

VOTING MACHINES & ONLINE VOTING

Nicolas Werner, Aleksandr Koloskov, Lena Kislitcyn

November 14, 2023 | Winter term 23/24

Outline

1. The voting process in Germany
2. Voting machines
3. Online voting
4. Conclusion
5. Questions

Voting in Germany

Voting in Germany - An overview

■ Wahlbeteiligung bei Bundestagswahlen

Bundestagswahlen 1949 bis 2021



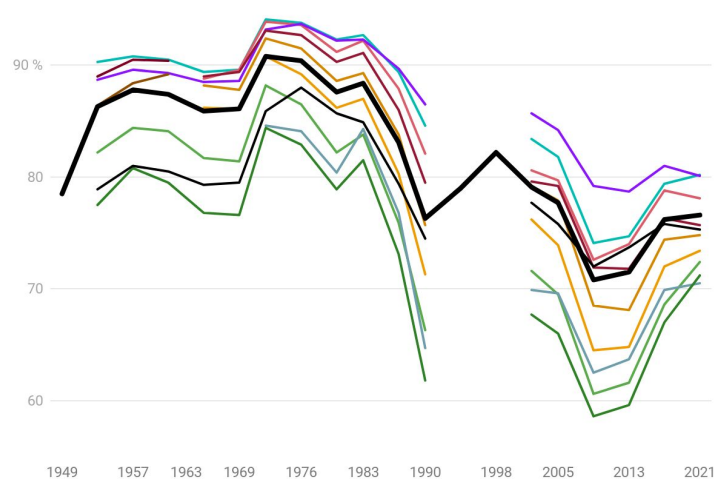
Grafik: bpb • Quelle: Der Bundeswahlleiter



■ Wahlbeteiligung nach Altersgruppen

Bundestagswahlen 1949 bis 2021

— 18 - 20 — 21 - 24 — 25 - 29 — 30 - 34 — 30 - 39 — 35 - 39 — 40 - 44 — 40 - 49
— 45 - 49 — 50 - 59 — 60 - 69 — 70+ — Gesamt



Die Angaben über die Wahlbeteiligung nach Altersgruppen stammen aus der repräsentativen Wahlstatistik. 1949, 1994 und 1998 wurde keine repräsentative Wahlstatistik durchgeführt. 1953 nur ohne die Beteiligung der Länder Rheinland-Pfalz, Bayern und Saarland.

Die Daten stehen unter der Datenlizenz Deutschland – Namensnennung – Version 2.0.

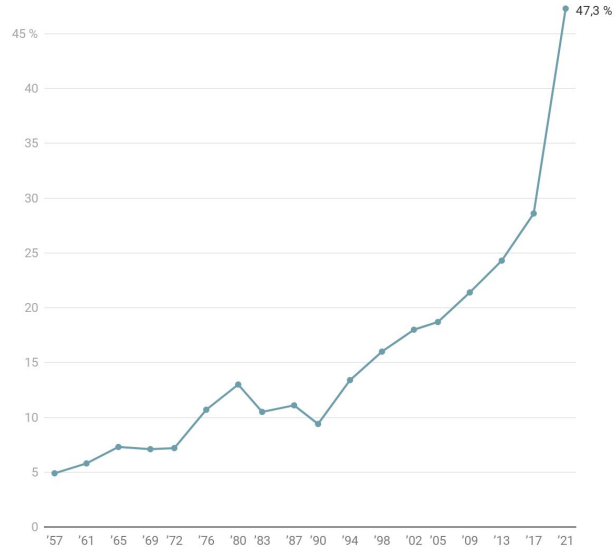
Grafik: bpb • Quelle: Der Bundeswahlleiter



Voting in Germany - An overview

■ Briefwähler 1957 bis 2021

Anteil der Briefwähler an den allen Wählern in Prozent, Bundestagswahlen 1957 bis 2021

