Preliminary Study: Electronic Counting in Indonesian National Election Using Computer Answer Sheets and DMR Software

Ferly Norman
Binus Graduate Program – Master of Industrial Engineering
Bina Nusantara University
Jakarta, Indonesia
ferly.norman@binus.ac.id

Syarif Hadiwijaya
Binus Graduate Program – Master of Industrial Engineering
Bina Nusantara University
Jakarta, Indonesia
syarif.hadiwijaya@binus.ac.id

Fergyanto. E. Gunawan
Binus Graduate Program – Master of Industrial Engineering
Bina Nusantara University
Jakarta, Indonesia
fgunawan@binus.edu

ABSTRACT

The 2019 election is the most expensive, complicated, and the worst of the 12 elections in Indonesian history. There are 894 election officers' death due to overworking load and it cost the nation 25 trillion Rupiah or about 1.8 billion USD, involved 16 parties, 192.2 million voters, 7.6 million officers, and 810,329 polling stations spreading in 83,405 villages throughout Indonesia.

The election was held simultaneously for selecting legislative members and the president, utilized five ballots, and was held one day, including for polling, and counting, making the 2019 elections the most complicated in the world. The time for processing five ballots for voting took about 5-7 minutes on average and another five minutes for counting.

Moreover, the ballot tabulation process from polling stations to the national level was manual and took 36 calendar days, adding complexity to the post-election process. This work aims to propose an approach to improve the efficiency and accountability of the voting and tabulation process.

Propose to use a single ballot like a computer answer sheet, marked with a regular marker, optical scanned, and finally processed by Digital Mark Reader (DMR) software. The proposal can save 280.7 million square meters of paper use nationally, shorten 80% of voting time to no more than one minute, increase pooling station capacity by 930%, and 8 working hours for officers in. And in the Kapuk-Jakarta Administration Area alone, it can save a budget of Rp 3.4 billion and 38,556 working hours.

ICONETSI, September 21–22, 2022, Tangerang, Indonesia

ISBN 978-1-4503-9718-6/20/09…$15.00
https://doi.org/10.1145/3429789.34298xx

CCS CONCEPTS

• Software and its engineering • Software creation and management • Software verification and validation • Process validation • Traceability

KEYWORDS

Election, Voting, Optical Scanning, Ballot

ACM Reference format:

Ferly Norman, Syarif Hadiwijaya, Fergyanto. E. Gunawan. 2022. Preliminary Study: Electronic Counting in Indonesian National Election Using Computer Answer Sheets and DMR Software. In Proceedings of International Conference on Engineering and Information Technology for Sustainable Industry (ICONETSI 2022), September 21-22, 2022, Tangerang, Indonesia. ACM, New York, NY, USA, 7 pages.

1 Introduction

Indonesia, the third-largest democratic state [1], has conducted 12 times national election since independence from 1955 until 2019. And the 2019 election is the most expensive, complicated (refers to the number of ballots that the voters shall cast at the voting booth, number of parties, and number of candidates each party) [2], and the worst in 12 times election in Indonesian history refers to many victims' election officials died and were sick.

It cost the nation 25 trillion Rupiahs, 16 parties, more than 245 thousand candidates [3], 192.2 million voters, 7.6 million officers, 810,329 polling stations (TPS) spreading in 83,405 villages throughout Indonesia. A poor election system has a big contribution to make the 2019 election is the worst, using 5 ballots with a big dimension and was held one day including for polling and counting. Moreover, the election results also cannot be known quickly, ballot counting and tabulation process (from TPS to the national level) were done manually and took 34 days, adding complexity to the post-election process.

The impact, a lot of hoaxes arose, conspiracy theories emerged in the community, vulnerable to tabulation manipulation [4], all the aspects increased political tension and uncertainty to the public. The indisputable fact of making the worst 2019 election in history is the fall of the victims of election officers, caused by working hours of up to 24 hours non-stop, leading to extreme fatigue. Chief Commissioner of Election Commission (KPU) reported 894 officers' death and 5,175 others suffered a serious illness [5].

With same format, KPU has been proposed a budget of 86.2 trillion Rupiahs for 2024 Election, which almost 3.5 times the 2019 Election, and 44.9% budget for official in operational level like TPS. This became a concern for the House Representative and asked the KPU to recalculate the budget [6]. This study tries to find a new method of voting, counting, and tabulation process that is more efficient, sustainable, transparent, and humane.

1.1 Ballot

There are 5 types of ballots used for voting (except Jakarta Province used 4 types of ballots) to select Presidential candidate, Regional Representative Council candidate, and Legislative candidate at various levels (national, province, and city/district) see figure 1. It needs the 1.5852 square meter paper to produce ballot for one voter needed [7].

Figure 1: Five type ballots used for voting, from left to right: Presidential candidate, National legislative (DPR), Provincial legislative (DPRD TK I), City/District legislative (DPRD TK II), and Regional Representative Council (DPD).

1.2 Voting Process Flow

TPS is opened at 7 am and closed at 1 pm for voting process then following counting process.

