

Can we Solve the Issues with eVoting Systems?

Danny De Cock
K.U.Leuven ESAT/COSIC

Slides available from <http://godot.be/slides>

Outline

- Introduction
 - Classification of eVoting systems
- Analysis
 - Issues with current eVoting systems
- Use case – eVoting in Belgium
 - Historical context
 - Currently used eVoting system
 - Proposed solution 😊

Different views...

- Connectivity
 - Online
 - Voting server keeps the score
 - Voting server receives voting ballots
 - Offline
 - Controlled environment
 - Non-controlled environment
- Transparency
 - Voter can/cannot check voting ballot correctness
 - Observer can/cannot check voting ballot correctness
- Auditability
 - Voter can/cannot audit election
 - Observer can/cannot audit election
- Secrecy
 - Voter is the only person knowing the vote 😊

Mechanisms to Cast a Vote

- Uncontrolled environment
 - Pencil + paper
 - Postal vote
 - Electronically
 - Internet voting
- Controlled environment
 - Pencil + paper
 - Voting booths
 - Electronically
 - Offline voting machines
 - With voting ballot
 - Without voting ballot – Direct Recording Equipment (DRE)
 - With or without (paper) trail
 - Networked voting machines
 - With or without trail

Issues – Trustworthiness

- Voting system =
 - Technology + People + Processes
- Paranoia:
 - Does the technology function correctly?
 - Did the voting officials validate the configuration?
 - Is the vote correctly recorded?
 - Is the vote correctly counted?
 - Is the election result correct?
 - Did independent auditors validate the elections?
- Pop quiz:
 - Why would a voting system reflect the voter's choice?

Use case – eVoting in Belgium

- Historical context
- Interesting things to know
- Requirements for (Belgian) Voting Systems
- Current and Future eVoting Systems

History of eVoting in Belgium

- Introduced in 1991, pilots in 1994, large scale deployment in 1999, currently 44% coverage
- Standalone voting computers – not networked
 - Impossible to cast invalid vote – only valid or blank
 - Open-source software
- Voter uses light pen to select candidates
- Voting ballot encoded on magnetic stripe card
 - Ballot secrecy & integrity through cryptography

Interesting Things to Know (ITK) 😊

- Different voting channels
 - Belgian citizens abroad
 - Postal vote, paper ballot
 - Voting booth in polling stations
 - Vote by proxy in polling stations
 - Belgians and other citizens in Belgium
 - Paper voting ballot
 - Voting booth for Belgian citizens in polling station
 - Vote by proxy in polling station
 - Online/Internet
- Ballot types
 - Paper ballots
 - Counted manually or automatically
 - Electronic ballots
 - Cast in voting booth
 - Cast online

Interesting Things to Know (ITK) 😊

- Voting is mandatory in Belgium
 - Everyone strictly older than 17 **must** go to the polling station
 - Sanctions & Fines with respect to ignored voting duty:
 - Police court rules, no appeal possible
 - First offender: 50 Euro
 - Second offense: 125 Euro
 - 4 offenses in less than 15 years: 10 years revocation of
 - Voting rights
 - Right to become a civil servant
 - Possibility to get a promotion or distinction as a civil servant
- 7 Election types → 7 Paper ballot forms 😊
 - European, Federal (Chamber + Senate), Provincial, Regional, Communal, Local Council

Requirements for (Belgian) Voting Systems

- Universal
 - Everybody can cast a vote
- Equal
 - Everybody has just one vote
- Freedom
 - Everybody can cast his/her vote of his/her choice
- Secrecy
 - Only the voter knows who he has voted for
- Transparency
 - All procedures are simple, publicly available and known
- Verifiability
 - Voting and counting systems are verifiable

Requirements for Belgian eVoting Systems

- Be combinable with classic paper voting system
- Be usable in the Belgian context
 - Cf. 7 election types, complex ballots...
- Not too expensive
- Available at all times
- Modular & flexible
 - Different voting systems may be used in one canton
 - Installable in voting offices and voting booths
- Customizable
 - List of elections, candidates & parties varies per election
- Easy to verify
 - Correct casting of votes, 1 voter = 1 ballot
 - Correct counting of votes
 - Secrecy of the vote
- Encourage the automated processing of votes
 - Automated casting of votes is less important
- Be very easy to use (user friendliness, simple,...)
- Be very accessible/attractive to
 - Non-computer literate people, elderly, disabled people,...



Belgium's Voting systems of Today and Tomorrow

- Paper + Pencil
- Current System (Magnetic Stripe Cards)
- Improved Paper-based Voting

Paper + Pencil

- Cheap
- Simple
 - Everybody understands how it works
 - Not everybody understand potential problems...
- Invalid votes
- Unclear voting ballot marks
- Physical traces on paper: finger prints, scratches, stains,...
- In practice
 - Size of voting ballot in some cantons
 - Preparation, printing and distribution of ballots
 - Counting is cumbersome and slow

Classic Electronic Voting Booth



Observations wrt the Magnetic Stripe Cards System

- How to convince a voter that the magnetic stripe card corresponds with the voter's choice?
 - Voting computer may have stored a different ballot
- How to convince a voter that his/her vote is read from the magnetic stripe?
 - Voting urn may have overwritten the magnetic stripe

