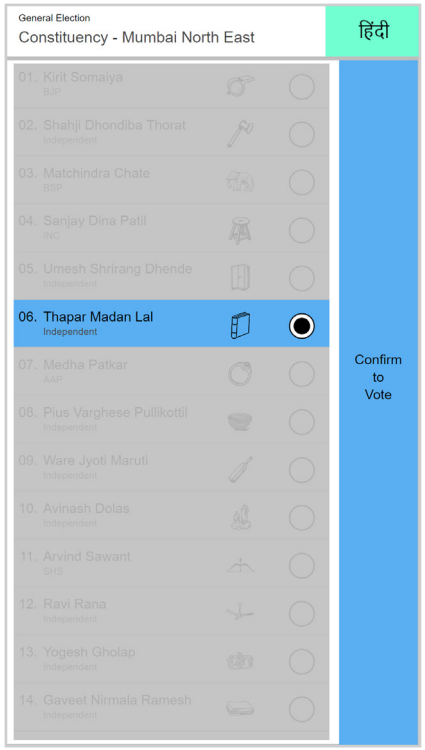
Ballot unit over the paper audit unit



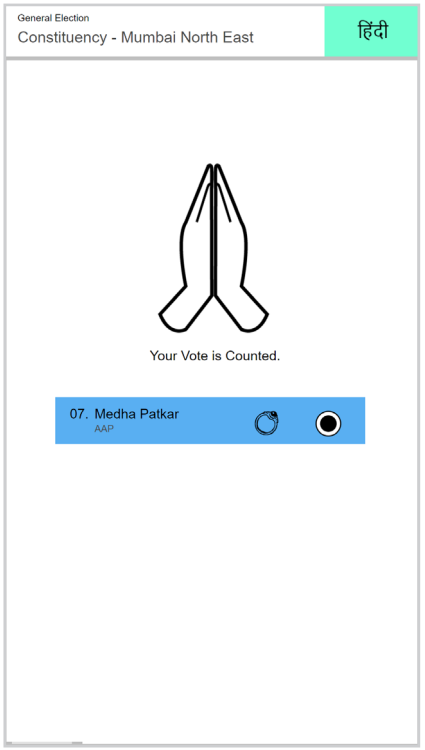
1. **Default screen before authentication**



2. **Candidates list shown for selection**



3. **Confirm selection screen or go back**



4. **Vote recorded feedback screen**

Once the eligibility of voter is verified, the ballot button is pressed by polling officer to change the default screen on the touch screen display to the ballot list with all the candidates for selection. All the candidates are accommodated in a single ballot unit unlike the earlier system where only a maximum of 16 candidates could be accommodated in one unit and more units need to be attached for showing more candidates. The voter can select the preferred candidate to proceed to the confirmation screen or cancel the selection and reselect another candidate. After a satisfactory selection and by pressing the confirm button, visual and auditory feedback is given to the voter along with a paper audit which gets printed down in the audit unit attached below the ballot unit.

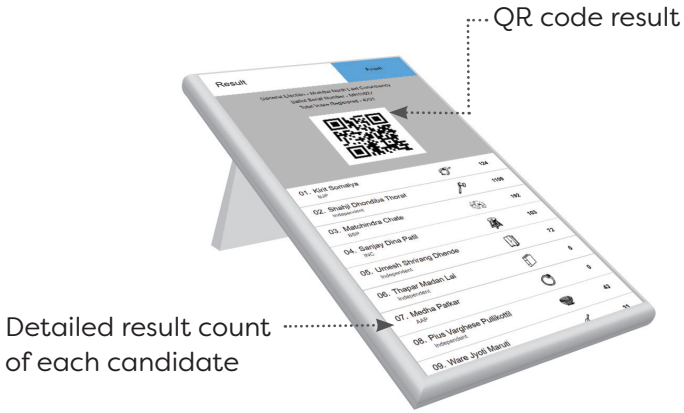
This section of ballot unit is discussed in detail with the decisions taken to design its interface in the following chapter.

4 Counting and Result

Once the polling gets over the close button is pressed in the control unit to lock the candidates list screen and prevent further manipulation of the vote count digitally recorded in the database of the ballot unit.

When the counting session starts, the password locked result section is opened by the counting officers using the common password announced by the election commission just before the counting. The party agent also verify the physical security protocol of their signature on the sealed pink slip before unlocking the result section.

The results are shown in the ballot unit screen as a QR code along with the detailed count of votes received by each of the candidates. Now the zonal officer of the counting station uses the result aggregator device to total all the votes by scanning the QR code from each ballot units of the constituency to realize the final result.

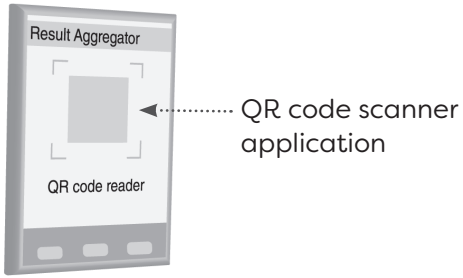


Ballot unit showing result section

Advantages :

- The QR code aggregation of result ensures prevention of human errors while adding the results from individual ballot units and also make the process faster.

- The device acts as a totaliser which blocks the information to the viewers in counting station on the change in vote count after counting a particular ballot unit from a polling booth. This avoid the possibility of revenge by the winning candidate who can recognize the section of voters from the party agent who came for verification.



Result aggregator

6. Ballot unit interface design

To evaluate the proposed voting system, one section of the system namely the ballot unit was chosen and designed in detail.

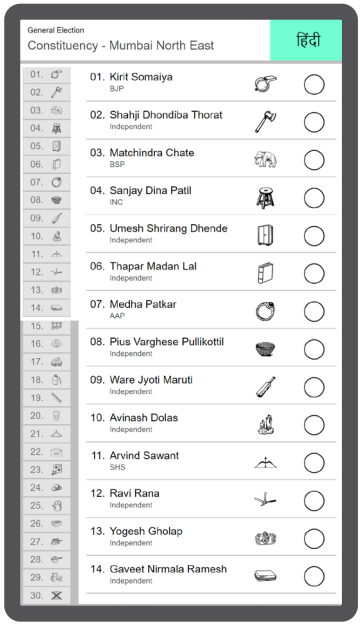
The ballot unit interface for the voting section which would be used by the voters during election was chosen and mock-up design screens were created. Three screens were to be designed as shown by the images on the right side.

Screen 1 needs to have the content :
Serial number, candidate name, party name, party symbol, constituency name, option to toggle languages, option to accommodate any number of candidates and signifier for easy navigation across all of them and signifier for letting voter know that there are more candidates below.

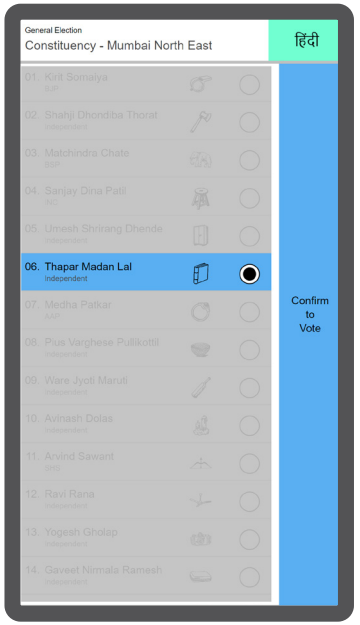
Screen 2 needs to have the content :
Signifier for the selected candidate, option to cancel the selection and go back, confirm button to vote for the selected candidate.

Screen 3 needs to have the content :
Audio and visual feedback represented graphically and through text.

