Improving voting technology is hard: the trust-legitimacy-participation loop and related problems

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ABSTRACT

Experience shows that the best technology is not always adopted. In the security arena no technology has to stand a harder challenge or has higher consequences for changing society by failure than voting technology. Best technology in voting is defined by accuracy, security, and integrity. But trust prescribes what technology we use. In practice, voting technology choices are driven by what people are politically comfortable with or by initiatives administrators can take trying out technology someone has made for them. This paper analyses how this kind of "trust" plays out: its influencers and consequences, such as a negative trust-legitimacy-participation-incentive loop. The paper then lays out problems that developers of improved systems face. The analysis is underscored by examples, especially drawing from issues faced by a recent experiment on the implementation of multiple voting systems in parallel.

CCS CONCEPTS

• **Applied computing** → **Voting / election technologies**; • **Human-centered computing** → User studies;

KEYWORDS

Voting technology, Technology adoption, User studies

ACM Reference Format:

Nikola K. Blanchard and Ted Selker. 1997. Improving voting technology is hard: the trust-legitimacy-participation loop and related problems. In *Proceedings of ACM Woodstock conference (WOODSTOCK'97)*, Jennifer B. Sartor, Theo D'Hondt, and Wolfgang De Meuter (Eds.). ACM, New York, NY, USA, Article 4, 8 pages. https://doi.org/10.475/123_4

1 INTRODUCTION

The security risks linked to airplanes crashing, money being taken from banks, or one's identity being stolen legitimise appropriate security. Voting technology affects the most important things in society and its quality is often defined by accuracy, security, and integrity. Trust in the voting process, however, might trump these. Do we know how to make voting secure, and do we make decisions on what to use based on its security?

Legitimising a secure system is a process that includes technical basis and trust by both the decision-makers and the stakeholders. Hopefully, it starts with an auditable engineering process that provides well-engineered, reliable and auditable security. The next step requires following – but also improving – standards. Today many states in the USA have election technology guided by the Voluntary Voting Systems Guidelines with different guidelines in other states and countries. The Voluntary Voting Systems Guidelines, for example, relies on independent equipment certification. Beyond the guidelines is the certification process that might take a year or more for voting equipment. The certification procedure varies, as in California's LA county which avoided buying new voting machines they were convinced would be decertified in a changing regulatory environment. It created lawsuits but saved them $300,000,000 in 2002 after the newly certified and required equipment was decertified as expected. In the rest of this paper, **legitimacy** will be defined as the perception (generally by the public) that the decision-making system used is suitable in the given context, or, for a decision, that it was made using legitimate methods. **Trust** will be defined as the belief that the system is behaving as it should, with no risk of manipulation or modification of results (e.g. through voter suppression, fraud and hacking).

Voting is an act that we do rarely; this makes it more unusual and therefore easier to make mistakes on. It is an activity that carries great import, which brings with it stress, making it, again, easier to make mistakes. Most elections are local: they are run by local people most more of the decisions on ballots surround local decisions. In some places, the constituency of the ballot might change up till the election, and it is typical that ballot design is laid out by a self-taught election official. This need for planning and executing elections locally is part of the reason why decisions are often made on the spot or by individuals that might or might not know all the ramifications of them. Local officials are generally tasked with presiding over the following issues, all of which can impact elections and their legitimacy [1]:

- How people register, which is now often done online but has historically been an important source of lost votes in the USA [7, 44].
- How people find out about the polling places, which is being obviated by mail-in voting and independent information campaigns, although fraud in mail-in voting is being increasingly scrutinised [23].
- How people find out about the times and places they will vote: making this difficult in various ways has been a popular approach for voter suppression.
- How polling places are set up, especially regarding accessibility, and how people line up to enter, which is also one of the biggest ways votes have been lost.

