

05-04-2026

EaR Introduction



Elections and Referendums

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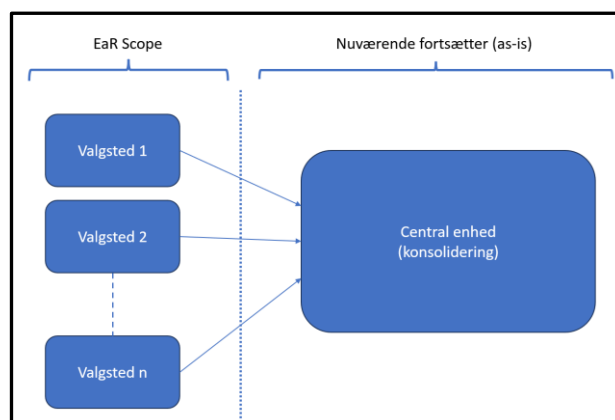
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2. Introduction

The purpose of this document is to provide an introduction to the EaR (Elections and Referendums) system. The system's sole purpose is to streamline the counting of votes at polling stations after the election process has ended. This streamlining addresses counting speed, correctness in counting and reporting of the polling stations' results to a central unit, which then carries out consolidated counting and possibly distribution of seats for several polling stations.

The EaR system can simultaneously handle several elections and election types, such as elections to the parliament, municipalities, regions, referendums (introduction of the Euro, abolition of the opt-out) and local referendums (e.g. 'stop for the Lynettholm construction'). The desired choices can be configured so that they are carried out in a coherent process for the citizen.

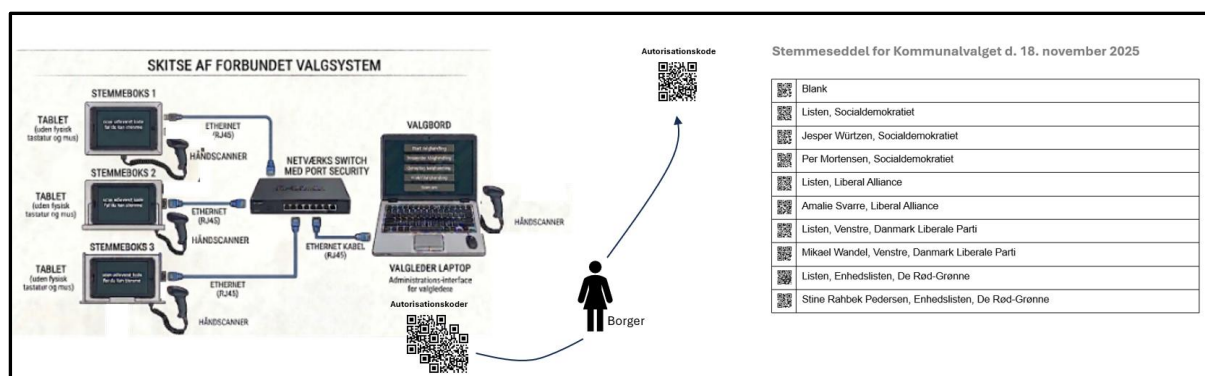
As outlined below, EaR only deals with election processing at the polling stations with structured reporting of results from each polling station, where a typical polling station's result can be counted and ready for reporting in less than a minute.



This document is primarily aimed at election authorities, including decision-makers, election managers, election officials and IT personnel in the state, municipalities and regions.

3. System Overview

From a user perspective, the system looks like this:



In the sketch above, the overall topology of EaR is shown on the left, where the system consists of a polling table from which the election process is controlled and a number of voting booths, in the example above there are three voting booths. Both the voting booths and the polling booth are all equipped with a hand scanner.

It is a key security element that the voting booths and the polling table all have disabled all wireless communication (WIFI, Bluetooth, NFC). The ballot boxes are therefore connected to the election table via a traditional network switch. It is recommended to use a network switch that supports 'Port Security'.

Port Security is a mechanism where you can lock a given port on the switch to a specific computer and where unused ports will be disabled.

The combination of Port Security and disabled wireless communication makes cyberattacks and other attacks from external networks more difficult.