Organizational and procedural measures
neutralize these potential issues

Key Arguments to Introduce New System

- Hardware of “current” system is outdated
 - Supply issues
- Countering issues with magnetic stripe cards
- Dependable and verifiable marking of candidates
 - Voter can verify voting ballot
- Secure transport of voting ballots
 - Protection against eavesdropping and modification of ballot storage and transmission
- Counting votes: accurate and fast
 - No need for manual counting
 - Support for recounting
 - Manual audit

Future eVoting Booth Components 😊



printer



Senate Election	Climate Election	European Election	Provision Election	Regional Election	Local Election
1. First Name	11. First Name	21. First Name	31. First Name	41. First Name	51. First Name
2. Second Name	12. Second Name	22. Second Name	32. Second Name	42. Second Name	52. Second Name
3. Third Name	13. Third Name	23. Third Name	33. Third Name	43. Third Name	53. Third Name
4. Fourth Name	14. Fourth Name	24. Fourth Name	34. Fourth Name	44. Fourth Name	54. Fourth Name
5. Fifth Name	15. Fifth Name	25. Fifth Name	35. Fifth Name	45. Fifth Name	55. Fifth Name
6. Sixth Name	16. Sixth Name	26. Sixth Name	36. Sixth Name	46. Sixth Name	56. Sixth Name
7. Seventh Name	17. Seventh Name	27. Seventh Name	37. Seventh Name	47. Seventh Name	57. Seventh Name
8. Eighth Name	18. Eighth Name	28. Eighth Name	38. Eighth Name	48. Eighth Name	58. Eighth Name
9. Ninth Name	19. Ninth Name	29. Ninth Name	39. Ninth Name	49. Ninth Name	59. Ninth Name
10. Tenth Name	20. Tenth Name	30. Tenth Name	40. Tenth Name	50. Tenth Name	60. Tenth Name
11. Eleventh Name	21. Eleventh Name	31. Eleventh Name	41. Eleventh Name	51. Eleventh Name	61. Eleventh Name
12. Twelfth Name	22. Twelfth Name	32. Twelfth Name	42. Twelfth Name	52. Twelfth Name	62. Twelfth Name
13. Thirteenth Name	23. Thirteenth Name	33. Thirteenth Name	43. Thirteenth Name	53. Thirteenth Name	63. Thirteenth Name
14. Fourteenth Name	24. Fourteenth Name	34. Fourteenth Name	44. Fourteenth Name	54. Fourteenth Name	64. Fourteenth Name
15. Fifteenth Name	25. Fifteenth Name	35. Fifteenth Name	45. Fifteenth Name	55. Fifteenth Name	65. Fifteenth Name
16. Sixteenth Name	26. Sixteenth Name	36. Sixteenth Name	46. Sixteenth Name	56. Sixteenth Name	66. Sixteenth Name
17. Seventeenth Name	27. Seventeenth Name	37. Seventeenth Name	47. Seventeenth Name	57. Seventeenth Name	67. Seventeenth Name
18. Eighteenth Name	28. Eighteenth Name	38. Eighteenth Name	48. Eighteenth Name	58. Eighteenth Name	68. Eighteenth Name
19. Nineteenth Name	29. Nineteenth Name	39. Nineteenth Name	49. Nineteenth Name	59. Nineteenth Name	69. Nineteenth Name
20. Twentieth Name	30. Twentieth Name	40. Twentieth Name	50. Twentieth Name	60. Twentieth Name	70. Twentieth Name



chip card reader




optional interface for visually challenged



mini PC


Example of a Voting Ballot of the Future ☺



Cast In Leuven

Senate Election Selected Party	Chamber Election Selected Party	European Election Selected Party	Province Election Selected Party	Region Election Selected Party	Local Election Selected Party
1. First Name	14. First Name	27. First Name	40. First Name	53. First Name	66. First Name
2. Second Name	15. Second Name	28. Second Name	41. Second Name	54. Second Name	67. Second Name
3. Third Name	16. Third Name	29. Third Name	42. Third Name	55. Third Name	68. Third Name
4. Fourth Name	17. Fourth Name	30. Fourth Name	43. Fourth Name	56. Fourth Name	69. Fourth Name
5. Fifth Name	18. Fifth Name	31. Fifth Name	44. Fifth Name	57. Fifth Name	70. Fifth Name
6. Sixth Name	19. Sixth Name	32. Sixth Name	45. Sixth Name	58. Sixth Name	71. Sixth Name
7. Seventh Name	20. Seventh Name	33. Seventh Name	46. Seventh Name	59. Seventh Name	72. Seventh Name
8. Eighth Name	21. Eighth Name	34. Eighth Name	47. Eighth Name	60. Eighth Name	73. Eighth Name
9. Ninth Name	22. Ninth Name	35. Ninth Name	48. Ninth Name	61. Ninth Name	74. Ninth Name
10. Tenth Name	23. Tenth Name	36. Tenth Name	49. Tenth Name	62. Tenth Name	75. Tenth Name
11. Eleventh Name	24. Eleventh Name	37. Eleventh Name	50. Eleventh Name	63. Eleventh Name	76. Eleventh Name
12. Twelfth Name	25. Twelfth Name	38. Twelfth Name	51. Twelfth Name	64. Twelfth Name	77. Twelfth Name
13. Thirteenth Name	26. Thirteenth Name	39. Thirteenth Name	52. Thirteenth Name	65. Thirteenth Name	78. Thirteenth Name

check and fold this ballot
 Vouw eerst hier – Fold here first – Pliez d'abord ici – Zuerst hier falten