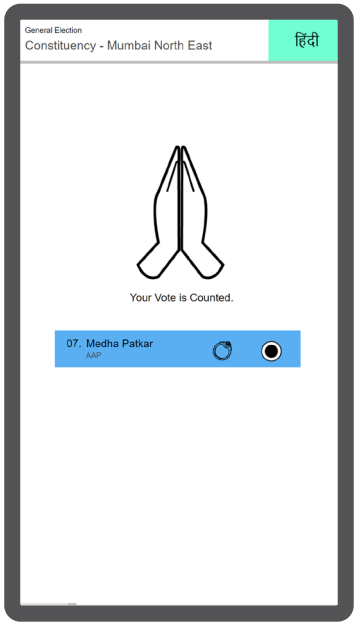
6.1. High fidelity mock-up screens :



Screen 1 : Ballot list



Screen 2 : Confirm vote



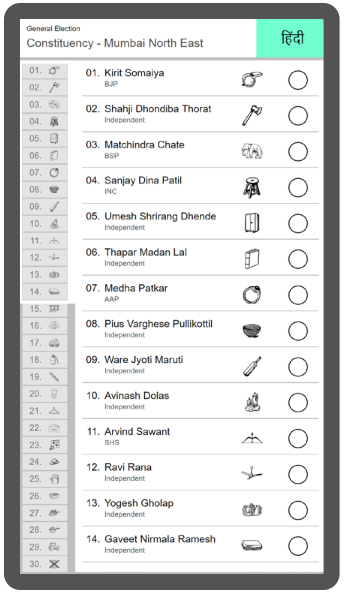
Screen 3 : Feedback

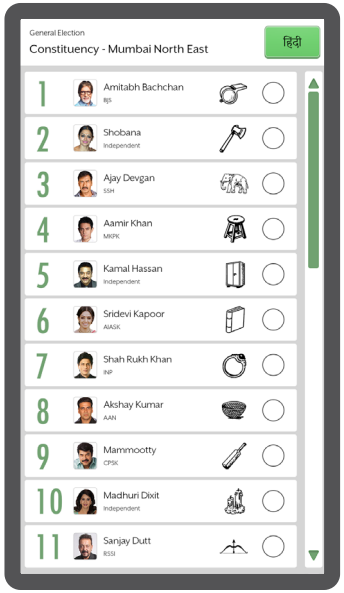
Screen 1 - Ballot list
mock-up designs options :

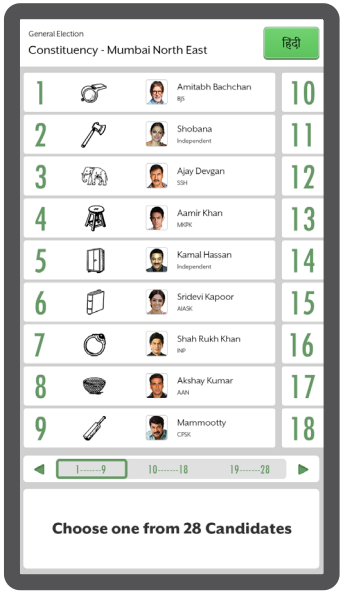
The ballot list mock-ups were tried out with respect to variations in the layout, the type of scroll bars, the signifiers that indicate the extent of list and the affordance to make the voter select a candidate.

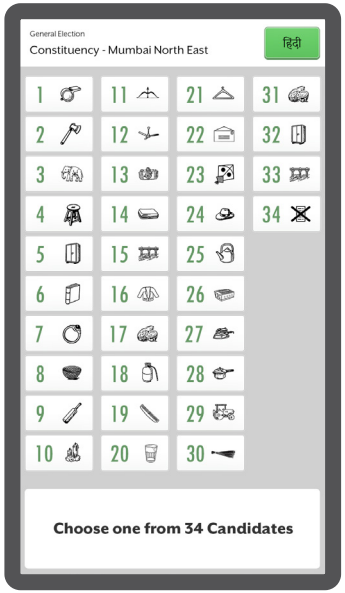
For the layouts, 3 variations were tired out namely - vertical scroll, horizontal scroll and grid view layout. Both the vertical and horizontal scroll bars indicate the entire serial numbers present in the list suggesting the voter to scroll down to view the other candidates. In the first layout the scroll bar along with the full serial number list in the background was kept in the left itself so that voters could notice that more candidates are there in the list before choosing to select one candidate. But this layout obstructs the main list view while scrolling with your right hand.

A black circle is shown to right of the party symbol in first two layouts as a signifier to make the voter select a candidate, which resembles the vote button in existing system. In the other two layouts written instructions were tried out to make the voters select the candidate.









Screen 2 - Confirm vote mock-up designs options :

Once the selection of a candidate was made, the candidate's items get highlighted. To proceed and cast the vote, confirm button has to be pressed. The placement of the confirm button was tried out in three different positions.

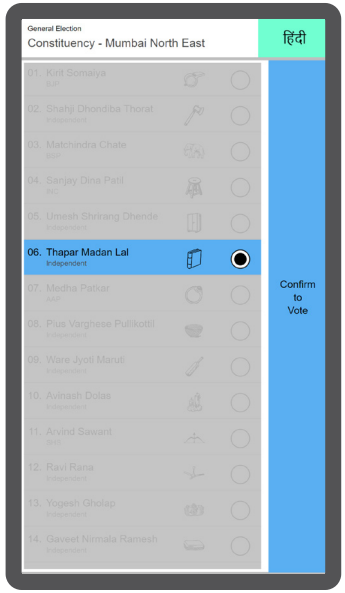
1. Confirm button to right of the selected candidate signifying the next step to do.

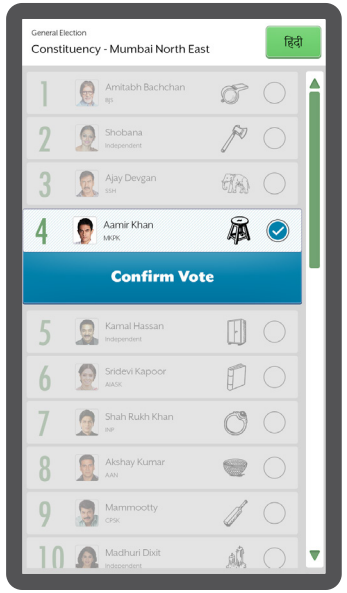
2. Confirm button just below the selected candidate for easy reach of the button and bringing better relation between them.

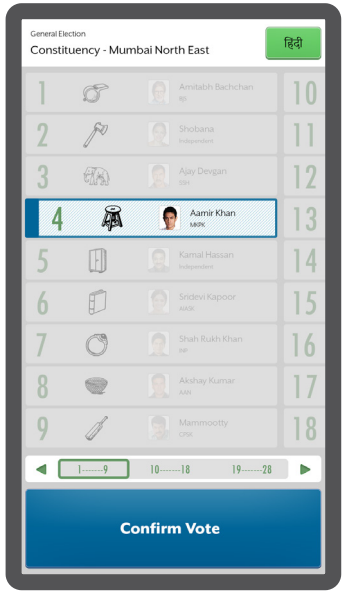
3. Confirm button at the bottom of the screen in a static position, so that voter has to take a conscious effort to reach down the screen and cast their vote, minimizing the chances of error.