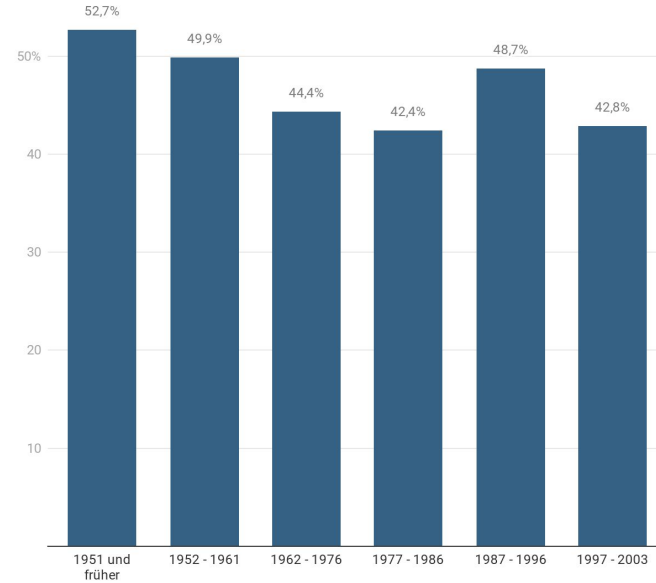


Grafik: bpb • Quelle: Der Bundeswahlleiter



■ Briefwähler nach Geburtsjahr

Anteil an allen Wählern der Jahrgangsguppe, Bundestagswahl 2021

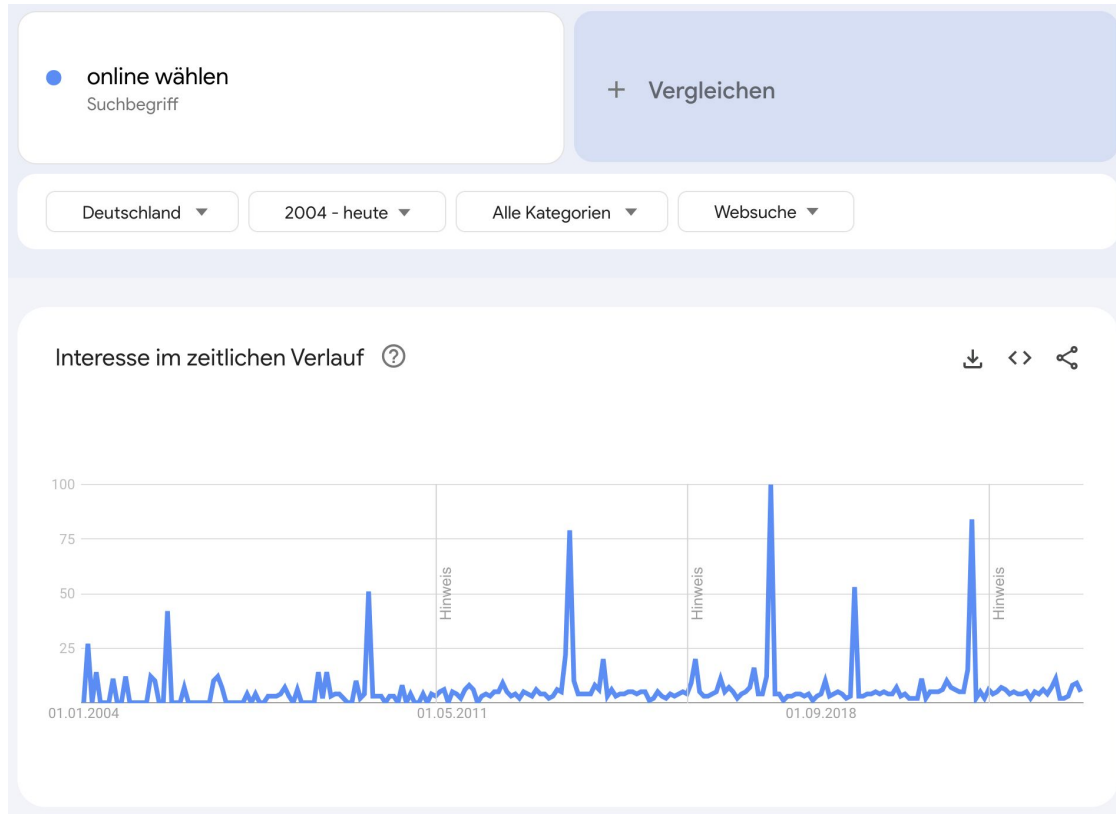


Die Daten stehen unter der Datenlizenz Deutschland – Namensnennung – Version 2.0.

Grafik: bpb • Quelle: Der Bundeswahlleiter



Voting in Germany - An overview



Voting in Germany - The five principles

A federal election in Germany must be ...

[Grundgesetz für die Bundesrepublik Deutschland](#)¹

Art 38

*(1) Die Abgeordneten des Deutschen Bundestages werden in **allgemeiner, unmittelbarer, freier, gleicher und geheimer** Wahl gewählt. Sie sind Vertreter des ganzen Volkes, an Aufträge und Weisungen nicht gebunden und nur ihrem Gewissen unterworfen.*

(2) Wahlberechtigt ist, wer das achtzehnte Lebensjahr vollendet hat; wählbar ist, wer das Alter erreicht hat, mit dem die Volljährigkeit eintritt.

Voting in Germany - The five principles

A federal election in Germany must be ...

- **General (Allgemein)**
- Direct
- Free
- Equal
- Secret

“Allgemein ist eine Wahl, weil alle Bürgerinnen und Bürger der Bundesrepublik Deutschland ein Stimmrecht besitzen – unabhängig von ihrem Geschlecht, Einkommen, Konfession, Beruf oder politischen Überzeugung.”

Voting in Germany - The five principles

A federal election in Germany must be ...

- General
- **Direct (Unmittelbar)**
- Free
- Equal
- Secret

“Die Unmittelbarkeit der Wahl bedeutet Direktwahl der Abgeordneten. Die Wählerinnen und Wähler entscheiden über die Wahlvorschläge ohne Dazwischentreten anderer Personen, etwa von Wahlfrauen und Wahlmännern.”

Voting in Germany - The five principles

A federal election in Germany must be ...