WOODSTOCK'97, July 1997, El Paso, Texas USA

ACM ISBN 123-4567-24-567/08/06.
https://doi.org/10.475/123_4

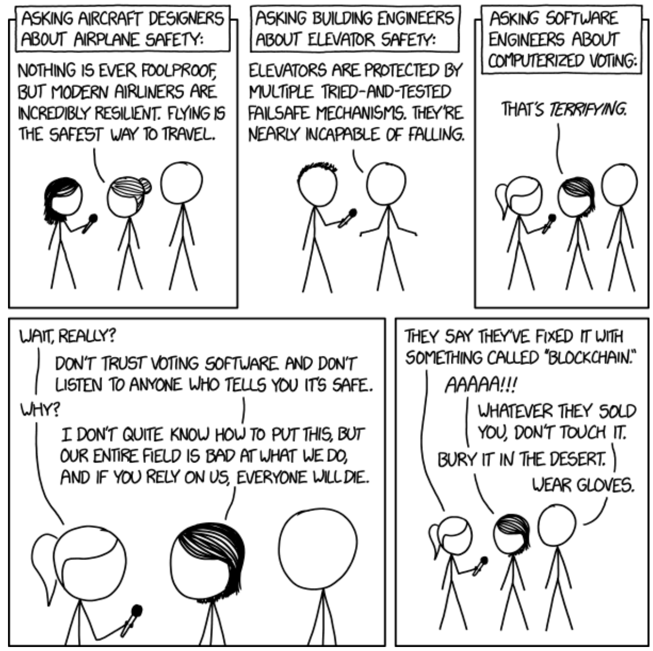
- How voters are allowed to present themselves (with or without ID and at which station), which has been a source of confusion and has been used for voter suppression as well.
- The way the equipment is made available to voters: improving voting equipment in Florida in 2002 didn't immediately change the percentage of residual votes [1] – a metric used to measure the quality of voting technology – which was 2.9% in 2000 [71]. Using the same equipment again in 2004 with a large training and supervision element brought this number down to 0.4%, a quality never seen before [30, 68].
- How the ballot is designed: the result of what was then the most famous House election in the USA was called into question because a design problem led more than 15,000 voters not to make a selection on that race in Sarasota in 2006 [34].
- The way the ballots are counted, with centrally counted votes having typically 0.5% higher residual ballots than locally counted votes.
- The way the ballots are transported before the tally is made, which can be by helicopter, by car, on foot or electronically.
- The way the tally is made (spoken over phone, by hand, with humans transferring numbers, with ballot modules, with ballots themselves) and the way the database is accrued.

Each of these steps must be done carefully; all steps need supervision, never letting a step be done by a single piece of software or person without being checked – *Single Agent Independence*.

With all these decisions to make and guidelines to follow, when a vendor says they can simplify the process, it is tempting to have them print or even lay out the ballots, deliver the ballots, choose the ballot machines, set up the counting machines, run the counting machines, supply the back-end counting equipment and even run the equipment.

The history of voting technologies has been fraught with trial-and-error, with certain countries like Estonia experimenting with internet voting since 2005. On the other hand, others haven't made real changes in a century, like France, where the voting is mostly done in the same fashion today as in 1913 – when it simultaneously adopted the secret ballot and the voting booth. This paper shows that, although this trial-and-error could now be guided by scientific evidence, it is still the product of both the will of the public and the whims of election officials, and multiple effects make real-world implementation of voting technology difficult. As trust and legitimacy are essential parts of voting practices, they need to be kept in mind when developing new technologies to increase their chance of success. Experiments that might improve understanding take care, cost money, and take time. And other issues of legitimacy are fickle with variations of public confidence, changing episodically and being very different from place to place. All this shows how progress is a balance of activities in a changing landscape that might not incite improvement. Indeed, even in an objective landscape, the issues of security and trust in voting change with statements and actions of advocates and adversaries.

[1] Residual votes are known as informal ballots in Australia, rejected ballots in Canada, and blank or null ballots in France and Spain. They consist of ballots that have been spoiled – for example, by writing on them – and are discarded during the counting.



A commentary on the state of voting technology by Randall Munroe on www.xkcd.com. The caption originally read "There are lots of very smart people doing fascinating work on cryptographic voting protocols. We should be funding and encouraging them, and doing all our elections with paper ballots until everyone currently working in that field has retired."