The EaR system is based on citizens scanning QR codes, the interaction with the system's voice boxes is based solely on a hand scanner and a touch-sensitive screen where there is no mouse or keyboard connected.

Before each election, there is an external preparation process where the polling stations are sent a number of QR authorization codes as well as ballot papers that are relevant to the polling station (constituency). The ballot paper shows lists and candidates that can be voted for, but differs from traditional ballot papers in that the box for ticking is replaced by a QR code next to each candidate, which the citizen must scan to vote for the candidate in question.

The QR authorization codes are handed out to each citizen, while a ballot paper is hung in each voting booth. Each polling station therefore receives a number of QR authorization codes that match the number of citizens entitled to vote. In the same way, each polling station receives the number of ballot papers that matches the number of the polling station's digital voting booths.

This memorandum attempts to describe the structure and operation of the EaR system. As can be seen from the description, the EaR system is dependent on receiving QR authorization codes, ballot papers and is also dependent on proper handling of encryption keys and Excel passwords.

The main programme **EaR.exe** uses the following seven support programmes. These seven programmes are not further described in this note.

EarInitiator.exe, is the 'master' program that is installed on the Choice Master PC. It is this program that generates the encryption key and initiates the secure USB keys that are distributed to the polling stations.

keyMgr.exe that handles the secure distribution of encryption keys and Excel passwords. The program must be run from the FIPS-140 Level-3 certified USB dongle

setupEaR.exe, is a program that handles the installation and configuration procedure for election desks and voting booths.

QRGenerator.exe that generates and encrypts the desired number of QR authorization codes for a polling station.

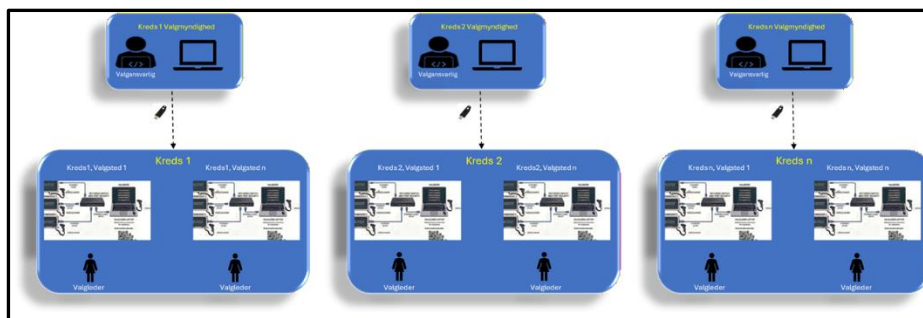
CandidateBuilder.exe, is a support program that forms ballot papers for polling stations.

zint.exe, is a freeware program that is part of Zint Barcode Studio that is used for program-driven creation of QR codes.

dhcpsrv.exe, a freeware default program (<https://www.dhcpserver.de/>) that installs on the selection table. This program is a standalone DHCP (Dynamic Host Configuration Protocol) program that ensures that ballot boxes at a polling station can be automatically assigned to network configuration without the need to be connected to an open network. dhcpsrv.exe is recommended because it is simple and free, there are other options.

4. Preparation of elections

Before an election, the various parties and candidates must be registered in the system. Each constituency is responsible for the constituency's setup. One can imagine a setup as outlined below.



The election manager is responsible for generating the required number of QR authorization codes for each polling station with the associated positive list.

The person responsible for each constituency is responsible for coordinating the individual parties, providing a list of candidates with the order of nomination or in order/alphabetically, as well as possibly a portrait photo of the candidates.

With the help of the Candidate Builder (CB.exe) support program, parties and candidates are registered in the EaR system. The election officer can choose to delegate CB.exe and thus the registration to the individual parties, and after registration, the registered candidates with a positive list are returned to the election officer, who enters this data into his version of EaR.exe.

The election officer must then use the program keyMgr.exe generate an encryption key and set up configuration parameters that are general for each polling station.

keyMgr.exe can only be run from a removable disk, where it is recommended to use a secure USB key, e.g. a USB stick.

https://www.kingston.com/datasheets/IKD500S_us.pdf

The USB stick contains necessary programs and data. After that, you are ready to configure the individual polling stations.