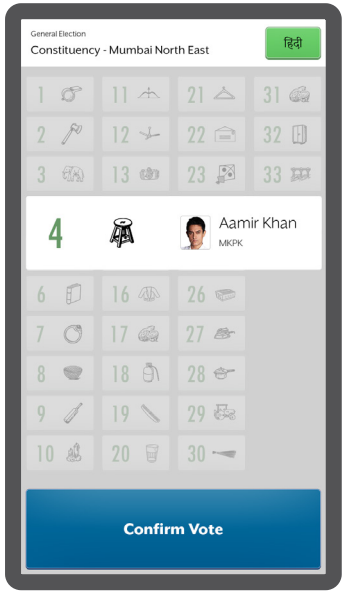
Even thought the first options doesn't look like a button, the second and third options could be challenging to choose from and needs to be evaluated for its measure of effectiveness.

The order of elements inside the candidate item is not changed after selection keeping in mind the usability problem of voter finding it difficult to relate if the layout of elements are changed. An option with bigger size of elements without altering the order and position is tried out.









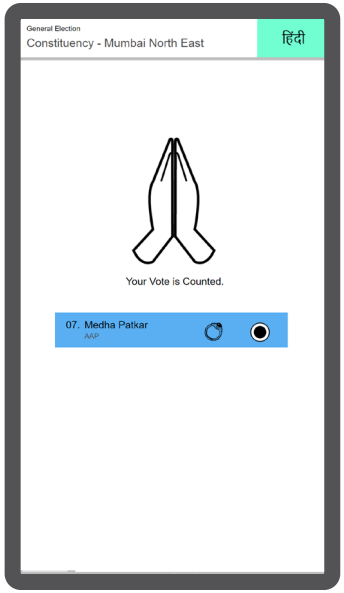
Screen 3 - Feedback mock-up designs options :

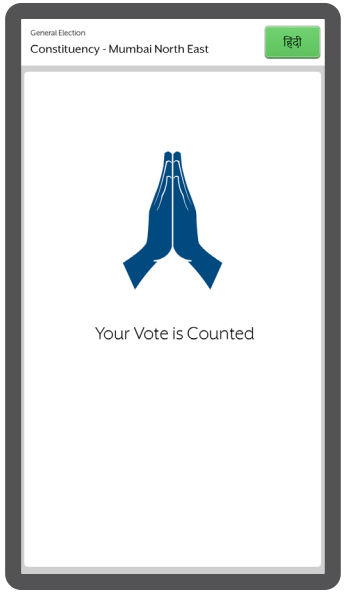
The visual feedback on the screen is tried out graphically, by animation and by text to make the voter feel confident that their vote has been recorded.

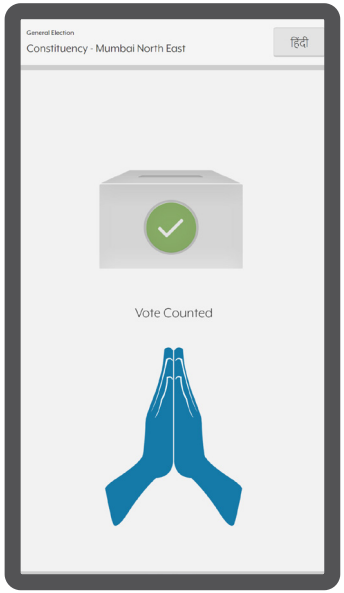
The “namaste” graphics with closed hands symbolizing “thank you” is tried out in flat style and in skeuomorphic style. An animation of the ballot slip falling into the ballot box signifying the old paper ballot system as metaphor is also tried out.

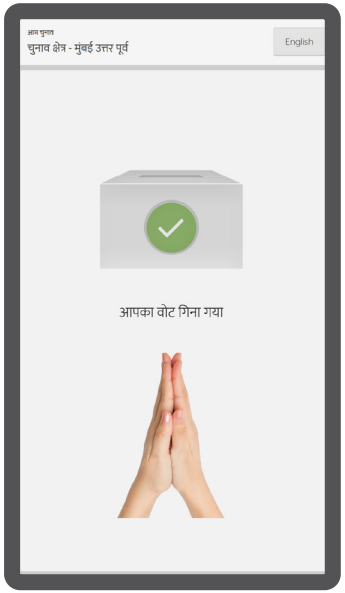
The elements of the selected candidate is shown as the vote recorded feedback in one of the options. It was avoided in the other screen so that user would check the printed slip coming out of the paper audit unit attached under the ballot unit.

This screen is also accompanied by a musical tone signifying that the vote is recorded by the machine and that your vote counts.









6.2. Final design and working prototype for ballot unit :

From the mock-up designs tried out, after applying the feedbacks, three options of the ballot unit interface designs were finalized to be evaluated. The designs are named A, B and C.

Design A and Design B has differences in layout and positioning. Where as Design B and Design C has differences in design style applied. One is more towards flat design and the other is towards skeuomorphism.

To make the working prototype, a 360^{0} flip laptop with touch screen and 15 inch display was used in portrait mode. The designs were developed using the following pipeline :

HTML - CSS - Jquery - PHP - MariaDB - XAMPP apache server

The prototype has the capability to cast the vote for a selected candidate as per the above mentioned procedures and record them in the MariaDB database. The results could be retrieved from the database in the result section of ballot unit, once the polling process gets over.

The green slip sealed around the machine represents the physical security protocol check, signed by the party agents as discussed in the previous chapters.



Touch screen ballot unit placed on a slanting acrylic base.

Design A : with Hindi ballot



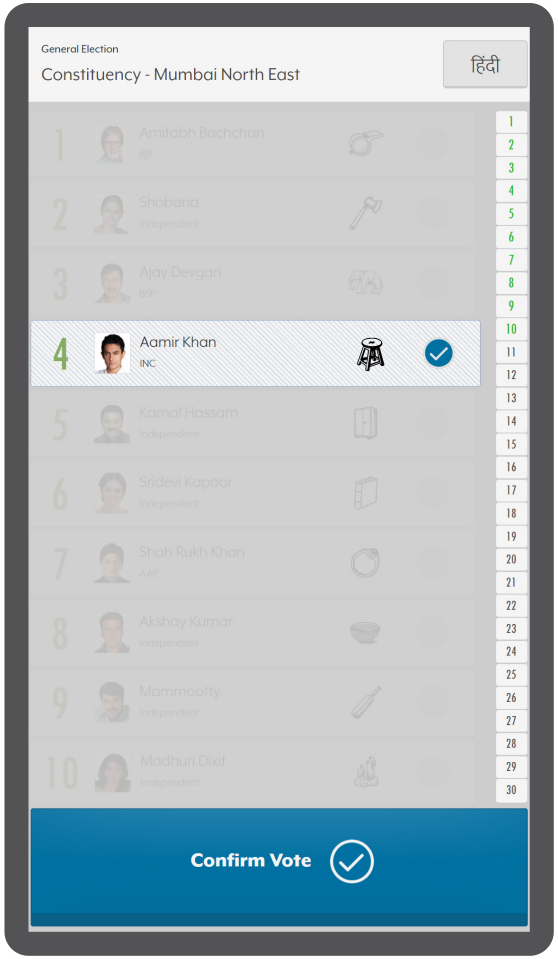
Design A is made for Hindi and English languages and a **vertical scroll layout** is tried out. There are 3 ways for viewing the candidates. One is by dragging the scroll bar on right, or by sliding the list view to scroll down or by pressing the down arrow to view the next set of 10 candidates. The scroll bar with the whole serial number in background and the down arrow acts as signifier to make the voter scroll down to view all the other candidates not in the default view.