There are 7 steps needed for one voter to complete their voting process in TPS [8]. From a simulation report performed by the General Election Commission (KPU) 1 month prior to the election, voters took 3-8 minutes with 5 minutes averagely to punch all five ballots (d). Senior citizens or people with disabilities tend to be longer than young or normal people.

The majoring of respondents felt difficulty opening and fold back all five ballots with the ballot dimension is wider than the voting booth dimension (exclude Presidential ballot). Due to the above reason, KPU set one TPS for 300 voters maximum to reach targetable to finish the whole voting process at 1 pm in following day.

1.3 Tabulation

The tabulation process is started from the ballot-counting process in TPS until the national level in Jakarta. This process took 36 days from 17 April (D-Day) until 22 May (Final Day) as Figure 2 below, it becomes one of the world's longest tabulation processes.

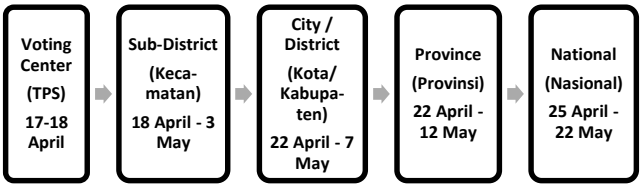

Figure 2: Tabulation of the 2019 election vote.

In the TPS, the counting process can be reached to 1-2 am on 18 April (D +1), then continuing with finalizing report and certificate until 3-5 am which prepared for the next tabulation in the Sub-District level. Afterward, officials in TPS delivered all ballots and boxes along with a report to the sub-district office. This exhausting process is finished around 7 – 12 am.

The tabulation process in the Sub-district office is no less tiring with TPS, especially for area in big cities which have a dense and lot of population, automatically have lots of TPS established. For example, Indonesia's biggest number of TPS within one Sub-District is Cakung, East Jakarta, there are 1,461 TPS totally and need to recapitulate one by one manually.

At this stage there is a plenary session which is attended by stakeholders in the election, officers in the sub-district tabulated one by one the election results at the TPS level. They took documents from the box containing the vote count results at one TPS then re-recorded the results manually. If there are no objections from witnesses or those present at the time, then the results at this TPS will be finalized [9]. This process is redone exactly 1,460 times for the rest of TPS in this Cakung Sub-District.

The tabulation is done in the city's level with the same format (plenary session and manually), next in Province level and the last is the National level. This is the end of the election process which the data came from 810,329 TPS spread the whole of Indonesia territory was pushed to KPU in Jakarta manually in multi-stages.

1.4 Cause-Effect Analysis

Based on Indonesian law number 7/2017 article 167 paragraph 3 concerning General Elections, "Voting is held simultaneously on public holidays or days that are closed nationally" [10]. Article 168 states that the General Election is a means of popular sovereignty to elect members of the House of Representatives at the national and regional levels, members of the Regional House of Representatives, the President and Vice President, which are carried out directly, publicly, freely, confidentially, honestly, and fairly. In 2014 the election has two stages, legislative election first then-presidential afterward.

With the simultaneous election, automatically increased working load and pressure to the officers at TPS level. Due to same system

used, in 2019 KPU reduced maximum voters in one TPS from 500-600 to 300 voters to balance the working load of 7 officers. Based on actual simulation did by KPU in several areas 1-month prior election (300 voters and well-trained TPS officers), the whole process is finished around 12 pm. In election day, mostly TPS finished it at 2 – 4 am on the following day although with 70 - 85 % voter participation.

Figure 3 illustrated what is the impact of the simultaneous election using the previous system in 2014.

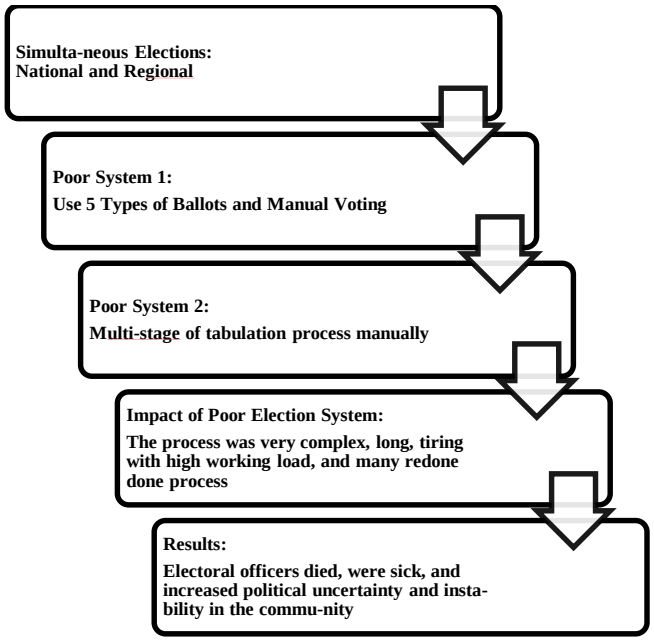

Figure 3: Cause Effect Analysis The 2019 Indonesian Election

1.5 Election Technologies

Paper ballots have served the election process well. They are relatively easy to produce, easy to mark and easy to count, but they can be quite expensive to print and distribute, they can only be used once, and they are not a particularly good use of resources [12].