Cast In Leuven

Vouw daarna hier – Second fold here

Pliez ensuite ici – Anschließend hier falten

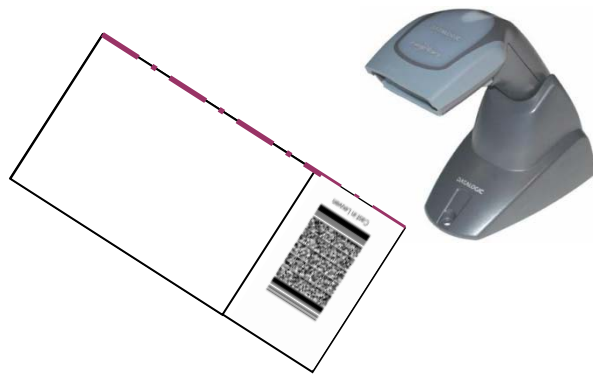
check and fold this ballot



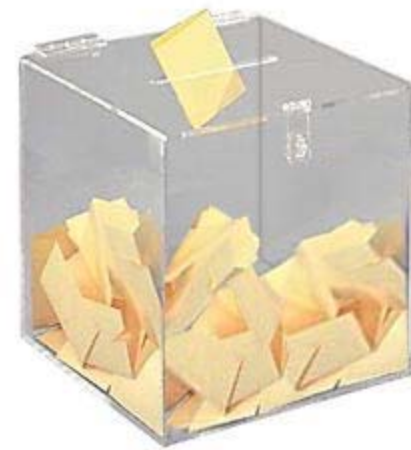
Cast In Leuven

Vouw daarna hier – Second fold here

Future Voting Office's Equipment



Ballot Verifier



Ballot Box

© George Patton Associates, Inc.

Voter's Secrecy

- Belgian election system is 'vulnerable' to pattern-based voting
 - Avoid manual processing of ballots
- Voter's fingerprints or marks on paper based ballots
- Cameras in mobile phones, cf. vote selling
- Miniaturized cameras in voting office or booth
- Electromagnetic radiation (TEMPEST)
 - Perfect protection is complicated and expensive
 - Adequate protection is feasible

ITK – Representation of a Voting Ballot

- Candidates are numbered
- Large voting ballot is represented electronically in two-layered menus:
 - Party Menu
 - Voter selects his/her party
 - Candidates Menu per party
 - Number of candidates determines the number of columns
 - Voter selects candidates or list

ITK – Casting a Valid Vote

- Number of elected seats equals number of List votes + number of votes of main candidates + number of votes of successors
- Number of list votes influences the number of elected candidates per list
- A ballot is rendered invalid if a voter ticks candidates of more than one list

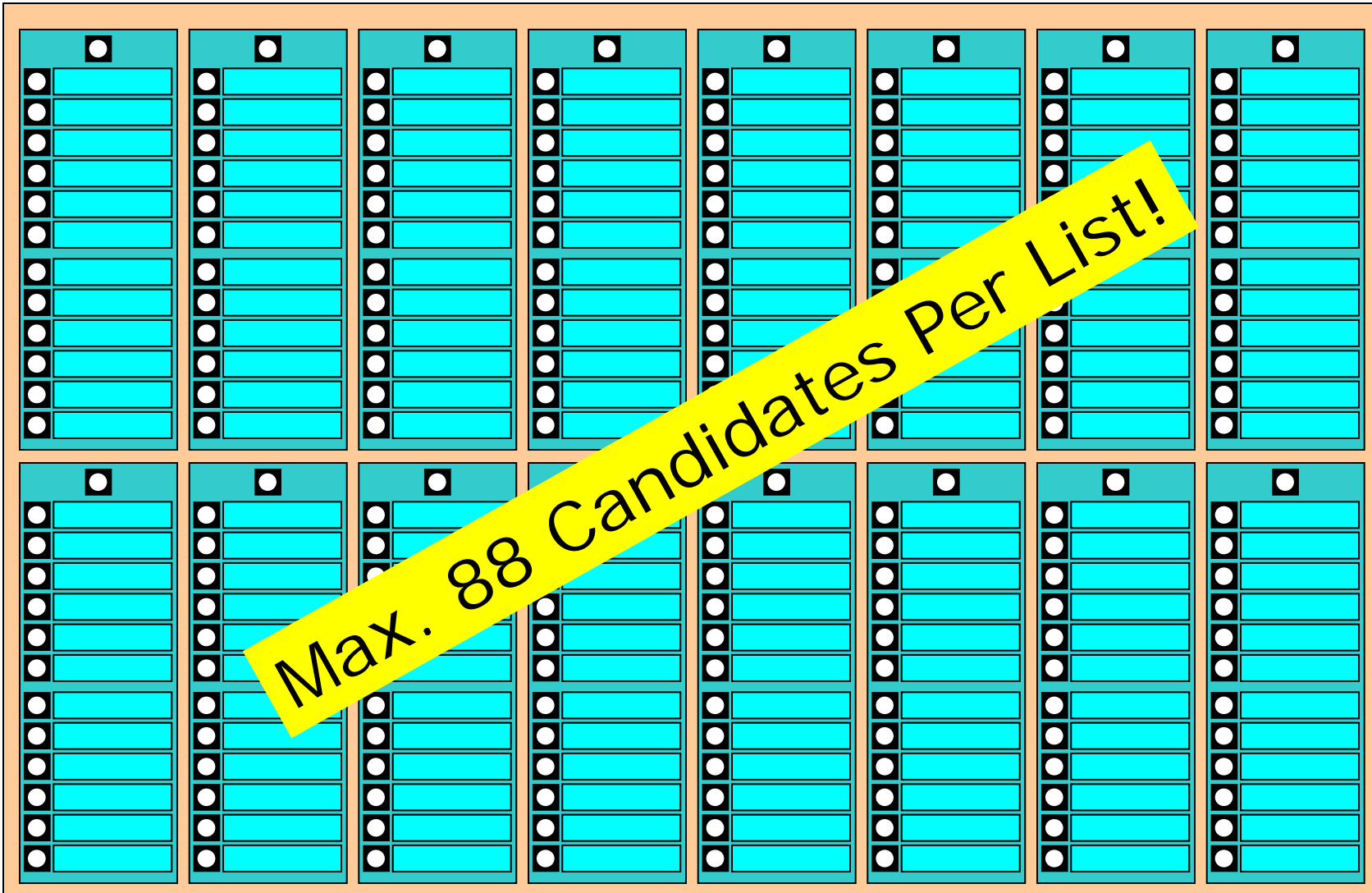
The diagram shows a vertical ballot interface. At the top is a large white circle inside a black square. Below it is a list of candidates, each with a white circle checkbox on the left and a cyan rectangular box on the right. The candidates are numbered 1 through 29, with ellipses (...) between 3 and 4, and between 6 and 7. The list is divided into three sections by horizontal lines: the first section contains candidates 1-4, the second contains candidates 5-6, and the third contains candidates 7-29.