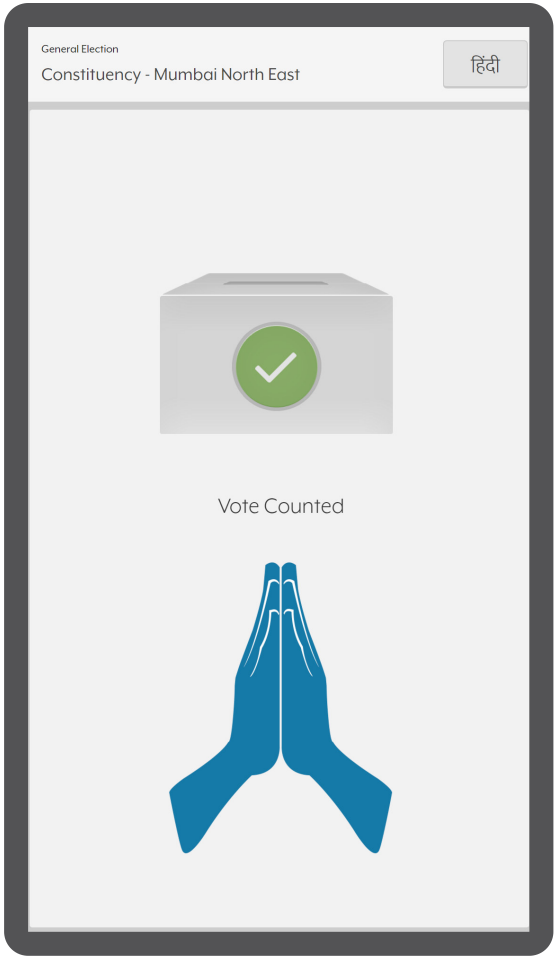
In Design A the **confirm button is placed statically at bottom** of the layout always to finalize the vote. To cancel the selection or go back, one has to press anywhere on the gray area or selected item or the serial numbers.

Overall a **flat graphic style** is incorporated in Design A. Like the hand graphics in the feedback screen being an abstraction.
To toggle the language, “English” button needs to be pressed.

Design A : with English ballot







Design B : with Hindi ballot



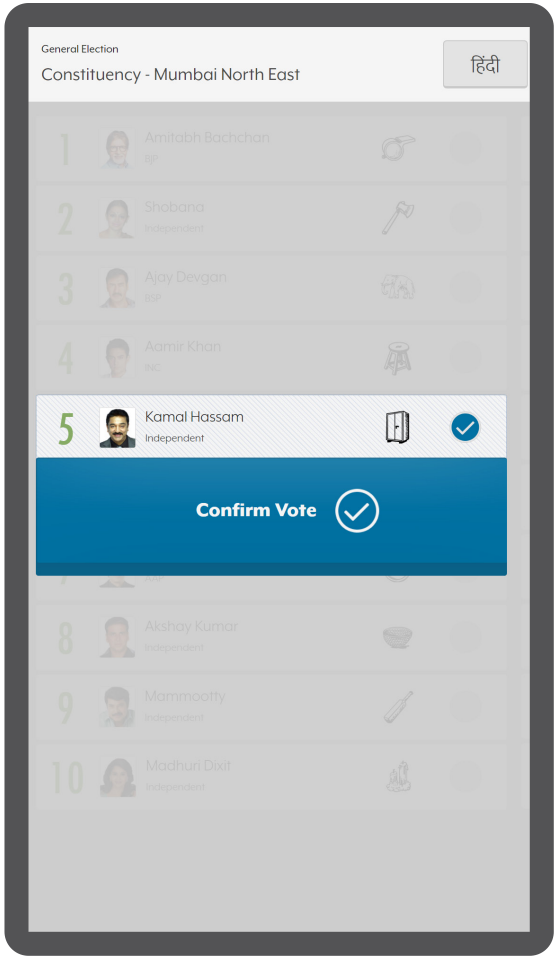
Design B is made for Hindi and English languages and a **Horizontal scroll layout** is tried out. There are 3 ways for viewing the candidates. One is by pressing the green arrow button, or by sliding the list view side wise like a page or by pressing the number set buttons to view the candidates in sets of 10.

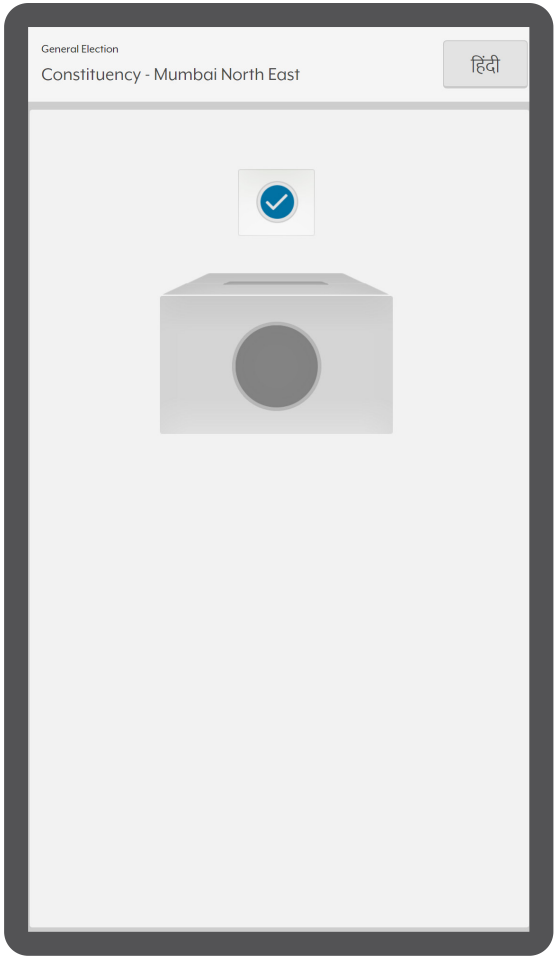
In Design B the **confirm button is placed dynamically below the selected candidate** to finalize the vote. To cancel the selection or go back, one has to press anywhere on the gray area or selected item or the serial numbers.

Overall a **flat graphic style** is incorporated also in Design B. To toggle the language, “English” button needs to be pressed.