2 THE LOOP

New voting technologies face the trust-legitimacy-participation loop, a conundrum in which each one of these aspects requires the other two. Here, turnout is used as a proxy for participation, as it is a commonly used measure of how invested the population is in the result of the vote [21, 64]. This cycle is based on three different phenomena, detailed below:

- High turnout depends on the presence of strong incentives;
- Perceived legitimacy depends at least on participation;
- The ability to give better incentives requires the legitimacy of the system to already be established.

2.1 Incentives and turnout

The first link in the cycle is well established: increasing the incentives (what pushes the individual to vote) increases the turnout. When we consider incentives that have to do directly with the election, such as decision-making power, this has multiple forms:

- Reducing the size of the electorate for similar decisions positively affects turnout;
- Increasing the importance of the decisions positively affects turnout;
- Increasing the closeness of the vote (making it harder to guess who will win) positively affects turnout.

These effects have been studied extensively both in theory [27, 53], in the laboratory [43], and a posteriori on national and supranational statistics [13, 16]. For an example, one can look to French elections for how voter turnout increases with perception of the value of the election. Turnout in recent years went from 40.6% in European legislative elections to 74.6% in the presidential elections, as the public perceived the first as having lower importance [56]. To compensate for this and maintain high turnout in all elections, some countries, like Australia, have implemented compulsory voting. In its first year, in 1924, compulsory voting increased turnout from 59.4% to 91.4%, and kept it between 90% and 95% since, in both state and federal elections [24].

2.2 Turnout, trust and legitimacy

Turnout is a common standard for the legitimacy of a democratic system that can be directly linked to trust. This manifests in two ways: first, trust in the fairness of the electoral process and equitable access to voting is validated by high turnouts, establishing the legitimacy of the outcome. Second, trust in that fairness pushes people to vote, increasing turnout – the observed low turnouts in ex-soviet Eastern European countries have been tentatively explained by the limited legitimacy of post-USSR regimes [21]. The correlation has been observed repeatedly all over the world [18, 29, 33]. There is no simple causality at hand here, as multiple feedback effects come to bear: the first being that turnout is often seen as a proxy for the legitimacy of the vote (or the regime) [8]. What complicates the matter is that trust in the voting process – which partially depends on the legitimacy of the regime – in turn affects turnout. Indeed, people who don't believe their vote will matter will tend not to vote – and perception that the politicians are corrupt has been shown to negatively affect turnout on a European scale [69]. The most appropriate model for this might be as an evolving multi-variate system, where the levels of both legitimacy and trust at time t have an impact on turnout at time $t+1$, and reciprocally.

Perversely, vote buying and coercion have been used to give the impression of trust and boost the perceived legitimacy of elections, from Russia to Honduras [18, 25, 28]. The other way around, claims by Donald Trump that the election was rigged, during the American 2016 presidential race, could have been meant to lower turnout, following the commonly stated – although partially refuted [50]– theory that increased turnout favours Democrats in the USA.

Because of this established link, any vote that suffers from low turnout could be challenged with the result perceived as illegitimate[2]. This has happened with the presidential election in the United States of America, the Brexit, and more recently in the French legislative elections [32, 45, 48]. More severely, in August 2018 in Pakistan, an election was declared void due to low turnout among women [37], and in April 2018 a by-election was cancelled in Kashmir due to both fear of violence and very low turnout (7%) at the previous by-election [6].