- } Voter can tick List Vote
- } Voter can also tick any number of main candidates
- } Voter can also tick any number of successors

1 Voting Ballot per Election (Chamber, Senate, Regional, European Parliament,...)

Easily 1 meter

Easily 0.5 meter



Electronic Representation of a Voting Ballot

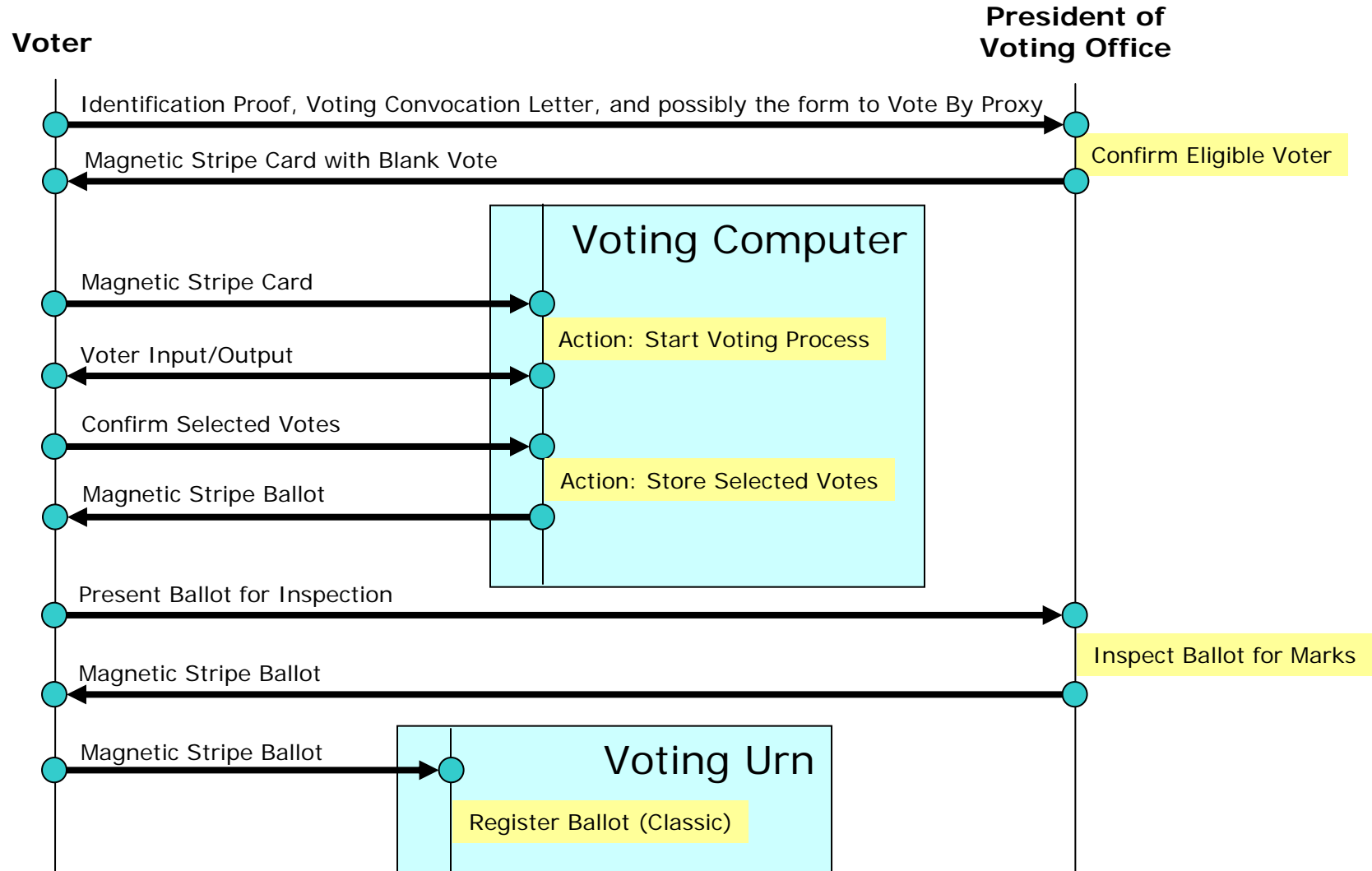
- Candidates are numbered
- Large voting ballot is represented electronically in two menus:
 - Party menu
 - Voter selects his/her party
 - Candidates Menu per party
 - Number of candidates determines the number of columns
 - Voter selects candidates or list
- Note:
 - It is impossible to cast an invalid electronic voting ballot
 - Voter can vote blank by choosing the “Blank party”