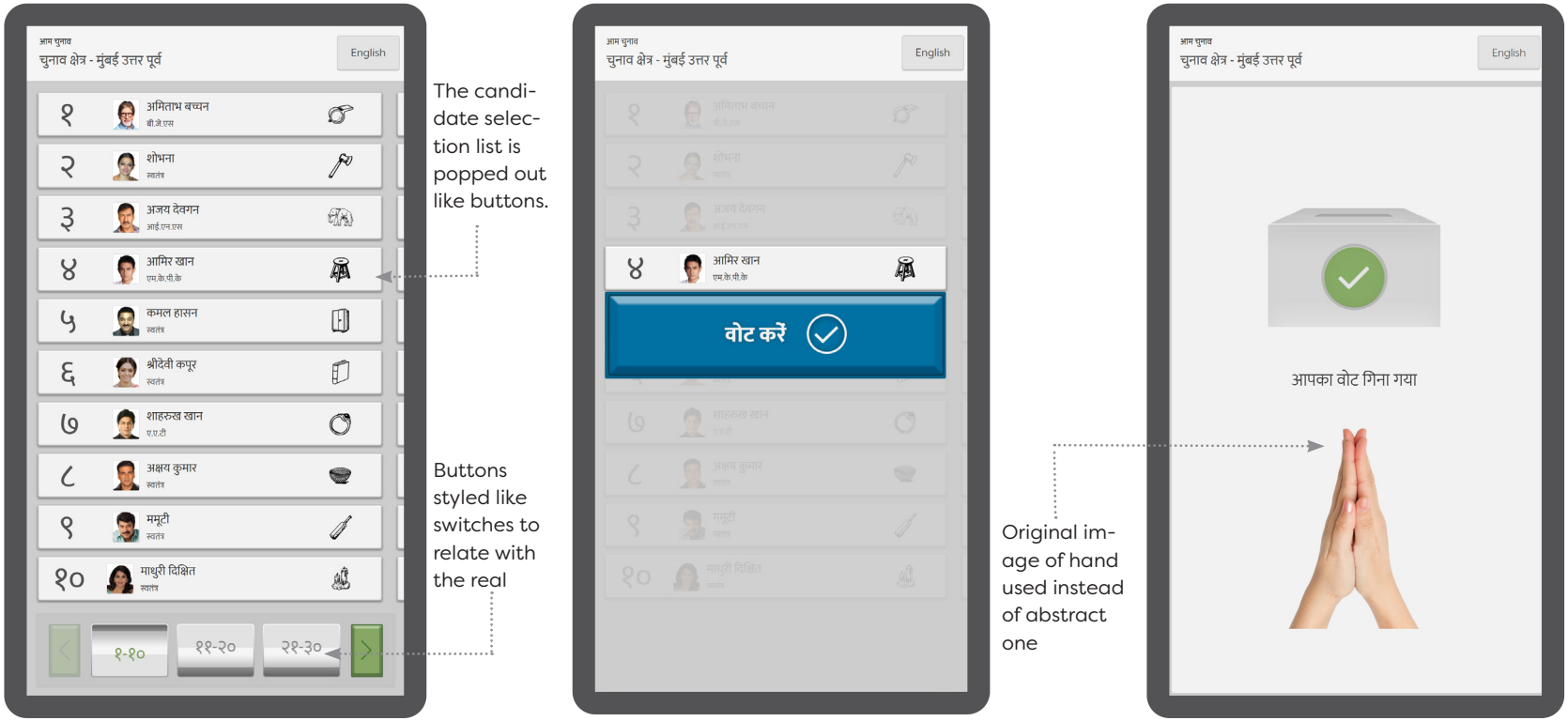
Design B : with English ballot







Design C : with Hindi ballot



Design C is made for Hindi and English languages and a **Horizontal scroll layout** is tried out similar to the Design B tried out previously and the **confirm button is also placed dynamically below the selected candidate.**

The major difference in Design C comparing Design B is the graphic style used for the elements in the user interface.
A **skeuomorphic style** was incorporated in the design. The buttons in the design resemble closely to the real life and a original image of the hand in the feedback screen is used instead of an abstraction.

The reason for creating these 3 design layouts was to do a user testing and evaluate which design is more intuitive and balances the cognitive effort required to perform the task of voting.

7. Evaluation

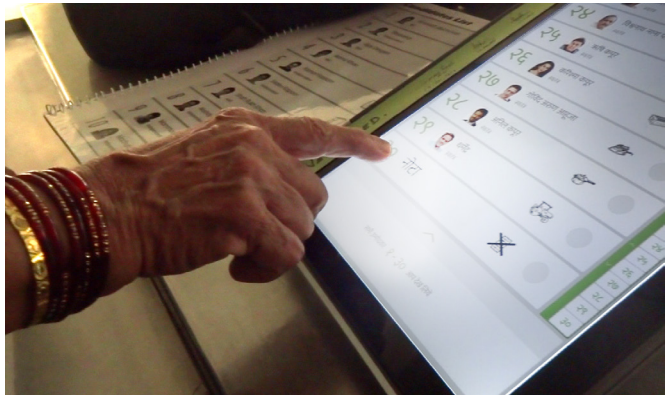
7.1. Evaluation Protocol

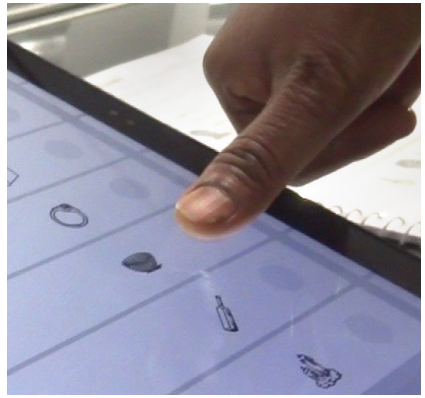
The three design options were evaluated by making different profile of people to vote by creating a mock election setup. Before showing the ballot unit, the printed candidates list was shown to the voters to choose their candidate. This was necessary because in the real scenario, the voter needs to choose the candidate in mind before entering the polling booth to reduce time taken to think and vote inside the pooling booth.

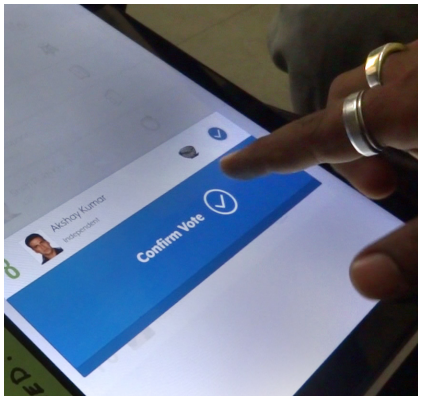
All the voters were show all the 3 design options. 1/3rd of the them where shown Design A first, and the others where shown screen B and C respectively to randomize the influences of viewing order. Think aloud tests where conducted and their feedback were taken simultaneously. A Google form was created to record the feedback and analyze the result. The questions which were asked during the evaluation session are given in the next section along with the results.

Evaluation count – 27 people

The profile of people who were made to vote is discussed in the next section.





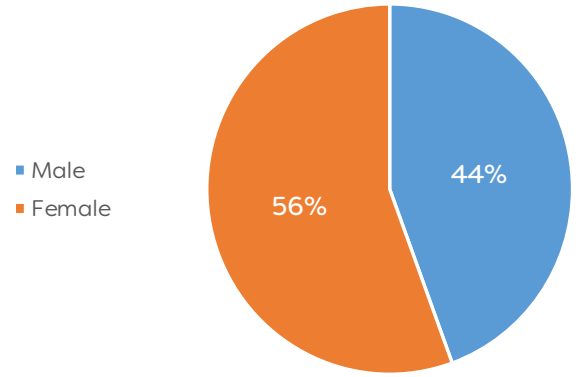




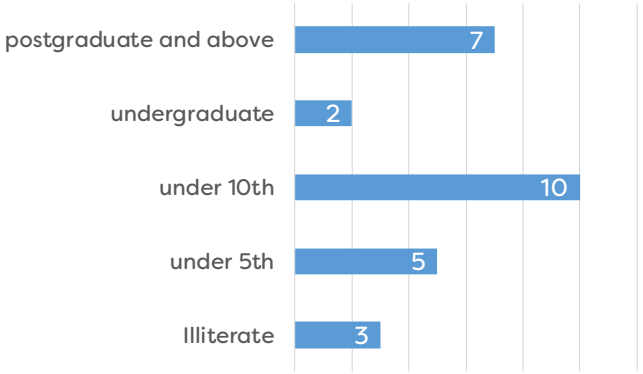
7.2. Profile of people used for evaluation

The profile of **27 people** who used the ballot unit and cast their vote are as follows -