When each polling station is technically/hardware-wise, personnel from the election officer's office will visit the polling stations with the secure USB key and with the USB key initiate the polling booth as well as the number of voting booths available at the individual polling station. This is done simply by inserting the USB key and starting the program setupEar.exe first for the polling booth, then for each voting booth and then again for the polling booth.

This EaR.exe install on the polling booth and ballot boxes, copy various files with parameters and languages, and install the generated encryption key, encrypted under the TPM chip on the polling booth and the ballot boxes, respectively.

The procedure ensures that the polling table and voting booths can only communicate with each other.

5. Conduct of elections

5.1 Preparation

The polling table and voting booths are prepared with the installation of programs and configuration files that match the current election action. The configuration files include positive lists for QR authorization codes and for the candidates who can be voted for. When a citizen scans a QR code, the scanned code is checked against these lists.

It is recommended that the voting boxes are configured for wake-on-lan, which means that all voting boxes can be left off and automatically start up when they receive a command from the election table, each voting box should be configured to automatically start the EaR program at startup.

At startup, each voting booth will have a passive screen that shows the text 'the election action has not started':



5.2 Identification and Access

The citizen contacts the election table in the usual way and hands in his or her election card, after which the citizen is given a QR authorization code and is shown one of the digital voting booths. Here, the citizen must first scan the QR authorization code provided, which will also appear in the text on the voting booth screen. If the citizen mistakenly starts scanning a candidate, the EaR system will detect this and guide the citizen to first scan the QR authorization code provided.

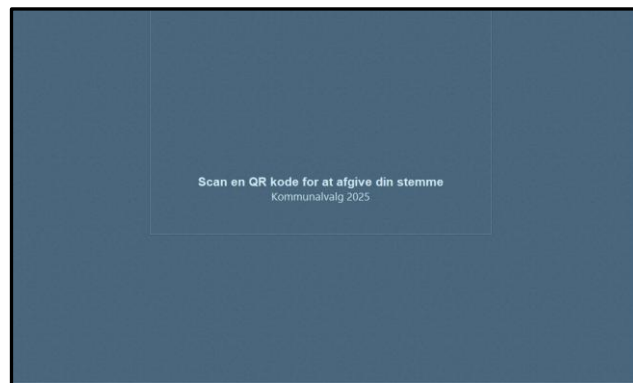
From the election table, a start command can be sent to all voting boxes, after which each voting box will show the text 'scan provided code before you can vote':



This means that the election process is active and citizens can vote.

5.3 Voting

When the QR authorization code has been scanned, the citizen is presented with this screen:



Then the citizen must scan the QR code on the ballot paper next to the desired election:

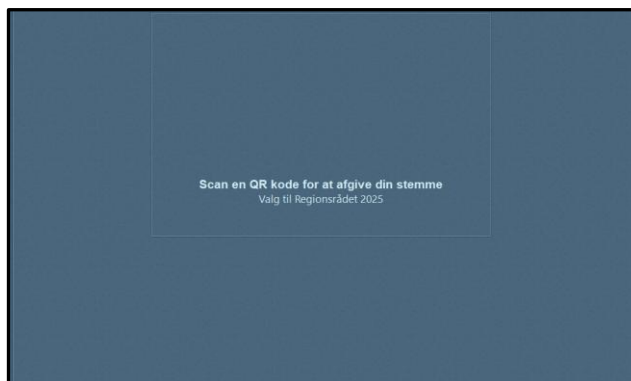
Stemmeseddel for Kommunalvalget d. 18. november 2025	
	Blank
	Listen, Socialdemokratiet
	Jesper Würtzen, Socialdemokratiet
	Per Mortensen, Socialdemokratiet
	Listen, Liberal Alliance
	Amalie Svarre, Liberal Alliance
	Listen, Venstre, Danmark Liberale Parti
	Mikael Wandel, Venstre, Danmark Liberale Parti
	Listen, Enhedslisten, De Rød-Grønne
	Stine Rahbek Pedersen, Enhedslisten, De Rød-Grønne