Voting in Practice – Voters cast their vote at a Polling Place

Facts:

1. Voters living in a municipality cast their vote in a voting office
2. Each voting office has a list with eligible voters
3. Each voting office has one voting urn to collect completed voting ballots
4. A voting ballot consists either of a paper ballot or of a magnetic stripe card
5. Election period = 1 Sunday, starting at 9.00
 1. Offices using paper ballots close at 13.00
 2. Offices using magnetic stripe cards close at 15.00

Voting Procedure – Magnetic Stripe Ballots



Voting in Practice – Voters cast their Magnetic Stripe Ballot at a Polling Place

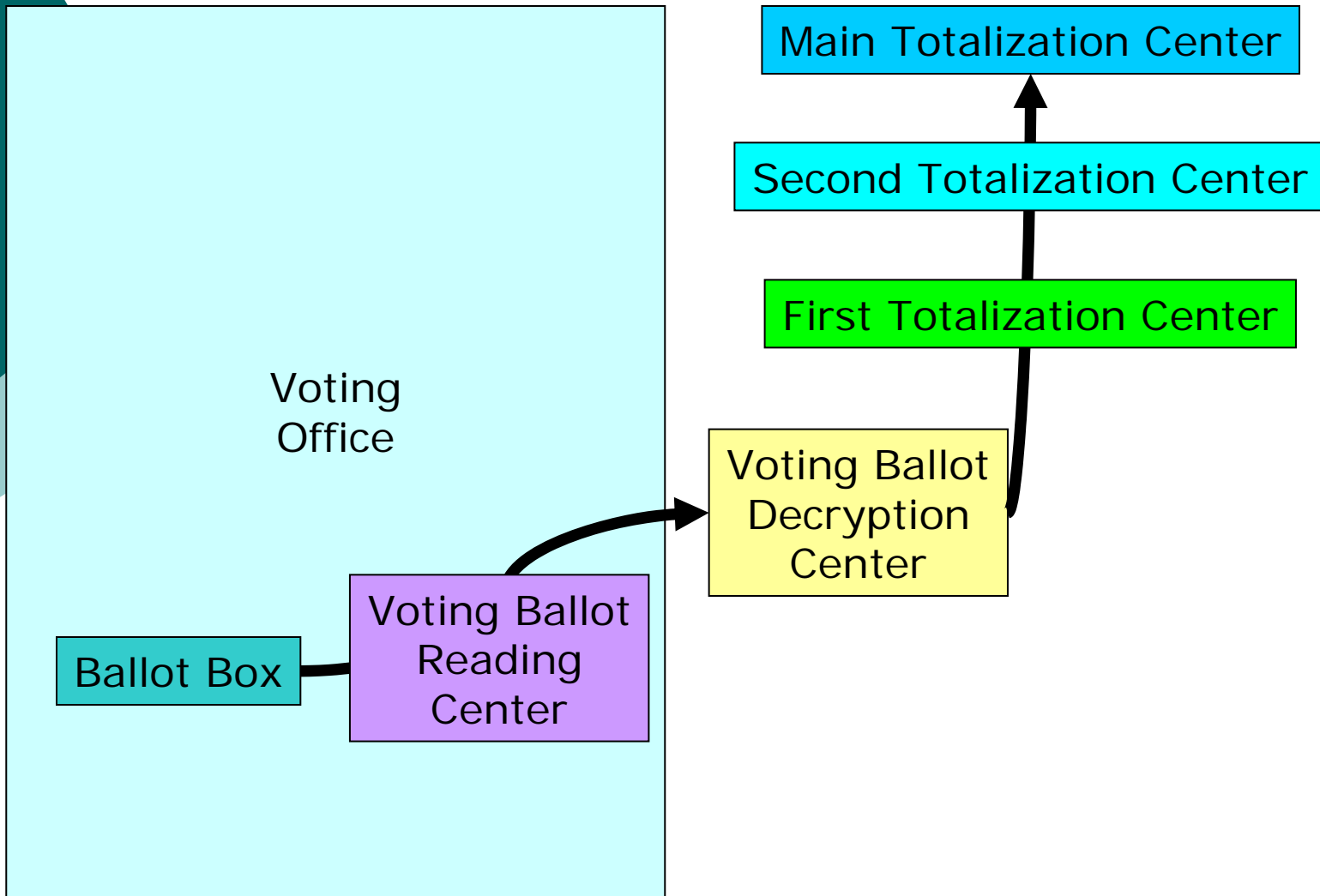
Procedure:

1. Voting officials seal an empty voting urn before first voter arrives
2. Administration broadcasts invitation cards by paper mail to all Belgian citizens who are 18 or older on the Election Day
3. Voter hands over the identity card and invitation card to the voting officials
 - Officials verify identity of the voter
 - Officials check whether the voter is listed on their list with eligible voters
4. Voter receives voting ballot or magnetic stripe card from voting officials
5. Voter casts his/her vote in the voting booth
 - If voter makes a mistake, the president of the voting office may decide to give the voter a second chance
6. Voting official verifies whether the voter did not put a mark on the ballot or magnetic stripe card
 - Marked ballots are invalid
7. Voter inserts the ballot or magnetic stripe card in the voting urn
8. Voting officials stamp the invitation letter to confirm that the voter completed his/her duty
9. Voting officials return identity card and invitation card to voter

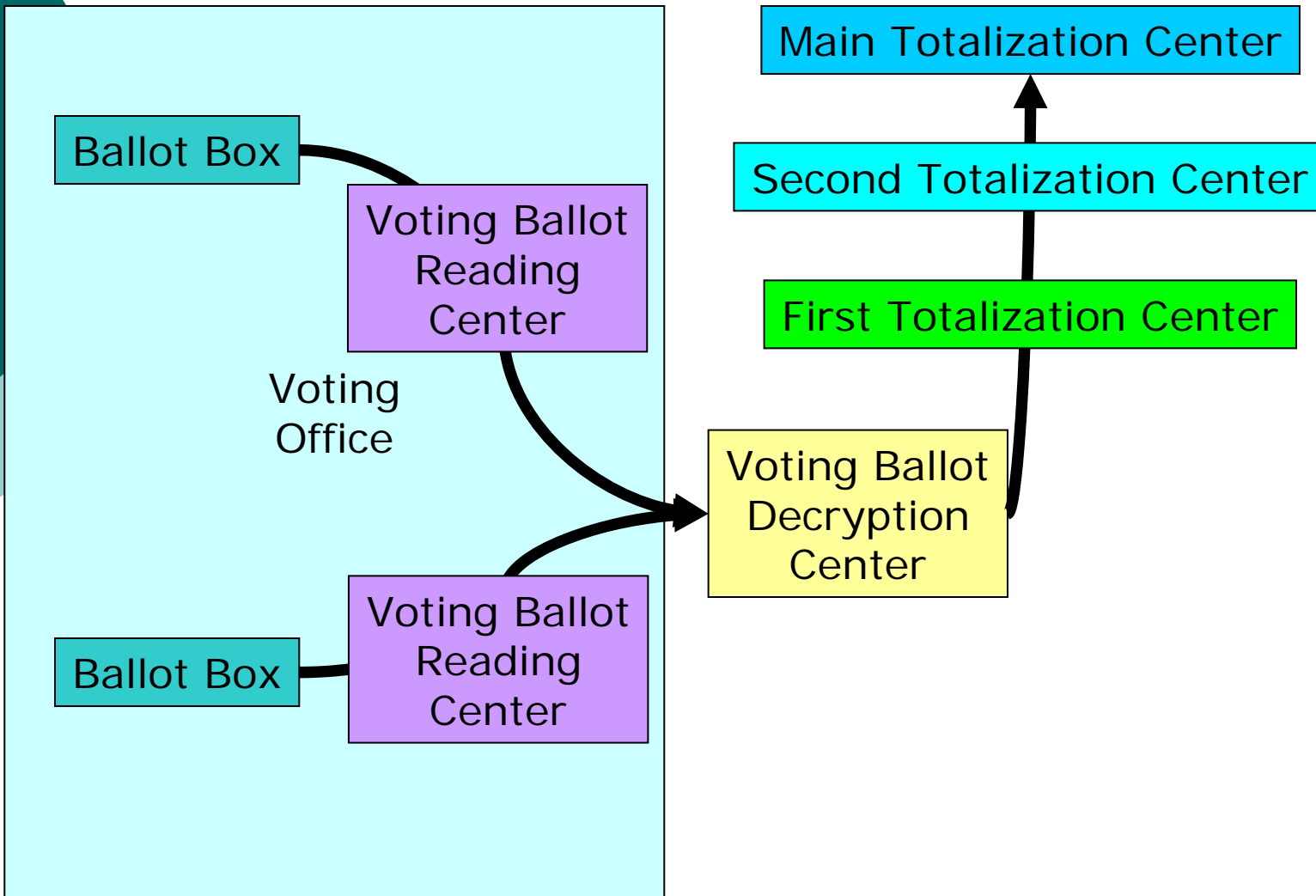
Counting the Magnetic Stripe Ballots

- Paper ballots
 - Seal of the voting urn is removed at the end of the Election Day, e.g., around 14.00
 - Talliers keep tallying at voting office-level until they count twice the same result
- Magnetic stripe cards
 - Voting urn reads magnetic stripe card ballot immediately
 - PC controlling voting urn keeps the score on a floppy
 - All floppies of voting offices are aggregated per municipality at the end of the Election Day
 - Seal of the voting urn with magnetic stripe cards is only removed when recounting is necessary