This is a real risk for innovative voting technologies, as a single failure to provide high enough turnout in a real election could be used as a motive to void its outcome and drop the technology. Thankfully, two aspects could mitigate this and offer potential remedies. The first is that this effect is mostly present in countries where voting is not compulsory or where the compulsory nature is not enforced [29], so those countries can provide interesting testing grounds while mitigating the risk of harming the legitimacy. The second comes from work done in countries with low turnouts, such as the USA, with historical turnouts oscillating around 55% for presidential elections and around 40% for midterm elections. In those, other metrics for election quality have already been used. One common standard for voting technology quality in the USA has focused on residual votes: which percentage of the people who went to vote did not succeed at having a selection recorded for the top race on the ballot [1]. Care should be taken with this metric, however, as residual votes can also be interpreted as "protest" votes that were left intentionally blank to fulfil the voting obligation without giving assent. This is dependent on the political culture, and residual vote can be a consequence of political choice and not technological issues. For example, in the USA, residual vote rates around 1% have been considered normal, and their uptick to almost 2% in 2000 was a scandal. With better supervision and technology many states in the USA have since enjoyed residuals under 0.5% [2]. In France, residuals might run between 0.9% and 3%, with frequent bumps due to *protest voting*, up to 12% in the 2017 presidential election [62].

2.3 Incentives and legitimacy

The third link in the loop comes from the problem that implementing strong incentives is hard when legitimacy is not established. This is related to the fact that changing technology on a large scale is hard to do unless there is a strong public desire to do so. Let's first establish the relationship between those two before studying the second.

Incentives can come in a variety of ways: civic duty, social pressure, passion for an election, legal obligation, or financial reward. The first two are some of the most frequently cited reasons to vote, with more than 45% of voters in certain countries citing that civic duty is the main reason they vote [72]. The last one can also be dangerous as it has come with undemocratic fraud in certain settings [42, 51], but also because it can have detrimental effects as an incentive [12, 46, 47].

To attain high turnout, tests and demonstrations of voting technologies require not only strong incentives, but also incentives that follow the same structure as the system they seek to replace [5]. For example, saying that a voting technology is easy to use and showing as proof its huge turnout in an experiment where participants were paid to vote would probably not get accepted by the public (or experts). This is mostly true for experiments that change the nature of the voting rules, and less applicable to interface changes, and usability experiments have helped develop better ballots, better accessibility technology and even tested how to improve people's ability to audit their ballots.

Still, acceptance can be fickle and without it you have no voters. Making people vote on subjects of no importance, on the other hand – or artificial importance, through gaming, for example – is a poor indicator for the participation rate in actual live elections. The final

[2]Historically, this could have been reversed: after the implementation of secret ballots in the USA, which hindered vote buying, turnout decreased by 7% in gubernatorial elections [31].

test must then be to actually implement them in live meaningful elections.

To get strong ecologically valid incentives, voting technology might then need to be used in real-world situations and live elections where the result of the vote matters. This can typically fall into two categories: either in the public eye following a national deliberation on the subject, or independently through the initiative of local officials in low-profile "pilot" elections. Evidence for the difficulty of the first abound, as, even when the legitimacy of the new system is well-established, changing it requires enormous pressure.

The secret ballot (also called the *Australian ballot*), which was adopted in 1858 in Australia, took about 40 years to be used in the USA. There is strong evidence that the main reason that eventually led to its adoption was the concerns over massive fraud and intimidation in the 1876 and 1884 elections [35, 40]. Even when the legitimacy of the candidate system is already established, changing systems generally requires a scandal – more recently, the 2000 USA presidential election scandal was the impetus for creating and funding the Help America Vote Act [38]. And when local officials decide to change the system's rules, this is fraught with risks, as is shown in section 4.

3 COMPARING VOTING SYSTEMS AND THE STANDARD FOR LEGITIMACY

Two effects reinforce the last point on the difficulty of implementing large-scale changes in voting technologies. There is a nuance between them but they work in the same fashion, by comparing the new system to an idealised pre-existing one. The first effect is quite simple, as for any voting system:

- Either it cannot change the outcome of an election, in which case it can only be legitimised by being more secure, cheaper or easier to administer.
- Or it can change the outcome, in which case it is not considered legitimate.

It is known that various electoral systems – like first-past-the-post, Borda or instant-runoff – elect different candidates under the same conditions [53]. And recent experimentation has shown that this happens not only in theory but also in practice [4, 5]. Recently, some activists have had a measure of public support in fighting for alternative voting systems, like majority judgement [3]. However, the ultimate decision generally resides in the hands of elected officials, and those have little interest in changing the system that elected them unless it improves their odds – for example, through gerrymandering [52, 57].