If the citizen wants to cast a list vote for the Social Democratic Party and scans the QR code next to the line with the text: 'The list, the Social Democratic Party' will now appear this screen for the citizen to confirm:

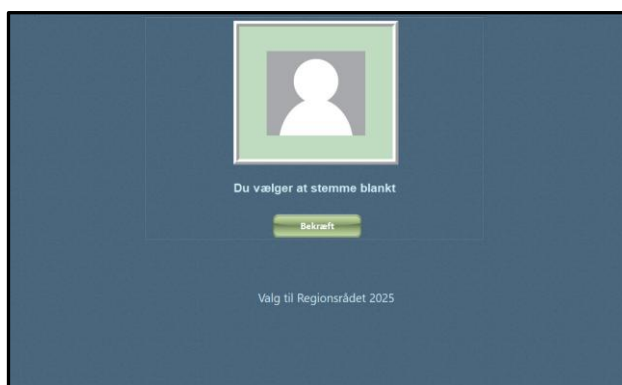


If the citizen at this time should change their mind, the citizen can simply scan a QR code next to the candidate who is desired instead - then a portrait photo of the candidate will appear with name and party, this choice the citizen can then confirm by pressing the green 'Confirm' button with his finger.

If the election process is configured to handle multiple elections, such as elections to the Regional Council, the EaR system will automatically proceed to this election action and present the citizen with this screen:



For the Regional Council election, the citizen scans the QR code next to 'Blank' and is presented with this screen:



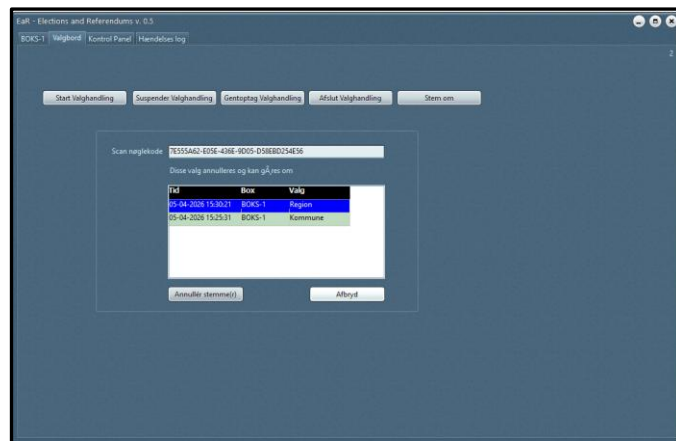
When the citizen confirms his or her blank voice, this screen is presented:



The citizen in question has now completed his or her election and can leave the voting booth. After a few seconds, the voting booth returns to its original state where it shows the text: 'scan the code before you can vote' and is thus ready for the next citizen

There may be situations where a citizen regrets his or her vote, in such a situation the citizen must contact the election table with his/her provided QR authorization code. The election officer can via a 'Vote About' function scan the citizen's QR authorization code, which will then show for which elections the citizen has voted, but not show what has

been voted. The election official can then cancel the votes for the QR authorization code:

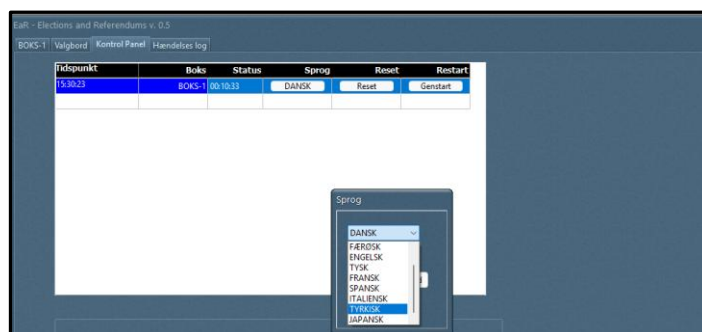


This cancels the votes shown above and the citizen can go back to the voting booth and use the QR authorization code provided again.