- General
- Direct
- **Free (Frei)**
- Equal
- Secret

“Frei ist eine Wahl, wenn die Bürgerinnen und Bürger in ihrer Wahlentscheidung nicht beeinflusst oder unter Druck gesetzt werden. Der Grundsatz der Freiheit der Wahl gewährleistet, dass ein Wähler seinen wirklichen Willen unverfälscht zum Ausdruck bringen kann und sein Wahlrecht ohne Zwang oder sonstige unzulässige Beeinflussung von außen ausübt. Dazu gehört auch, dass es keinen Wahlzwang gibt und jeder Bürger frei darin ist, an einer Wahl teilzunehmen.”

Voting in Germany - The five principles

A federal election in Germany must be ...

- General
- Direct
- Free
- **Equal (Gleich)**
- Secret

“Gleich ist eine Wahl, weil jede Stimme gleich viel zählt, und jede Art von Gewichtung unzulässig ist.

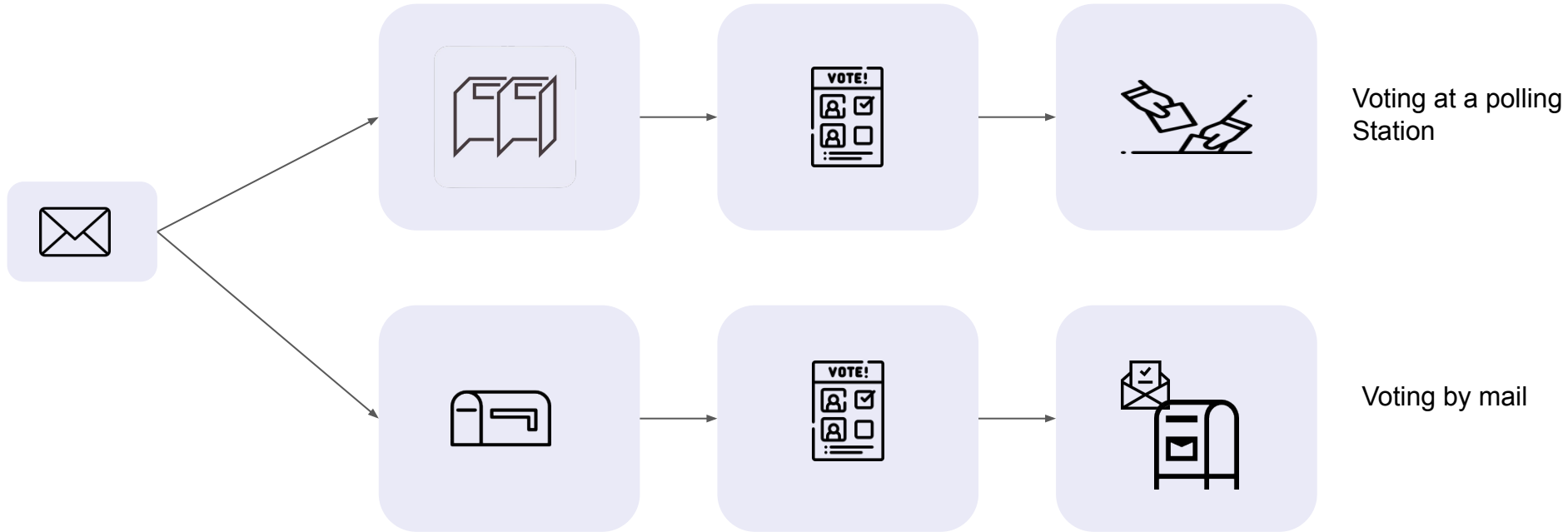
Voting in Germany - The five principles

A federal election in Germany must be ...

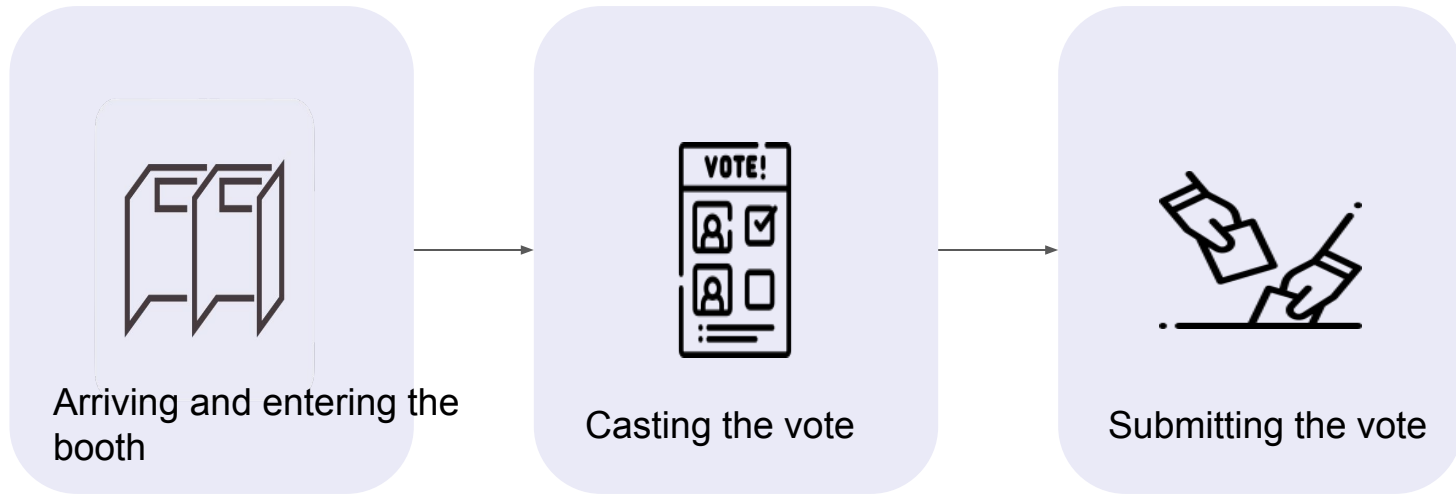
- General
- Direct
- Free
- Equal
- **Secret (Geheim)**