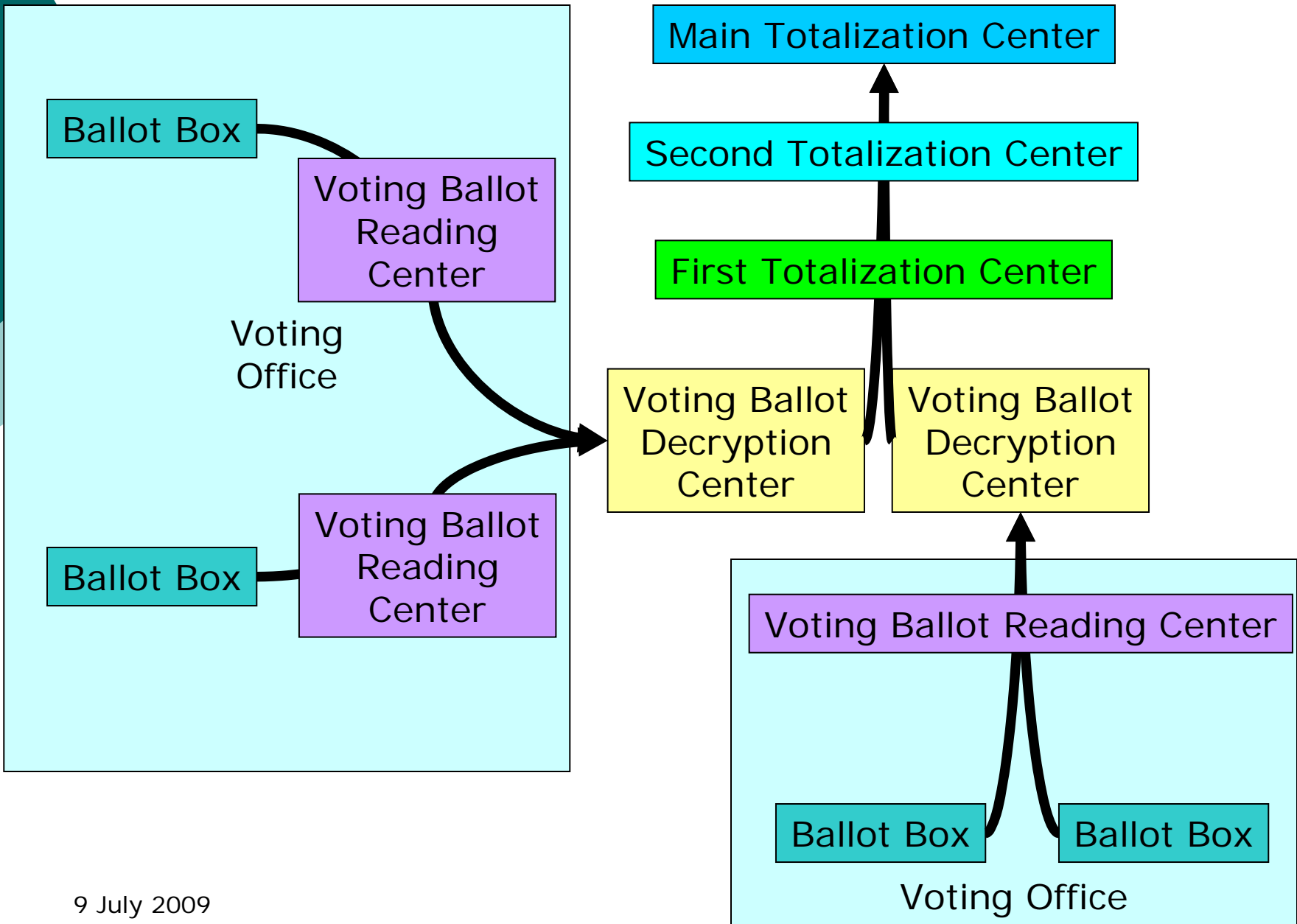
Counting New Voting Ballots



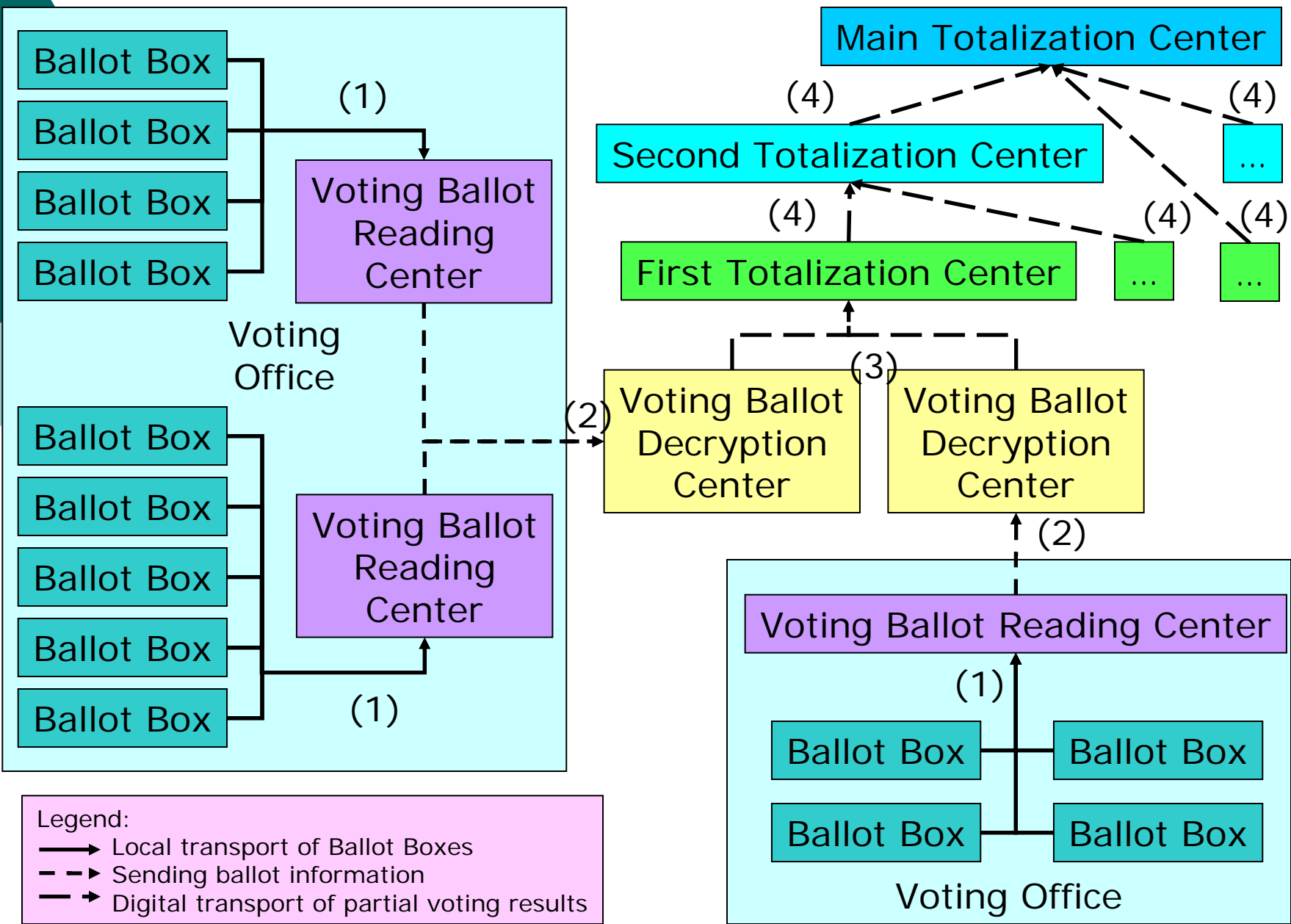
Counting New Voting Ballots



Counting New Voting Ballots



Counting New Voting Ballots



Proposed System

- During Election Day
 - Vote cast using voting machine
 - Machine prints voter's ballot (paper trail)
 - Voter validates correctness of voting ballot
 - Voter folds voting ballot
 - Ballot is entered in the voting urn
- End of Election Day
 1. All voting ballots are registered using Reading Center
 2. Decryption of each individual voting ballot
 3. Totalization of decrypted voting ballots
 4. Publication of Election Result

Proposed eVoting system vs. Requirements

- Ok
 - Be combinable with classic paper voting system
 - Be usable in the Belgian context, cf. 7 election types
 - Available at all times
 - Modular & flexible
 - Customizable
 - Easy to verify
 - Correct counting of votes
 - Encourage the automated processing of votes
 - Automated casting of votes is less important
- Mostly
 - Be very easy to use (user friendliness, simple,...)
 - Be very accessible/attractive to
 - Non-computer literate people, elderly, disabled people,...
 - Easy to verify
 - Secrecy of the vote
 - Correct casting of votes, 1 voter = 1 ballot
- Failed
 - Not too expensive

Questions?

- Email:

- Danny.DeCock@esat.kuleuven.be
- godot@godot.be

- Homepage:

- <http://godot.be>

- Slides:

- <http://godot.be/slides>

Electing the Dead 😊

- If a candidate dies after closing the candidate list but before printing the paper ballots
 - The list does not include the name of the deceased
- If a candidate dies before the Election Day