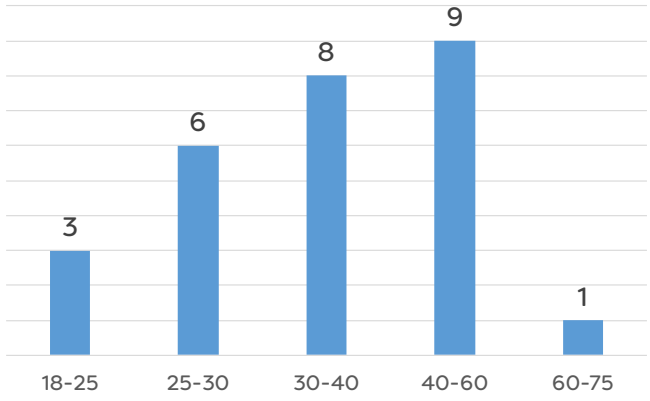
Gender



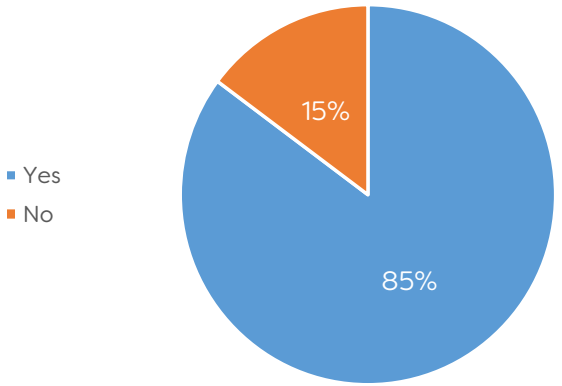
Educational qualification



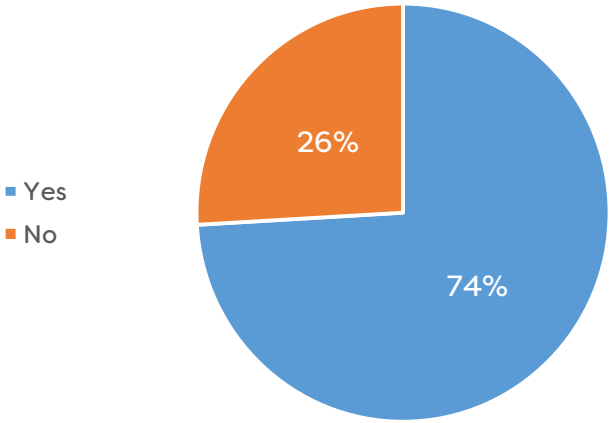
Age



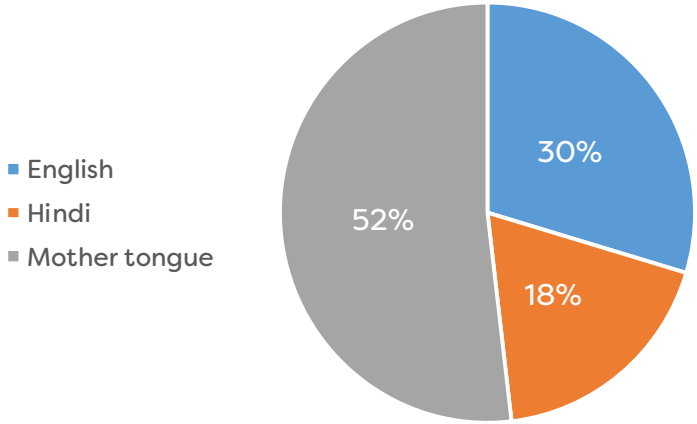
Have you voted before ?



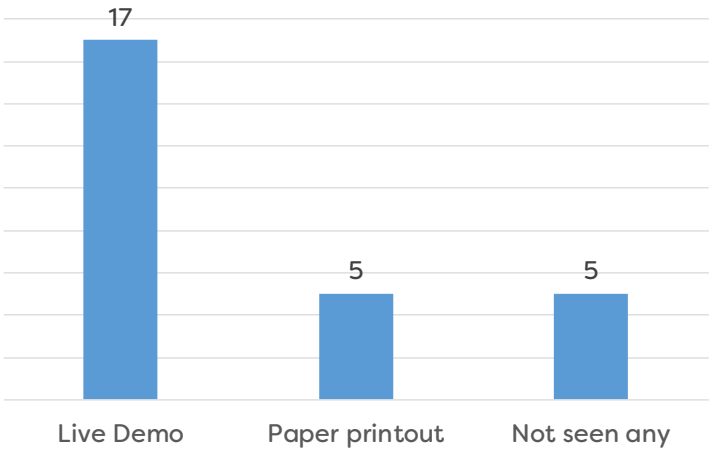
Have you used touch screen display before ?



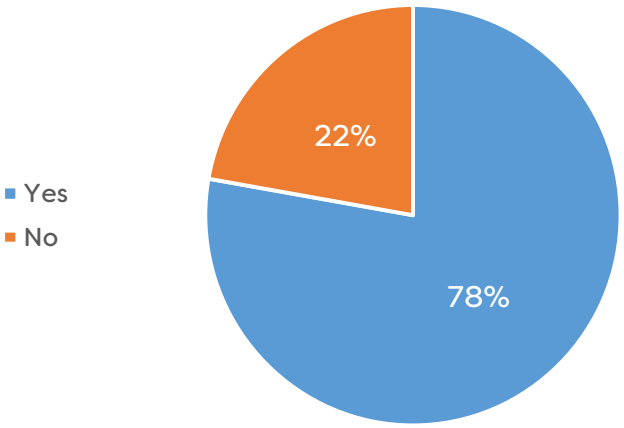
In which language you prefer to vote ?



Seen demo on paper/video on how to vote ?



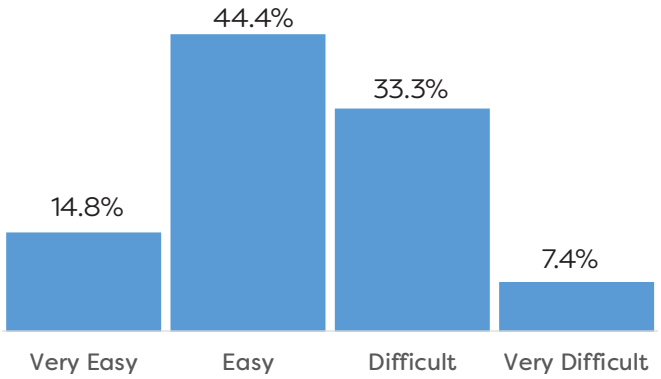
Did you understand Hindi numbers ?



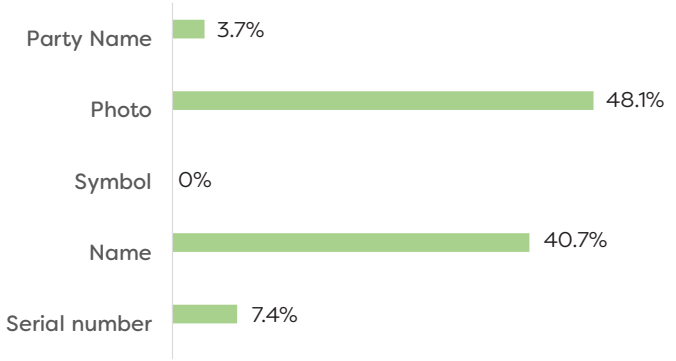
7.3. Results

The following are the evaluation results plotted from the excel sheets created from Google forms -

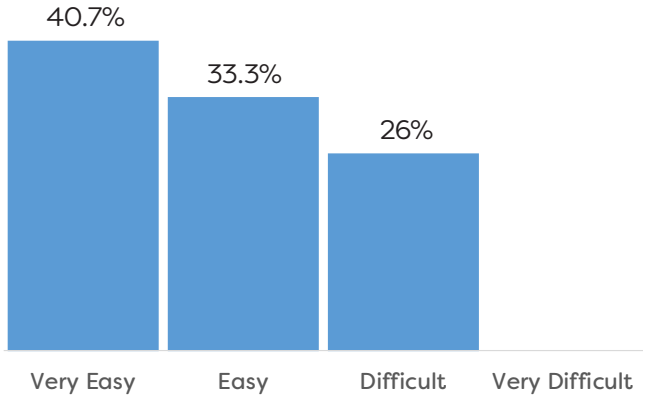
How was your experience finding the candidate of your choice, as per [Navigation] ?