“Die geheime Wahl erfordert, dass jede Person ihr Wahlrecht so wahrnehmen kann, dass nicht nachvollziehbar ist, wie sie gewählt hat. Das hat der Staat durch geeignete Maßnahmen wie den Einsatz von Wahlkabinen, einer verdeckten Stimmabgabe und versiegelte Wahlurnen sicherzustellen.”

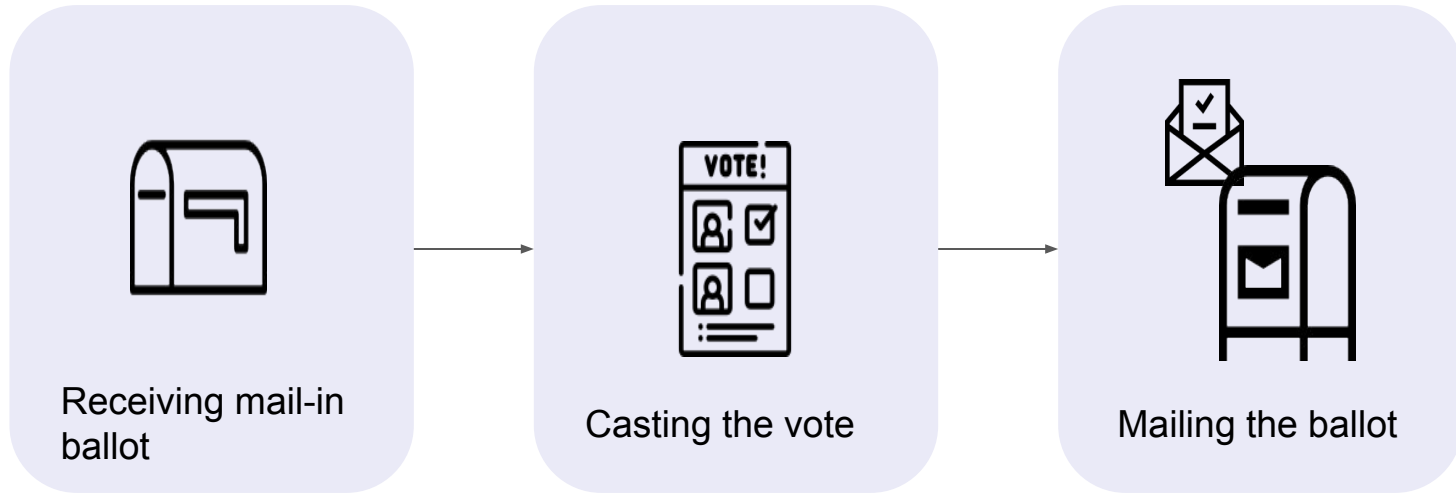
Voting in Germany - Procedure overview



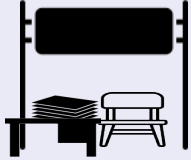
Voting in Germany - Voting at a polling station



Voting in Germany - Voting by mail



Voting in Germany - The role of election helpers



Organizing and
preparing the polling station



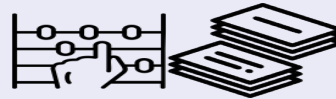
Checking voter
identification



Handing out
ballots



Assisting a voter
with disabilities



Counting votes and recording
results

Put yourself in the role of a ...

Voter

Politician

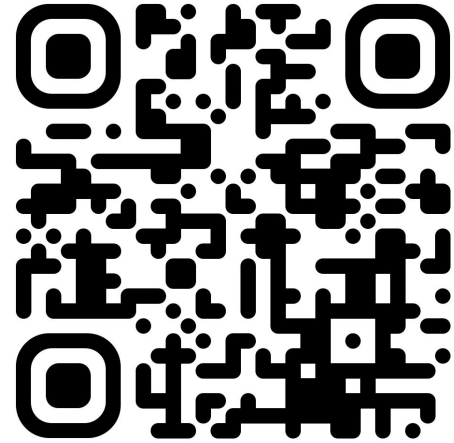
Election administrator

Cybersecurity expert

Rural voter

Accessibility advocate

Do you see any advantages/disadvantages in using voting machines/online voting?