This doesn't mean that changing systems in radical ways is impossible, but it does add an additional obstacle to overcome. It is especially true for projects that include one form of direct or liquid democracy [11] – which has seen a revival recently partially due to the emergence of blockchain technology [14]. What matters here is not whether those projects have inherent value, but that there is sometimes large public support for it, which officials might want to use. This can lead to actual successful implementation on a large scale, as in Taiwan [49]. However, it can also be a front, as when the city of San Sebastian organised the Global Forum on Modern Direct Democracy in 2016 [10], which led to public demonstrations, as citizens criticised the hypocrisy of the city having rejected all local direct democracy initiatives[3].

Although elected officials might not idealise the system that got them elected, they generally have an incentive to keep it intact unless there is massive public pressure. But the public is the target of the second effect, as it is more vulnerable to idealisation of the status quo. Studies have shown that the perception of a voting system is not directly linked to its properties. Instead, although security aspects have a relevance in the public estimate of the trustworthiness of a system, social considerations and networking effects also have a major impact [54]. This is even more relevant in unusual voting systems, for example, ones that use probabilities either as part of the validation [58, 61], or as part of the voting itself [19]. In an experiment on one such voting system [10], participants expressed great concerns over the legitimacy of probabilistic systems, with the main argument being that it raised the possibility of an error or misrepresentation. This status quo bias came from the assumption that the system they were most used to – paper ballots that are hand-counted under supervision of multiple assessors – is error-free. This is naturally a wrong assumption, as a recent study has established that the error rate for such ballots in the same country (measured as discrepancies between number of votes and number of voters) was around 0.18% with 9.7% of polling stations reporting at least one error [22][4].

4 A HOSTILE ENVIRONMENT FOR SCIENTIFICALLY RIGOROUS INNOVATION

The trust-legitimacy-participation loop and the problem of standards for legitimacy mentioned previously would not necessarily be detrimental by themselves, when combined they only increase the inertia of voting systems by making it harder to change the status quo. Imposing a high level of evidence to make changes at the centre of our democracies only follows the precautionary principle.

The main issue with those effects is that they only apply when the changes made to the voting technologies and methods are implemented with well-designed evaluation, supervision and following a public decision. In many cases, the public is barely informed of changes being made by election officials, or those can make changes in an arbitrary fashion. Here we must be careful, because the changes are generally made in good faith by people who believe they notice longstanding problems in their voting systems but do not have funding or access to technology and expertise. Election officials are the people that see the system work – or not – first-hand. They are typically motivated, in a place where they can fix things, and have the desire to do so.

In one example of good initiative on the part of election officials, one of the authors was poll-watching in some split precincts in Chicago that had different instructions for different punch cards in one jurisdiction. In most such places election officials had taken it upon themselves to put a sign up directing the voters to the

[3]To push this a bit further, while discussing such technologies with UK politicians, one salient comment came up, with a politician claiming that they agreed with direct democracy, but that the elected officials should be able to override the people. Approving a system where you follow the will of the people only as long as the people agree with you didn't seem to raise ethical concerns for this politician.

[4] This study showed that despite their automated nature, usability issues raised the error rates on electronic voting machines to 0.86%, with 34.4% of polling stations concerned.

booth with the right ballot instructions. However, in one location they hadn't done this, which meant that 50% of the voters in that precinct were being given the wrong punch card template and instructions, risking the loss of half the votes – a danger made possible by separating the instructions from the ballot. We must, therefore, not depend on the ingenuity of poll-workers to make things work correctly; they have too many other things to concentrate on.