5.4 Status monitoring and language independence

Before a new citizen is allowed into the voting booth, an election official must check the status of the voting booth in question. If the previous citizen has left the voting booth without having cast one or more votes, the election official must scan his QR-Reset code, which 'resets' the voting booth in question. After this, the voting box will again show the text: 'scan the code before you can vote' and is thus ready for the next citizen.

If a citizen who has a different ethnic background cannot read and understand Danish, then you can change the language in a given voting booth from the voting table. E.g. into Turkish:



In this case, the citizen in the voting booth will then meet this screen:



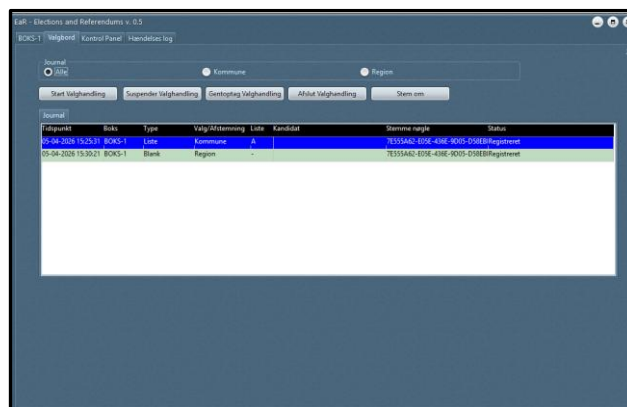
After the election process has been completed, the language will go back to being the default language, in this case Danish. If desired, it is possible to keep Turkish as the applicable language for the voting booth in question.

From the election table, it is also possible to close down a voting booth.

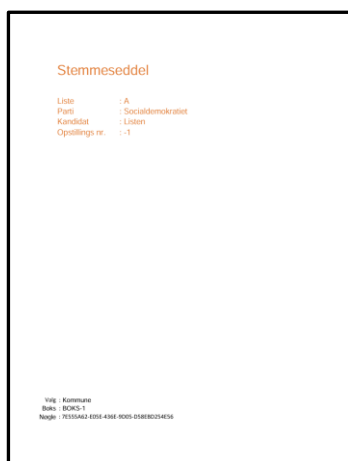
It should be mentioned that the election table basically has language files for Danish and English, it will not be difficult to construct language files for any language, and thus EaR is full language agnostic.

5.4 Finishing and counting

From the election table, the election manager can complete the election process and is then shown an overview of the votes cast, where you can immediately see the counts from the two elections 'Municipality' and 'Region':



In addition, EaR is designed to document the election results, partly by a leaflet on the desk showing ballot papers and screen printouts documentation for each individual vote cast:



Please note that at the bottom of both the ballot paper and the documenting screen print, there is an election stamp that shows the time, voting box and the QR authorization code. The construction of this stamp can be configured, so if you feel that the indication of time and voting booth may violate the citizen's anonymity, then you can simply state in the configuration file that it is only the QR authorization code that should be included.

In situations where a citizen has voted against, the cancelled votes are documented:

Stemmeseddel

Liste : A

Parti : Socialdemokratiet

Kandidat : Listen

Opstillings nr. : -1

Annuleret

Valg : Kommune

Boks : BOKS-1

Nøgle : 7E55A62-E05E-436E-9D05-D58EBD254E56

EaR also creates an Excel file, which is a journal of votes cast as well as Excel files for each election, which contain both a count of list and personal votes for the polling station in question. Below is an example of an Excel report.