<https://waehlen-im-neuland.duckdns.org/>

Voting machines

Analog voting machines

History
Accessibility
Parlaments

Procedure example: UN general assembly

1. Unlocking machine (verbal protokol)
2. Voting
3. Votes verification!
4. Machine locking

Item 5 - Draft resolution A/ES-11/L.1

Aggression against Ukraine

<input checked="" type="checkbox"/> AFGHANISTAN	<input type="checkbox"/> CAMEROON	<input checked="" type="checkbox"/> FINLAND	<input checked="" type="checkbox"/> KUWAIT	<input checked="" type="checkbox"/> NEPAL	<input checked="" type="checkbox"/> SAUDI ARABIA	<input checked="" type="checkbox"/> UKRAINE
<input checked="" type="checkbox"/> ALBANIA	<input checked="" type="checkbox"/> CANADA	<input checked="" type="checkbox"/> FRANCE	<input checked="" type="checkbox"/> KYRGYZSTAN	<input checked="" type="checkbox"/> NETHERLANDS	<input checked="" type="checkbox"/> SENEGAL	<input checked="" type="checkbox"/> UNITED ARAB EMIR...
<input checked="" type="checkbox"/> ALGERIA	<input checked="" type="checkbox"/> CENTRAL AFR REP...	<input checked="" type="checkbox"/> GABON	<input checked="" type="checkbox"/> LAO PDR	<input checked="" type="checkbox"/> NEW ZEALAND	<input checked="" type="checkbox"/> SERBIA	<input checked="" type="checkbox"/> UNITED KINGDOM
<input checked="" type="checkbox"/> ANDORRA	<input checked="" type="checkbox"/> CHAD	<input checked="" type="checkbox"/> GAMBIA	<input checked="" type="checkbox"/> LATVIA	<input checked="" type="checkbox"/> NICARAGUA	<input checked="" type="checkbox"/> SEYCHELLES	<input checked="" type="checkbox"/> UNITED REP TANZA...
<input checked="" type="checkbox"/> ANGOLA	<input checked="" type="checkbox"/> CHILE	<input checked="" type="checkbox"/> GEORGIA	<input checked="" type="checkbox"/> LEBANON	<input checked="" type="checkbox"/> NIGER	<input checked="" type="checkbox"/> SIERRA LEONE	<input checked="" type="checkbox"/> UNITED STATES
<input checked="" type="checkbox"/> ANTIGUA-BARBUDA	<input checked="" type="checkbox"/> CHINA	<input checked="" type="checkbox"/> GERMANY	<input checked="" type="checkbox"/> LESOTHO	<input checked="" type="checkbox"/> NIGERIA	<input checked="" type="checkbox"/> SINGAPORE	<input checked="" type="checkbox"/> URUGUAY
<input checked="" type="checkbox"/> ARGENTINA	<input checked="" type="checkbox"/> COLOMBIA	<input checked="" type="checkbox"/> GHANA	<input checked="" type="checkbox"/> LIBERIA	<input checked="" type="checkbox"/> NORTH MACEDONIA	<input checked="" type="checkbox"/> SLOVAKIA	<input checked="" type="checkbox"/> UZBEKISTAN
<input checked="" type="checkbox"/> ARMENIA	<input checked="" type="checkbox"/> COMOROS	<input checked="" type="checkbox"/> GREECE	<input checked="" type="checkbox"/> LIBYA	<input checked="" type="checkbox"/> NORWAY	<input checked="" type="checkbox"/> SLOVENIA	<input checked="" type="checkbox"/> VANUATU
<input checked="" type="checkbox"/> AUSTRALIA	<input checked="" type="checkbox"/> CONGO	<input checked="" type="checkbox"/> GRENADA	<input checked="" type="checkbox"/> LIECHTENSTEIN	<input checked="" type="checkbox"/> OMAN	<input checked="" type="checkbox"/> SOLOMON ISLANDS	<input checked="" type="checkbox"/> VENEZUELA
<input checked="" type="checkbox"/> AUSTRIA	<input checked="" type="checkbox"/> COSTA RICA	<input checked="" type="checkbox"/> GUATEMALA	<input checked="" type="checkbox"/> LITHUANIA	<input checked="" type="checkbox"/> PAKISTAN	<input checked="" type="checkbox"/> SOMALIA	<input checked="" type="checkbox"/> VIET NAM
<input checked="" type="checkbox"/> AZERBAIJAN	<input checked="" type="checkbox"/> COTE D'IVOIRE	<input checked="" type="checkbox"/> GUINEA	<input checked="" type="checkbox"/> LUXEMBOURG	<input checked="" type="checkbox"/> PALAU	<input checked="" type="checkbox"/> SOUTH AFRICA	<input checked="" type="checkbox"/> YEMEN
<input checked="" type="checkbox"/> BAHAMAS	<input checked="" type="checkbox"/> CROATIA	<input checked="" type="checkbox"/> GUINEA-BISSAU	<input checked="" type="checkbox"/> MADAGASCAR	<input checked="" type="checkbox"/> PANAMA	<input checked="" type="checkbox"/> SOUTH SUDAN	<input checked="" type="checkbox"/> ZAMBIA
<input checked="" type="checkbox"/> BAHRAIN	<input checked="" type="checkbox"/> CUBA	<input checked="" type="checkbox"/> GUYANA	<input checked="" type="checkbox"/> MALAWI	<input checked="" type="checkbox"/> PAPUA NEW GUINEA	<input checked="" type="checkbox"/> SPAIN	<input checked="" type="checkbox"/> ZIMBABWE
<input checked="" type="checkbox"/> BANGLADESH	<input checked="" type="checkbox"/> CYPRUS	<input checked="" type="checkbox"/> HAITI	<input checked="" type="checkbox"/> MALAYSIA	<input checked="" type="checkbox"/> PARAGUAY	<input checked="" type="checkbox"/> SRI LANKA	