 - The deceased is treated as if he/she never existed
 - Votes for the deceased are taken into account to determine the number of voters for the candidate's list
- If a candidate dies on the Election Day or after the Election Day but before the official announcement of the Election Result
 - The deceased may be elected, but the first successor takes his seat
- If a candidate dies after the official announcement of the Election Result
 - The deceased is replaced by the first successor

Operational Aspects

- D-80: Preparation of lists with eligible voters
- D-40: Independent experts can start auditing the Election procedure
- D-33: Publication of banned acronyms in Belgian Gazette
- D-30: Lottery to rank parties on voting ballots
- D-26: Publication of parties and their numbers in Belgian Gazette
- D-28: Deadline to submit election candidates
- D-24: Fixing lists with election candidates
- D-15: Publishing names of election witnesses, Mail broadcast of election convocation letters
- D-12: Appointing presidents and assistants of voting offices
- D-10: Mail broadcast of lists with eligible voters per voting office
- D- 5: Appointing election witnesses of voting & counting offices
- D- 3: Deadline of voting computer boot floppy delivery to president of cantonal headquarters
- D- 1: President of voting office receives voting ballots, distribution of computer boot floppies to presidents of voting offices
- D : Election day, processing voting ballots after closing election period
- D+15: End of the audit possibility of independent experts
- D+45: Publication of election results
- D+75: Finalization of election-related expenses