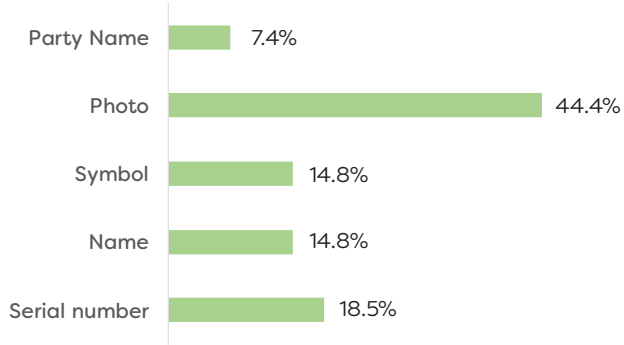
Which one of these did you "first" look at to find your candidate ?



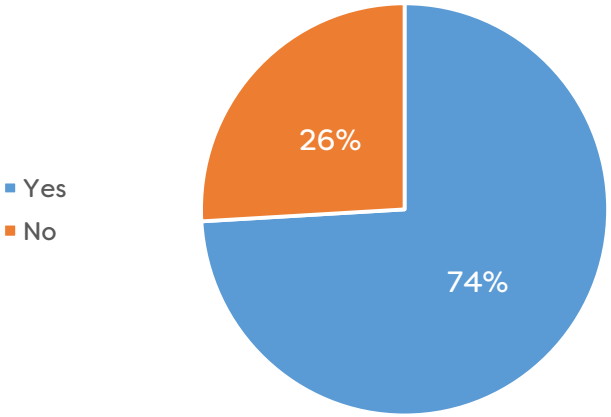
How was your experience finding the candidate of your choice, as per [Legibility / font size] ?



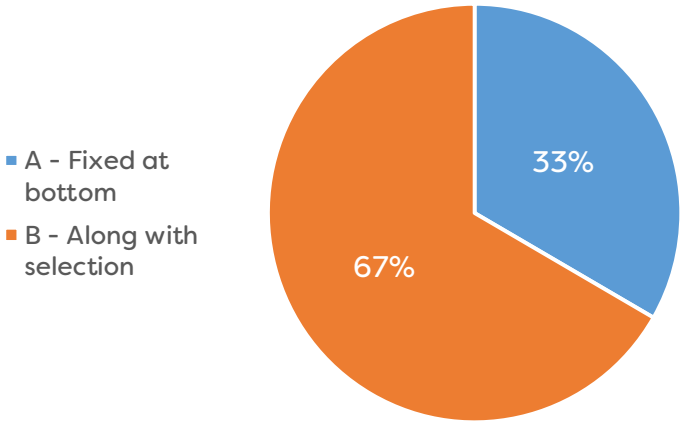
Which one of these did you "Second" look at to find your candidate ?



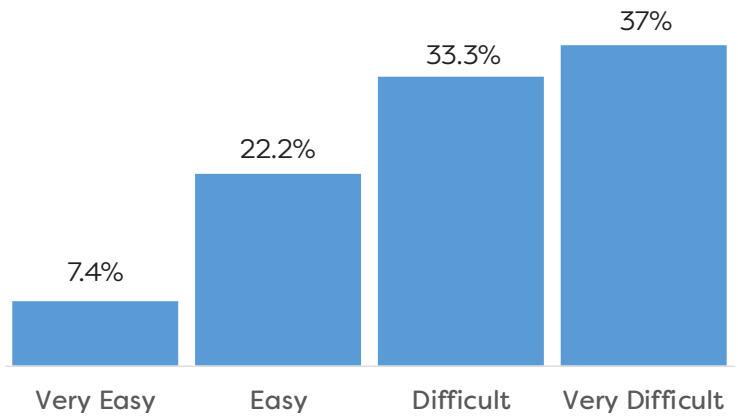
Was the option to undo the selection of candidate necessary?



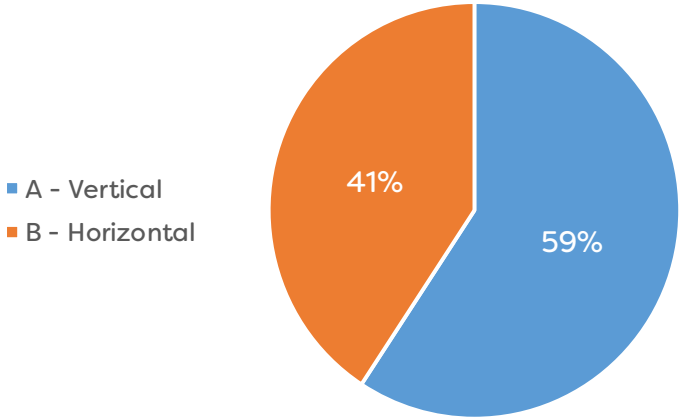
Which layout you liked comparing A and B with respect to [Placement of confirm button] ?



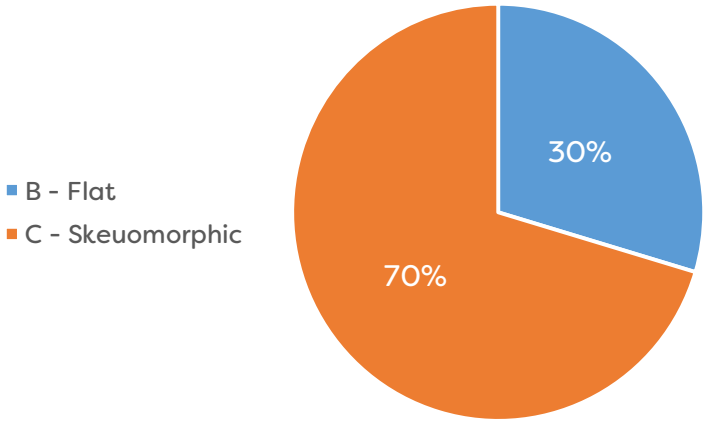
How easy was it to undo the selection and select another candidate?



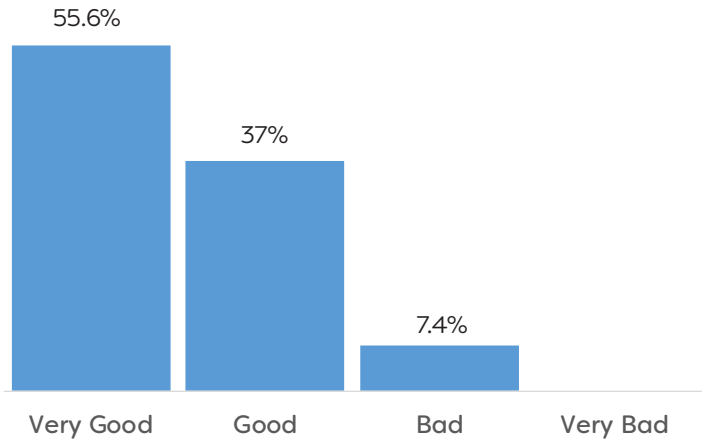
Which layout you liked comparing A and B with respect to [Horizontal and vertical scroll] ?