<input checked="" type="checkbox"/> BARBADOS	<input checked="" type="checkbox"/> CZECH REPUBLIC	<input checked="" type="checkbox"/> HONDURAS	<input checked="" type="checkbox"/> MALDIVES	<input checked="" type="checkbox"/> PERU	<input checked="" type="checkbox"/> SUDAN	
<input checked="" type="checkbox"/> BELARUS	<input checked="" type="checkbox"/> DEM PR OF KOREA	<input checked="" type="checkbox"/> HUNGARY	<input checked="" type="checkbox"/> MALI	<input checked="" type="checkbox"/> PHILIPPINES	<input checked="" type="checkbox"/> SURINAME	
<input checked="" type="checkbox"/> BELGIUM	<input checked="" type="checkbox"/> DEM REP OF THE C...	<input checked="" type="checkbox"/> ICELAND	<input checked="" type="checkbox"/> MALTA	<input checked="" type="checkbox"/> POLAND	<input checked="" type="checkbox"/> SWEDEN	
<input checked="" type="checkbox"/> BELIZE	<input checked="" type="checkbox"/> DENMARK	<input checked="" type="checkbox"/> INDIA	<input checked="" type="checkbox"/> MARSHALL ISLANDS	<input checked="" type="checkbox"/> PORTUGAL	<input checked="" type="checkbox"/> SWITZERLAND	
<input checked="" type="checkbox"/> BENIN	<input checked="" type="checkbox"/> DJIBOUTI	<input checked="" type="checkbox"/> INDONESIA	<input checked="" type="checkbox"/> MAURITANIA	<input checked="" type="checkbox"/> QATAR	<input checked="" type="checkbox"/> SWITZERLAND	
<input checked="" type="checkbox"/> BHUTAN	<input checked="" type="checkbox"/> DOMINICA	<input checked="" type="checkbox"/> IRAN (ISLAMIC REP...	<input checked="" type="checkbox"/> MAURITIUS	<input checked="" type="checkbox"/> REP OF KOREA	<input checked="" type="checkbox"/> SWITZERLAND	
<input checked="" type="checkbox"/> BOLIVIA	<input checked="" type="checkbox"/> DOMINICAN REP...	<input checked="" type="checkbox"/> IRAQ	<input checked="" type="checkbox"/> MEXICO	<input checked="" type="checkbox"/> REP OF MOLDOVA	<input checked="" type="checkbox"/> SYRIAN ARAB REP...	
<input checked="" type="checkbox"/> BOSNIA-HERZEGOVI...	<input checked="" type="checkbox"/> ECUADOR	<input checked="" type="checkbox"/> IRELAND	<input checked="" type="checkbox"/> MICRONESIA (FS)	<input checked="" type="checkbox"/> ROMANIA	<input checked="" type="checkbox"/> TAJIKISTAN	
<input checked="" type="checkbox"/> BOTSWANA	<input checked="" type="checkbox"/> EGYPT	<input checked="" type="checkbox"/> ISRAEL	<input checked="" type="checkbox"/> MONACO	<input checked="" type="checkbox"/> RWANDA	<input checked="" type="checkbox"/> THAILAND	
<input checked="" type="checkbox"/> BRAZIL	<input checked="" type="checkbox"/> EL SALVADOR	<input checked="" type="checkbox"/> ITALY	<input checked="" type="checkbox"/> MONGOLIA	<input checked="" type="checkbox"/> SAINT KITTS-NEVIS	<input checked="" type="checkbox"/> THAILAND	
<input checked="" type="checkbox"/> BRUNEI DARUSSAL...	<input checked="" type="checkbox"/> EQUATORIAL GUINEA	<input checked="" type="checkbox"/> JAMAICA	<input checked="" type="checkbox"/> MONTENEGRO	<input checked="" type="checkbox"/> SAINT LUCIA	<input checked="" type="checkbox"/> TIMOR-LESTE	
<input checked="" type="checkbox"/> BULGARIA	<input checked="" type="checkbox"/> ERITREA	<input checked="" type="checkbox"/> JAPAN	<input checked="" type="checkbox"/> MOROCCO	<input checked="" type="checkbox"/> SAINT VINCENT-GR...	<input checked="" type="checkbox"/> TOGO	
<input checked="" type="checkbox"/> BURKINA FASO	<input checked="" type="checkbox"/> ESTONIA	<input checked="" type="checkbox"/> JORDAN	<input checked="" type="checkbox"/> MOZAMBIQUE	<input checked="" type="checkbox"/> SAMOA	<input checked="" type="checkbox"/> TONGA	
<input checked="" type="checkbox"/> BURUNDI	<input checked="" type="checkbox"/> ESWATINI	<input checked="" type="checkbox"/> KAZAKHSTAN	<input checked="" type="checkbox"/> MYANMAR	<input checked="" type="checkbox"/> SAN MARINO	<input checked="" type="checkbox"/> TRINIDAD-TOBAGO	
<input checked="" type="checkbox"/> CABO VERDE	<input checked="" type="checkbox"/> ETHIOPIA	<input checked="" type="checkbox"/> KENYA	<input checked="" type="checkbox"/> NAMIBIA	<input checked="" type="checkbox"/> SAO TOME-PRINCIPE	<input checked="" type="checkbox"/> TUNISIA	
<input checked="" type="checkbox"/> CAMBODIA	<input checked="" type="checkbox"/> FIJI	<input checked="" type="checkbox"/> KIRIBATI	<input checked="" type="checkbox"/> NAURU		<input checked="" type="checkbox"/> TURKEY	
					<input checked="" type="checkbox"/> TURKMENISTAN	
					<input checked="" type="checkbox"/> TUVALU	
					<input checked="" type="checkbox"/> UGANDA	