Valg	Dato	Type	Status	Kandidat	Stemmeseddel	Resultat
1	2018-05-20 14:14:24	820-007	Permitteret	Kommune	0	Anders Mortensen
2	2018-05-20 14:14:24	820-007	Permitteret	Kommune	1	Mikael Brandt
3	2018-05-20 14:14:24	820-007	Permitteret	Kommune	1	Anders Mortensen
4	2018-05-20 14:14:24	820-007	Permitteret	Kommune	1	Anders Mortensen
5	2018-05-20 14:14:24	820-007	Permitteret	Kommune	1	Anders Mortensen
6	2018-05-20 14:14:24	820-007	Permitteret	Kommune	1	Anders Mortensen
7	2018-05-20 14:14:24	820-007	Permitteret	Kommune	1	Anders Mortensen
8	2018-05-20 14:14:24	820-007	Permitteret	Kommune	1	Anders Mortensen
9	2018-05-20 14:14:24	820-007	Permitteret	Kommune	1	Anders Mortensen
10	2018-05-20 14:14:24	820-007	Permitteret	Kommune	1	Anders Mortensen
11	2018-05-20 14:14:24	820-007	Permitteret	Kommune	1	Anders Mortensen
12	2018-05-20 14:14:24	820-007	Permitteret	Kommune	1	Anders Mortensen
13	2018-05-20 14:14:24	820-007	Permitteret	Kommune	1	Anders Mortensen
14	2018-05-20 14:14:24	820-007	Permitteret	Kommune	1	Anders Mortensen
15	2018-05-20 14:14:24	820-007	Permitteret	Kommune	1	Anders Mortensen
16	2018-05-20 14:14:24	820-007	Permitteret	Kommune	1	Anders Mortensen
17	2018-05-20 14:14:24	820-007	Permitteret	Kommune	1	Anders Mortensen
18	2018-05-20 14:14:24	820-007	Permitteret	Kommune	1	Anders Mortensen
19	2018-05-20 14:14:24	820-007	Permitteret	Kommune	1	Anders Mortensen
20	2018-05-20 14:14:24	820-007	Permitteret	Kommune	1	Anders Mortensen
21	2018-05-20 14:14:24	820-007	Permitteret	Kommune	1	Anders Mortensen
22	2018-05-20 14:14:24	820-007	Permitteret	Kommune	1	Anders Mortensen
23	2018-05-20 14:14:24	820-007	Permitteret	Kommune	1	Anders Mortensen
24	2018-05-20 14:14:24	820-007	Permitteret	Kommune	1	Anders Mortensen
25	2018-05-20 14:14:24	820-007	Permitteret	Kommune	1	Anders Mortensen
26	2018-05-20 14:14:24	820-007	Permitteret	Kommune	1	Anders Mortensen
27	2018-05-20 14:14:24	820-007	Permitteret	Kommune	1	Anders Mortensen
28	2018-05-20 14:14:24	820-007	Permitteret	Kommune	1	Anders Mortensen
29	2018-05-20 14:14:24	820-007	Permitteret	Kommune	1	Anders Mortensen
30	2018-05-20 14:14:24	820-007	Permitteret	Kommune	1	Anders Mortensen
31	2018-05-20 14:14:24	820-007	Permitteret	Kommune	1	Anders Mortensen
32	2018-05-20 14:14:24	820-007	Permitteret	Kommune	1	Anders Mortensen
33	2018-05-20 14:14:24	820-007	Permitteret	Kommune	1	Anders Mortensen
34	2018-05-20 14:14:24	820-007	Permitteret	Kommune	1	Anders Mortensen
35	2018-05-20 14:14:24	820-007	Permitteret	Kommune	1	Anders Mortensen
36	2018-05-20 14:14:24	820-007	Permitteret	Kommune	1	Anders Mortensen
37	2018-05-20 14:14:24	820-007	Permitteret	Kommune	1	Anders Mortensen
38	2018-05-20 14:14:24	820-007	Permitteret	Kommune	1	Anders Mortensen
39	2018-05-20 14:14:24	820-007	Permitteret	Kommune	1	Anders Mortensen
40	2018-05-20 14:14:24	820-007	Permitteret	Kommune	1	Anders Mortensen
41	2018-05-20 14:14:24	820-007	Permitteret	Kommune	1	Anders Mortensen
42	2018-05-20 14:14:24	820-007	Permitteret	Kommune	1	Anders Mortensen
43	2018-05-20 14:14:24	820-007	Permitteret	Kommune	1	Anders Mortensen
44	2018-05-20 14:14:24	820-007	Permitteret	Kommune	1	Anders Mortensen
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46	2018-05-20 14:14:24	820-007	Permitteret	Kommune	1	Anders Mortensen
47	2018-05-20 14:14:24	820-007	Permitteret	Kommune	1	Anders Mortensen
48	2018-05-20 14:14:24	820-007	Permitteret	Kommune	1	Anders Mortensen
49	2018-05-20 14:14:24	820-007	Permitteret	Kommune	1	Anders Mortensen