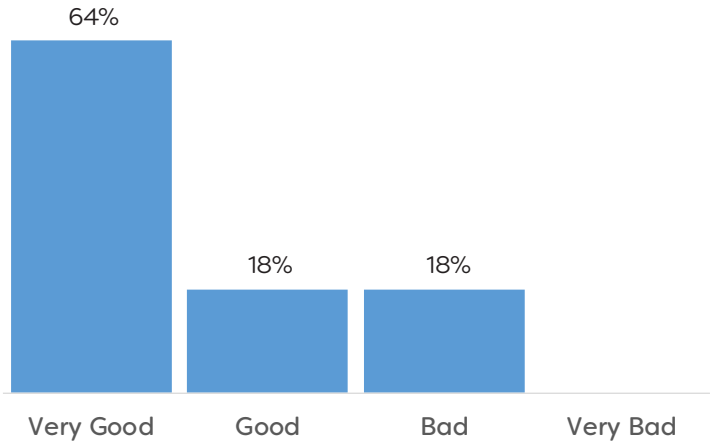
Which layout you liked comparing B and C with respect to [Skeuomorphic and Flat design] ?



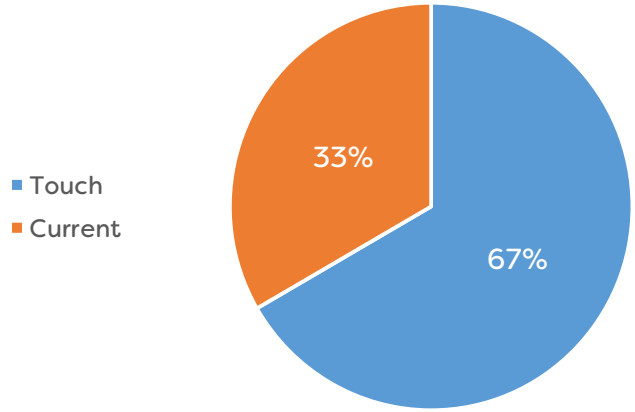
How was the final vote confirmed screen with respect to feedback for your cast vote? [Thank you screen] ?



Was the audio feedback intuitive? [Sounds]



If given a current voting machine and this touch screen voting machine to vote, which one would you prefer?



8. Feedback and insights

Other feedback from users :

- The option to undo the selection of candidate and go back to the candidates list is not clear. A back button might be required in the second confirmation screen.

- The design and technology looks clean and updated. “Acha diktha hein”(looks good in hindi). This made some users to believe that if the screen looks good, the system would also be done well. The animation and “namaste” in the feedback screen reinforces the reliability of the system to voters and gives them confidence that their vote is accounted for the election.

- The two step process of first selecting the candidate and then pressing the confirm button is not intuitive unless prior instruction are given.

- In the horizontal scroll design layout the fast next 10 candidate access buttons are not noticed much. Mostly arrows are used.

- Reduce the opacity of the arrow buttons to reveal the candidates list underneath, to make the voters know that more candidates are available to select from the list.

- The touch screen ballot unit needs to be kept away from window or any light source, as the screen reflects and the candidate details are blurred.

- Zoom-in the elements of candidate after selection so that the details can be viewed better before pressing the confirm button.

Insights :

- People where welcoming an upgrade in the voting machine saying that “things around us like ATM and mobile phone are touch screen, so this also could be”.

- With respect to the graphic design guidelines, the skeuomorphic design was welcomed by 70 % of the users even though the design was exaggerated a bit.

- 74% of the users preferred a two step process of confirming the vote, stating that they had made wrong vote earlier during elections.

- Since 48% of people first looked for photo of the candidate and then the name and only 14% looked at the symbol that too at the second time, we can even start thinking of giving more prominence to color photo of the candidate rather than symbol for illiterate.

- Only around 60% of the voters found the navigation of candidates list as easy, the others found it difficult. Most wanted a back button visually to navigate from confirm screen to the candidates list screen.

- Around 67% of voters opted for a confirm button placed dynamically below the selected candidate. But there was no clear preference between a horizontal and vertical layout for the candidates list and hence further study is required to take a decision.

- Voice over navigation as a separate interface for illiterate voters also can be pushed as per the voters choice.

9. Conclusion and Future work

The evaluation of the ballot unit suggest that people are welcoming an upgrade in the voting machine and improvements could be noticed in terms of the usability and accessibility of the ballot unit from the evaluation results. The major improvements being the ability of voters to re-select their candidate selection and have a better visual feedback on the vote recording process, which reinforces confidence that their vote is accounted. The touch screen interface also paves way for accessibility improvement for the visually and physically challenged voters.

Keeping in mind the future of elections in India, it would be a good idea to train the voters with the touch screen digital system because, if there is a possibility of incorporating a new electoral system in future with complex procedures like rank based voting, which could be implemented only in screen based virtual display units, this proposed system could act as a smooth transition.

But to touch upon the improvements on tamparability, security and reliability of the system, each component of the proposed system needs to be designed in detail and evaluated individually and as a whole to judge effectively.

Future work :

- The ballot unit interface for visually and physically challenged on a touch screen display has to be designed.
- The ballot unit setup interface for populating the candidates list has to be designed in detail.
- The result counting interface and the aggregator interface has to be designed.
- Prototype for rest of the components as proposed in the new voting system has to be developed to evaluate the effectiveness of improvements compared to the existing system.

10. References

1. Books -

[1] The Politics of Electoral Systems - Michael Gallagher, Paul Mitchell.

[2] IDEAs(Institue of Democracy and electoral assistance) - Handbook of Electoral system design.

[3] IDEAs - Electronic voting essential considerations.

2. Papers and Articles -

[4] Adaptation and sustainability of electronic voting and the mitigation of tamperability - Franklin Kumassah.

[5] Fingerprint Recognition Based Electronic Voting Machine - Shanu Agrawal, Pradeep Majhi, Vipin Yadav.

[6] Security Analysis of India's Electronic Voting Machines - J. Alex Halderman, Hari K. Prasad, Rop Gonggrijp.

[7] Interpreting Babel: Classifying Electronic Voting Systems - Joshua Franklin, Jessica C. Myers.

3. Online links -

[8] http://tnsec.tn.nic.in/elections/elections.html

[9] http://indianpoliticsprimer.blogspot.in/2011/07/basic-structure-of-indian-government.html

[10] https://www.quora.com/How-are-Rajya-Sabha-members-elected-2

[11] http://www.bbc.com/news/magazine-32421086

[12] http://www.tnrd.gov.in/index.html

[13] https://www.quora.com/How-different-and-similar-are-the-presidential-and-parliamentary-government-systems-and-what-should-they-understand-about-each-other

[14] http://www.ndtv.com/india-news/all-about-rajya-sabha-elections-explained-with-up-example-1417902

[15] http://www.elections.in/

[16] https://en.wikipedia.org/wiki/Voter-veried_paper_audit_trail

[17] http://www.cfp2004.org/program/materials/p12-shamos.pdf

[18] http://www.thehindu.com/news/national/tamil-nadu/vvpat-saves-the-day/article8622987.ece

[19] Indian EVM - https://www.youtube.com/watch?v=46I_3jWRx2s

[20] Punch card voting - https://www.youtube.com/watch?v=z-Pwrx8-yi8

[21] Arduino punch card reader - https://www.youtube.com/watch?v=6auO8djKRrM

[22] Lever voting machine - https://www.youtube.com/watch?v=6iphiBpgZBM

[23] Behind the Freedom Curtain" 1957 Automatic Voting Machine - https://www.youtube.com/watch?v=_GYdJAoHm-E

[24] India's EVMs are Vulnerable to Fraud - https://www.youtube.com/watch?v=ZlCOj1dElDY

[25] Mobile phone election Estonia- https://www.youtube.com/watch?v=iit5WdLYwns

[26] Rocker paddle interface - https://www.youtube.com/watch?v=SkrggCa3Ggs

[27] Sip and puff interface - https://www.youtube.com/watch?v=7sRi-Ur_Jxw8

All the images used from Fig-3 till Fig-54 in this report are taken from the above mentioned links as an image or screenshot of video.

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