Election officials have a complex job to do running elections, and far too often they inherit antiquated procedures, materials and technology. They may go to vendors to make up ballots, clean data or even write software – or they may invent solutions in-house, sometimes taking it upon themselves to build new voting systems from scratch. As these systems are developed in an ad-hoc fashion to solve local problems and not generally subjected to rigorous analysis, however, they sometimes ignore best practices and decades of prior work[5]

In Boone County, Missouri, Wendy Noren, working as a County Clerk, was frustrated with an inadequate and antiquated system she had inherited to run her elections. Before any state had a real solution, she "*decided to develop her own election handling software. She learned how to code and programmed the entire election system, attempting to make it also tamper-proof, and improved voter experience by making it faster*" [60]. According to the County Assessor in 2018, "*Wendy Noren wrote our personal property software, which is state-of-the-art and still in use today, second to none, in the state of Missouri*".

Noren's software continued for some time to be ahead of that used in most states – and then it wasn't[6]. At some point professional programmers at election companies wrote statewide database software, which was subject to certification and audits and tested in different contexts and by different organisations. Although Noren's approach was innovative and critical at the time, it does not hold up against standards of public oversight. The state was recently given a D rating on election security by the Center for American Progress [59] and the county had problems in their election software in their last elections [41]. Despite this, county officials were certain of the security of their system, their main stated reason being that the voting equipment were not connected to the internet; and although they didn't release how or even whether they tested their technology, they expressed strong reticence at the prospect of changing to the new statewide system [36]. Moreover, even when there is motivation to change technologies because of security risks, the companies standing to lose have sued decision-makers in the past [55].

Changing the implementation of part of a voting system – whether it is the counting software or the registration database – might affect trust and turnout even if it doesn't affect the outcome of an election [17, 39]. On the other hand, changing the voting system or the mode of computation of the winner can have major effects on both turnout and outcome [9, 53]. In particular, going from plurality rules on a local scale to proportional or semi-proportional representation has an immediate effect on the balance of forces in elected assemblies. Although decisions on the first kind of change might be legitimate without strong public supervision, the second kind is much more problematic. However, quoting Bowler, Brockington and Donovan in [15]: "*There is no single reason why some places adopted cumulative voting rather than single-member districting as a remedy, but contributing factors include the preferences of individual attorneys handling the plaintiffs' cases, differences between defendants and plaintiffs over potential districting plans, and local minority-group leaders' willingness to use an experimental system*". Hence, the changes made to voting systems and technologies often depend on arbitrary decisions with little global consistency.

The difficulty of changing a system once it is implemented can also be shown with one of the leading experimenters in voting technology today, Estonia. The country enjoys low political inertia – having declared independence only decades ago – and a reduced population of only 1.3 million inhabitants. The country's citizens carry one smart id card used by 98% of citizens, as well as most long-term residents. This card allows them to travel, log into their bank account, manage health insurance and prescriptions, and, more recently, vote.

After an initial deliberation phase in the early 2000s, the country decided to hold its first remote electronic vote in 2005, and used it in all subsequent elections with progressively increasing turnout [73, 74]. Despite agreement on the importance of having a publicly available source code, or at the very least an independent review, they only allowed the latter in 2013. During that first review, the testers found multiple fatal security flaws, and recommended an immediate shutdown of the system, in agreement with multiple critics inside Estonia's institutions [67]. Despite this warning, Estonia is still using their e-voting technology, improving and affirming its security [70].

5 A WARNING FROM A DEMONSTRATION AT THE COUNCIL OF EUROPE

The World Forum for Democracy is a three-day annual event organised by the Council of Europe, with a thematic focus that changes each year. In 2017, as part of their "Is populism a problem" theme, the forum solicited multiple teams of researchers – including one of the authors – to set up voting experiments. Four separate democratic tests were planned:

- A global vote using *evaluative voting* to rate all but one of the proposed recommendations for the published conclusions of the forum.
- A second vote for the conclusions using *Random Sample Voting* [19]. Ballot-holders could vote only on one of the five proposed recommendations – and couldn't choose which one.
- A public deliberation on the last recommendation to decide its wording and vote on it using the same technology as the Council of Europe.
- A vote on the third and last day to decide which initiative was to receive the Democracy Innovation Award.