50	2018-05-20 14:14:24	820-007	Permitteret	Kommune	1	Anders Mortensen
51	2018-05-20 14:14:24	820-007	Permitteret	Kommune	1	Anders Mortensen
52	2018-05-20 14:14:24	820-007	Permitteret	Kommune	1	Anders Mortensen
53	2018-05-20 14:14:24	820-007	Permitteret	Kommune	1	Anders Mortensen
54	2018-05-20 14:14:24	820-007	Permitteret	Kommune	1	Anders Mortensen
55	2018-05-20 14:14:24	820-007	Permitteret	Kommune	1	Anders Mortensen
56	2018-05-20 14:14:24	820-007	Permitteret	Kommune	1	Anders Mortensen
57	2018-05-20 14:14:24	820-007	Permitteret	Kommune	1	Anders Mortensen
58	2018-05-20 14:14:24	820-007	Permitteret	Kommune	1	Anders Mortensen
59	2018-05-20 14:14:24	820-007	Permitteret	Kommune	1	Anders Mortensen
60	2018-05-20 14:14:24	820-007	Permitteret	Kommune	1	Anders Mortensen
61	2018-05-20 14:14:24	820-007	Permitteret	Kommune	1	Anders Mortensen
62	2018-05-20 14:14:24	820-007	Permitteret	Kommune	1	Anders Mortensen
63	2018-05-20 14:14:24	820-007	Permitteret	Kommune	1	Anders Mortensen
64	2018-05-20 14:14:24	820-007	Permitteret	Kommune	1	Anders Mortensen
65	2018-05-20 14:14:24	820-007	Permitteret	Kommune	1	Anders Mortensen
66	2018-05-20 14:14:24	820-007	Permitteret	Kommune	1	Anders Mortensen
67	2018-05-20 14:14:24	820-007	Permitteret	Kommune	1	Anders Mortensen
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69	2018-05-20 14:14:24	820-007	Permitteret	Kommune	1	Anders Mortensen
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71	2018-05-20 14:14:24	820-007	Permitteret	Kommune	1	Anders Mortensen
72	2018-05-20 14:14:24	820-007	Permitteret	Kommune	1	Anders Mortensen
73	2018-05-20 14:14:24	820-007	Permitteret	Kommune	1	Anders Mortensen
74	2018-05-20 14:14:24	820-007	Permitteret	Kommune	1	Anders Mortensen
75	2018-05-20 14:14:24	820-007	Permitteret	Kommune	1	Anders Mortensen
76	2018-05-20 14:14:24	820-007	Permitteret	Kommune	1	Anders Mortensen
77	2018-05-20 14:14:24	820-007	Permitteret	Kommune	1	Anders Mortensen
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80	2018-05-20 14:14:24	820-007	Permitteret	Kommune	1	Anders Mortensen
81	2018-05-20 14:14:24	820-007	Permitteret	Kommune	1	Anders Mortensen
82	2018-05-20 14:14:24	820-007	Permitteret	Kommune	1	Anders Mortensen
83	2018-05-20 14:14:24	820-007	Permitteret	Kommune	1	Anders Mortensen
84	2018-05-20 14:14:24	820-007	Permitteret	Kommune	1	Anders Mortensen
85	2018-05-20 14:14:24	820-007	Permitteret	Kommune	1	Anders Mortensen
86	2018-05-20 14:14:24	820-007	Permitteret	Kommune	1	Anders Mortensen
87	2018-05-20 14:14:24	820-007	Permitteret	Kommune	1	Anders Mortensen
88	2018-05-20 14:14:24	820-007	Permitteret	Kommune	1	Anders Mortensen
89	2018-05-20 14:14:24	820-007	Permitteret	Kommune	1	Anders Mortensen
90	2018-05-20 14:14:24	820-007	Permitteret	Kommune	1	Anders Mortensen
91	2018-05-20 14:14:24	820-007	Permitteret	Kommune	1	Anders Mortensen
92	2018-05-20 14:14:24	820-007	Permitteret	Kommune	1	Anders Mortensen
93	2018-05-20 14:14:24	820-007	Permitteret	Kommune	1	Anders Mortensen
94	2018-05-20 14:14:24	820-007	Permitteret	Kommune	1	Anders Mortensen
95	2018-05-20 14:14:24	820-007	Permitteret	Kommune	1	Anders Mortensen
96	2018-05-20 14:14:24	820-007	Permitteret	Kommune	1	Anders Mortensen
97	2018-05-20 14:14:24	820-007	Permitteret	Kommune	1	Anders Mortensen
98	2018-05-20 14:14:24	820-007	Permitteret	Kommune	1	Anders Mortensen
99	2018-05-20 14:14:24	820-007	Permitteret	Kommune	1	Anders Mortensen
100	2018-05-20 14:14:24	820-007	Permitteret	Kommune	1	Anders Mortensen