IN FAVOUR:141



AGAINST:5



ABSTENTION:35



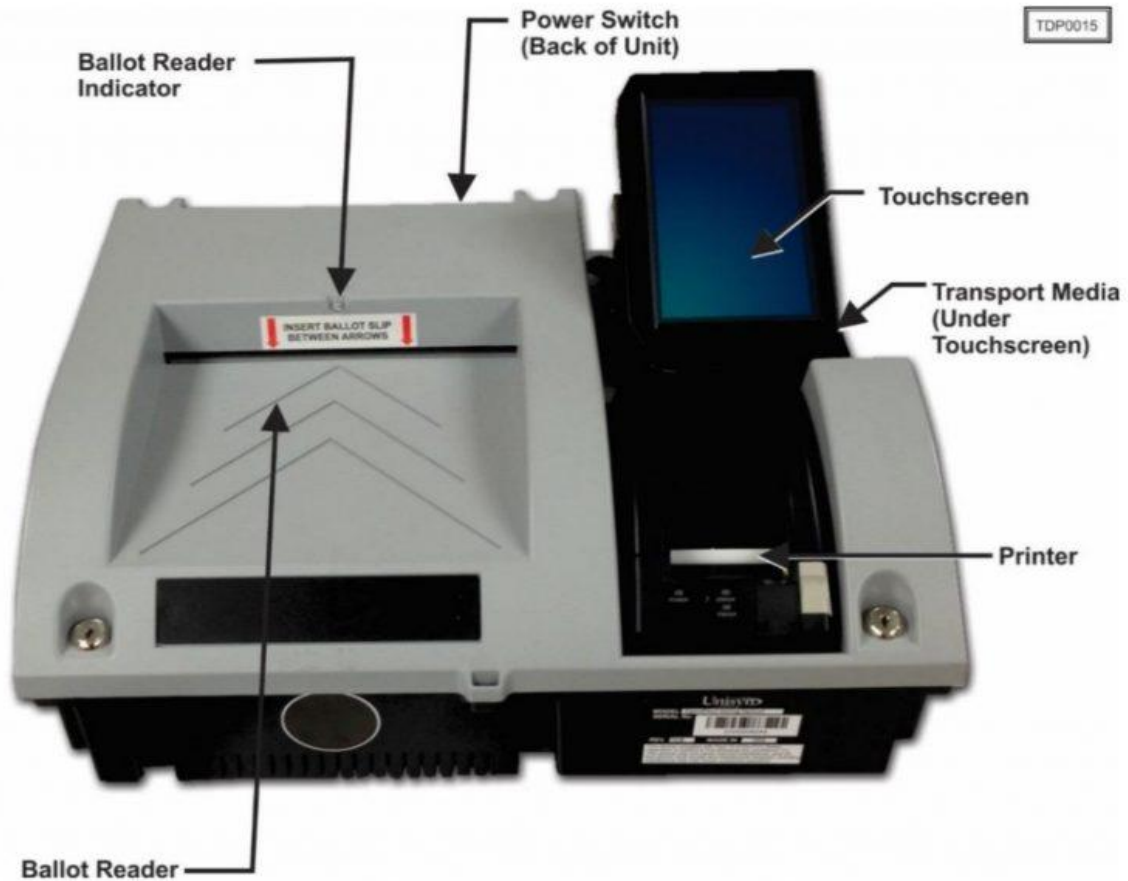
Problems

Security: <http://y2u.be/Co-JQFSYT5M>

Unpractical (approach for process automatisation)

Optical scan voting system

Ballot scanning device “Digitale Wahlurne”



Source: <https://verifiedvoting.org/>



Ballot scanning device in Russia

Problems

1. Physical object
2. Accessibility
3. Reliability
4. <http://y2u.be/xTtxtqBxzwek>

“Today”