[5]The same behaviour has been observed in cryptography and network security with people developing new flawed encryption systems instead of using ones that are already established as secure [63] Alas, they are often very hard to change even in the face of serious problems.

[6]Noren used her experience with registration databases in her work with the EAC, and her work contributed to requiring statewide registration databases to assess individuals voting in more than one place

Participant eligibility. Around 2000 people from more than 80 countries participated in the forum, with a third of academics, a third of representatives from NGOs and political parties, and the rest from a variety of fields [75].

The first two voting methods required ballots with secret codes. Those were distributed on the second day by a team of volunteers, making sure that no-one got multiple ballots by distributing it simultaneously in different places during a limited time frame and by putting stickers on the recipient's access card. The ballot promoted the voting experiment and gave an explanation, an online address and voting codes. Those codes were required to access the second voting system, but not the first (they were used afterwards to check that no-one tried to vote without a correct code). A total of 834 ballots were distributed by the volunteers, who also answered questions about the experiment. The voting period was from 10am on the second day till 10:30pm on the same day.

The third vote happened on the second afternoon in the main hemicycle auditorium of the Council of Europe – which has more than 500 seats equipped with voting technology and at least as many observer seats. It had a partial overlap with some of the conferences of the secondary tracks. It was open to every person present at the conference.

Finally, the fourth vote also took place in the hemicycle in the last main session, with everyone at a normal seat also having the possibility to vote.

Voting methods. The first method involved evaluation voting, with participants being asked to go online and rate all 5 proposed recommendations of the forum from -2 to +2. The focus was not on security but on consistency with other voting methods.

The second method used Random Sample Voting, which – in its designed use (slightly changed for this experiment) – randomly selects a fraction of the voters to vote on an issue. Here, instead of selecting them randomly for one vote, they were randomly assigned to vote on one given issue (a YES or NO question), the focus being to test security and legitimacy of the process.

The third method involved debating before voting using the push-button technology present at the hemicycle of the Council of Europe (previously used by the European Parliament). This technology is a simple electronic voting mechanism where one puts their hand inside the dedicated slot in their desk with three buttons present (but shielded from the view of others) and presses the one they want (with the possibility to vote YES, NO, or NULL).

The last method used the same technology as the third, but instead of debating, the three candidates for the prize gave presentation speeches explaining their project just before the vote.

Awareness and incentives. The last vote demonstration had the highest level of awareness and strongest incentives with many advantages:

- It happened in the main time slot when nothing else was happening, so the marginal cost of voting was low;
- It was advertised in the program of the conference, and was supposed to be the conclusion of many of the secondary tracks;
- Participants had a decent understanding of the issues, having just seen presentations on them;
- It had a real immediate consequence (the attribution of the award);
- It included the lustre of voting from the seats and using the historic private voting technology that had been used by the European Parliament;
- It was a shared experience.

The third demonstration also had a high level of awareness, being part of the main program and using the same technology.

The first two experiments suffered from an organisational mishap in which an organiser dismissed the assembly just before the keynote speeches announcing the experiments, with around 80% of the participants leaving the main room before that could be corrected. Despite work by volunteers to compensate this, awareness remained low. The marginal cost of voting was higher than for the other two demonstrations experiments, but both experiments redirected voters to the other experiment once they had voted to raise mutual awareness. Finally, the incentives were supposed to be relatively strong (as they decided the recommendations of the forum). Alas, many participants felt that the recommendations were obvious, diminishing the importance of that factor.

Results. As most recommendations being voted on were popular, they were all highly rated and selected with large enough margins to compensate for the low turnout – with no disagreement between the first two experiments. A recommendation was debated and voted on for approval in the third voting technology demonstration, and the innovation award in the fourth vote went by a large margin to Russian investigative newspaper *The Insider*.

The critical point in comparative experiment was the turnout:

- Evaluative voting received a total of 67 votes, out of 834 distributed ballots.
- Random Sample Voting got 120 total votes for the same number of ballots.
- 25 people were presented at the deliberative experiment (including organisers), of whom 21 voted.
- No accurate number exists for the number of people present at the last vote, but between 60% and 75% of them voted. This number includes the many votes for the NULL option.