Ballot papers, screen printout documentation, Excel files and a technical data file that makes it possible to reconstruct the entire election process on another PC, e.g. at a central election authority, are packed together in an encrypted zip file that is password protected and that cannot be modified without stating the password in question.

6. More about security

Earlier in this note, network security was described as 'air-gapped' with no connectivity to external systems, this is part of the overall topology.

In addition to the network security, all data is encrypted, this applies to all QR codes, the technical data file and the zip file with the complete polling station result. At the end of the election process, a folder is created on the voting table's desk with ballot papers and screen printouts, documentation and Excel files – these must be accessible to the election officials and are therefore not encrypted.

QR codes for ballot papers have embedded a district ID that can be perceived as a constituency number, this makes it possible to filter out QR codes for ballot papers from other constituencies that may have been sent to the voting citizen via mobile photo and SMS from a citizen in another constituency.

The encrypted data is dependent on access to an encryption key and the encrypted zip file is dependent on access to a password. Both the encryption key and password are centrally formed and completely outside the control of the polling station. Accesses are protected by installing an encryption key and password from a USB key under the Choice Desk computer's TPM chip (Trusted Platform Module), which is a specialized chip on the computer's motherboard that is designed to improve security by securely storing cryptographic keys and passwords.

The current implementation that uses a symmetric encryption algorithm should be assessed whether this can be replaced with an asymmetric algorithm based on elliptic curves. This is not critical and can be a difficult implementation, but using encryption based on elliptic curves will improve security.

All events are logged in an event log that is documented as part of the Excel files.

7. Concluding remarks

It should be emphasized that the digital election procedure described here can coexist without friction with the existing election procedure, where a limited number of ballot boxes can be digital while all other ballot boxes are traditional.

The choice of hand-held scanners and QR codes is partly due to the desire to avoid intense user interaction with voice boxes, which without the scanner concept would require navigation and typing, and thus require the voice boxes equipped with mouse and keyboard, which gives malicious citizens a better opportunity to hack the system. It is also assessed that scanning QR codes for most citizens is a well-known exercise, which is known from e.g. MitID.

It should be mentioned that the main program is polymorphic, where EaR.exe via specific configuration settings is run both as the election table and as a client program in all voting booths.

EaR.exe can also be configured to act as both a polling booth and a voting booth. This can be useful if you want to set up an isolated training and/or demonstration PC where citizens can be shown how the overall system works and practice themselves before the citizen decides whether to vote digitally or in a traditional way.

The system has tried to implement mechanisms that catch misguided operations from citizens and election officials, with instructions on the right action. The system has also tried to protect itself as best as possible against various external attacks. These systems handle the system automatically with proper logging of these events.

However, there is one situation that requires the attention of election officials. This situation occurs if a citizen enters a voting booth and scans the QR authorization code provided, and then leaves the voting booth without casting his or her vote. In this situation, the voting booth is open, so the next citizen will have the opportunity to directly cast their vote and then scan their QR authorization code and vote again – this citizen can vote twice.

If an election official discovers that a citizen has left the voting booth without voting, you can reset the voting booth in question from the election table so that it asks to have the code scanned.