USA: Direct Recording Electronic Voting Machine (since 2004)
Dominion Voting Systems

<https://www.dominionvoting.com/setting-the-record-straight/>



Problems

Security: Operating system

Trust issues

Capacity

Solution (2023)

Fingerprint

Online voting

Online voting

The voters submit their vote electronically to the election authorities, from any location



The process of an online election

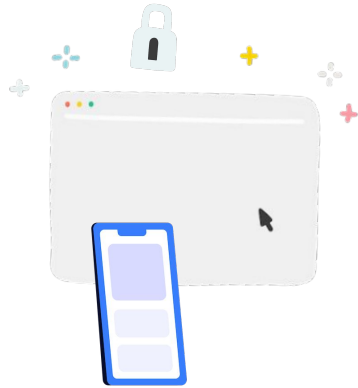
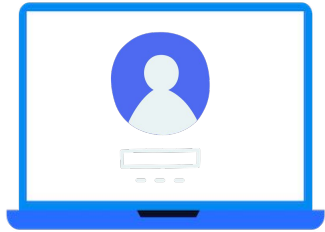
Voter registration & identification

Secure voting platform

Voting process

Encryption & security

Electronic tallying of votes



The process of an online election



Announcement of the results



Arguments in favor of online voting

Efficiency

Accessibility

Convenience

Cost savings

Increased voter turnout

Environment



Arguments against online voting

Security concerns

Less accessibility?

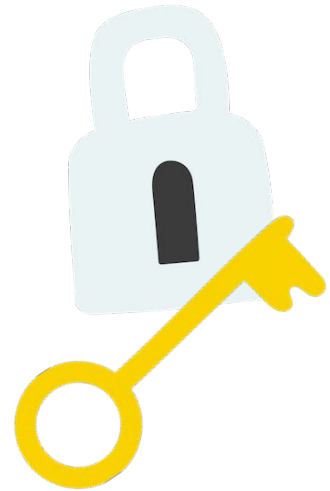
Vulnerability to errors

Better scaling cyber
attacks



Security, trust & understanding

- Strong encryption
- Multiple authentication procedures
- Physical security measures
- Regular security checks and penetration tests
- Transparency and verifiability
- Open source software
- Decontamination of networks and devices
- Contingency plans and recovery procedures
- Awareness and training
- Legal and regulatory frameworks
- International cooperations



Online voting worldwide

Germany

- No trust in technology and devices
- Trialled in 2005, but court found it unconstitutional in 2009



Population:

84,482,267

Online voting worldwide

Estonia

- 2023 parliamentary elections: For the first time >50% votes cast online
- Online voting possible since 2005
- Internet voting system builds on the Estonian ID card
 - Mandatory national identity document & a smart card (March 2007: 1,08 million cards)
- Paper 2007: Rather than eliminating inequalities, e-voting might have enhanced the digital divide between higher and lower socioeconomic classes
- 2007 massive cyber attack by Russian hackers



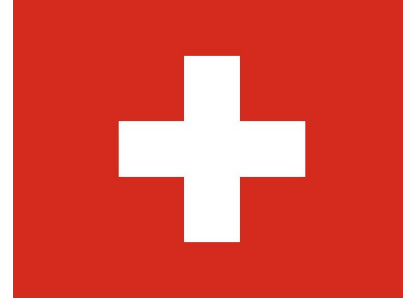
Population:

1,365,884

Online voting worldwide

Switzerland

- Online voting 2003 - 2015
- Currently no online voting, everything is paper-based
- Issue: To prove that people who vote have a permission, can only vote once
→ Has their vote been counted correctly? Did the vote stay anonymous?
- Postal voting remained more popular



Population:

8,815,385

Online voting worldwide

USA

- “Remote access vote by mail” in several states
 - Voters with a computer and printer can download a ballot to their computer, fill it out on the computer, print it and mail it back
- Hawaii, Idaho, Louisiana, Utah allow individual voters to submit completed ballots electronically
 - Email, fax
- Security experts have found problems in every attempt at online voting



Population:

333,287,557

Conclusion

Conclusion

- Balancing technology and trust
- The potential future of digital voting
- The need for rigorous security and transparency

Thank you :)

Questions?

Sources

- Schiedermaier, S. (2007). Gefährden Wahlcomputer die Demokratie? *JuristenZeitung*, 62(4), 162–171. <http://www.jstor.org/stable/20828611>
- Sayem, Md. A. (2023). Citizens' Behavioral Acceptance of Electronic Voting Machine (EVM) in the Electoral Culture of Bangladesh. *Journal of Asian and African Studies*, 0(0). <https://doi.org/10.1177/00219096231179654>
- S. D. Alapati, C. Chennamsetty, P. Dantam, A. Dabbara and M. Arunachalam, "Electronic Voting Machine Using Fingerprint Scanner with Image Enhancement Technique," 2023 International Conference on Computer Communication and Informatics (ICCCI), Coimbatore, India, 2023, pp. 1-5, doi: 10.1109/ICCCI56745.2023.10128376.
- <https://www.bundestag.de/dokumente/textarchiv/2022/kw14-pa-fachgesprach-bildung-882928>