Testing technologies, even with people who should have cared (but had low incentives), didn't get adequate participation: even in a conference dedicated to democracy, among political scientists, politicians and activists, with a strong message that high turnout was essential, and despite all its advantages, the highest-turnout system didn't get more than 75% participation, and others were all but ignored.

6 DISCUSSION

Despite or maybe because of many recent advances, voting technology is far from being unified, and technologists don't even easily agree on which metrics are best-suited to evaluating it. Having single agent independence, an audit trail, supervision and end-to-end verifiable voting might seem like an attainable gold standard, but none of these constraints are yet entirely standard, let alone all of them at once. There are strong reasons which motivate the discrepancies, even inside countries like the USA, such as expressly delegated authority to organise elections – as stated in Article I, Section 4, of the United States Constitution. Rogue technologists or election officials implementing their personal ideas have been a frequent avenue for innovative systems, or pilot studies, or promising new methods. Still, such experiments can and often do add problems of integrity, security, and accuracy. We must learn how to innovate without endangering the technical integrity and public legitimacy of outcomes.

Trust and security can work together but not always, as people's confidence in the security and trust is not based on technical issues alone. Instead, it is a combination of beliefs, experiences, what they are told, what they learn, and what is in their self interest. This paper highlights a central problem we call the trust-legitimacy-participation loop. This technical/political feedback system should be considered deeply in solving real problems of this sort. The voting process presents these issues in graphic detail, but it is not the only place where it happens, and a large delay between the USA and Europe in adopting smart cards for payment is another case of technological delay that seems linked to similar issues.

Despite these obstacles, some new systems have improved legitimacy, an exemplary one being participatory budgeting. Multiple factors can help explain this relative success. First, unlike developments that seek to change the way we use voting, participatory budgeting was typically implemented in places where the constituency had little to no say in the decisions taken. This means that the legitimacy could only increase [20], even with low turnouts generally around 10% [26, 66]. The initial low turnout can probably be attributed to difficulty in getting to the polls, linked to the infrastructure in the South and Central American countries which were the first to use this technology. As such, the baseline for turnout comparisons is also low, with correspondingly low expectations. The relatively successive forays made by this idea could potentially be replicated in other settings. New voting systems could be demonstrated in specific settings where people have naturally stronger incentives but where the leadership has fewer constraints (for example, when it comes to votes inside large unions, or for shareholder votes).

Voting legitimacy is often in question by the people who don't win, especially in contemporary times when anti-democratic discourse is visible and frequent. Advocates and developers of new voting technologies should be careful, both to avoid the pitfalls of low turnout if they want to be implemented, but also to avoid contributing to the delegitimisation of elections. This applies not only to the voting part but also to the auditing, where some promising technologies that avoid frequently found problems in paper audits, such as audio auditing, are discarded by officials and paper audit trail advocates [65].

This paper focused on the trust-legitimacy-participation loop in voting technology, an infrequently used but essential part of our societies. Every aspect of voting technologies has seen increased scrutiny and improvement in the last decade, with new ideas being experimented upon at different levels and with varying focus. Each change has the danger of causing problems as it attempts to solve others, as in some places centralising work on ballot design to prevent local hacking has only led to lack of oversight over the whole process. In others, new and unreliable technologies were installed without being fully tested. New developments like statistical auditing, electronic poll books, audio voting, ballot marking machine, and especially blockchain are sometimes heralded as having the potential to fix everything. Testing of these has so far focused on only one side of the problem, generally security or usability, while public legitimacy has been set aside. However, it is critical, as it is required both for ecologically valid live tests and for actual implementation of the technology on a large scale. Moreover, even systems for voting that seem simple depend on the smooth functioning of many different parts. New approaches must then be tested holistically and rigorously with teams including not only mathematicians and engineers but psychologists and voting theorists, keeping in mind that problems and constraints vary greatly with geography and jurisdiction.

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