Counting paper ballots manually, although relatively reliable can prove to be cumbersome and prone to errors which, in turn can result into the need for multiple counts of the same ballots. The development of cheap, easily delivered, reusable, reliable electronic voting methods may gradually replace the paper ballot in many countries

1.5.1 Electronic Voting

Digital technology brings greater efficiency in many walks of life, and elections are no exception. Online databases hugely facilitate the task of creating and managing accurate and up-to-date electoral rolls. In less developed countries, whose citizens often lack reliable identity documents, biometric technology can help to identify voters, thus preventing fraud in the form of multiple voting [11].

Electronic voting or e-voting is a way to get the people's vote electronically. There are different kinds of electronic voting systems used in several countries around the world. Most of these systems adapt existent technologies or develop specific technologies to be used for electoral purposes [12]. The main types of electronic voting systems include:

1. Punch card voting/tabulation systems:
   With punch card systems, voters punch holes in cards using a supplied punch device, to indicate votes for their chosen candidates. After voting, the voter may feed the card directly into a computer vote tabulating device at the polling place, or the voter may place the card in a ballot box, which is later transported to a central location for tabulation.
2. Optical scanning systems:
   An optical scanning device combines specialized computer hardware and software. The hardware devices capture an image and software converts the image to computer-readable data. Voters using machine-readable ballots are given a ballot card with the names of candidates printed on it. Next to each candidate a symbol is printed, such as a rectangle, circle. The voter indicates a choice for a candidate by filling in the appropriate rectangle or circle. After voting, the voter may feed the card directly into a computer vote tabulating device at the polling place, or the voter may place the card in a ballot box, which is later transported to a central location for tabulation.
   The computer tabulating device identifies the marks made by voters on the cards and records votes accordingly. The individual votes are recorded in a database and aggregated to give total results.
3. Direct recording electronic systems (DRE)
   Using DRE systems, voters mark their votes directly into an electronic device, using a touch screen, push buttons or a similar device. With DRE systems there is no need for paper ballots. Voting data is stored by the electronic device, on a computer hard disk, flash disc, or cloud system etc.
4. Internet
   By making electoral participation as easy as logging in to a website, checking a few boxes on a form, and clicking the "Vote" button, it is likely that voter turnout, and hence the overall legitimacy of the results, may be improved significantly. It could also allow significant cost-savings in the deployment and operation of physical polling stations, if the "adoption rate" of internet voting is at a sufficient level. The counting and tabulating of electronic ballots is potentially much faster and easier than counting traditional paper-based or even optical-scan or punch-card ballots, which may represent significant cost savings as well.

1.5.2 Other Countries Experience

Electronic voting machines are used on a large scale in Belgium, Brazil, India, Venezuela, and the United States among others. Although there is a trend for adopting this technology there are still many countries that prefer hand-marked and manually counted paper ballots like Indonesia.

Electronic voting machines count votes quickly and accurately, in US there are two basic forms of voting technology to record the choices: optical-scan ballots, in which voters fill in bubbles, complete arrows or make other machine-readable marks on paper ballots; or electronic voting machine called as direct-recording electronic (DRE) devices, such as touch screens, that record votes in computer memory [13].

Nearly half of US registered voters (47%) live in jurisdictions that use only optical-scan as their standard voting system, and about 28% live in DRE-only jurisdictions, another 19% of registered voters live in jurisdictions where both optical-scan and DRE systems are in use as figure 4.

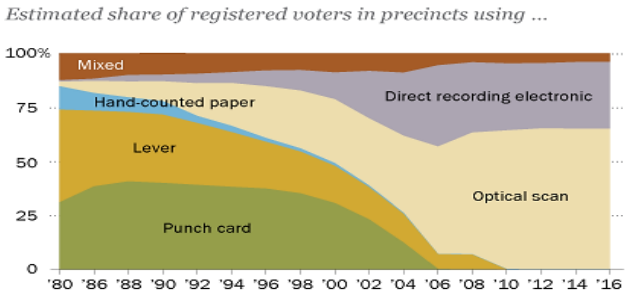

Figure 4: In 2016, on US Election Day, most voters use electronic (DRE) or optical-scan ballots (Pew Research Center)

However, for some aspects of election management, digitalization is more controversial. Electronic voting machines count votes quickly and accurately. First used in the United States, they have spread to several Latin American and Asian countries. However, the intangible nature of digital processes makes detecting tampering more difficult; as a result, most European countries are sticking to tried-and-trusted conventional paper ballots [14].

Filipina is a successful example for developing countries that left the traditional paper ballot system and moved to an optical scan on the election that has been used nationwide since 2010 which brought President Benigno Aquino III to power, there are more 76,367 counting machines deployed and only 0.6% counting machines were reported as malfunction [15].

Iraq which held Parliamentary Elections on 10 October 2021, has implemented some technologies on election process. Election Commission used of the voter verification device (VVD), the polling count optical scanner (PCOS) and the results transmission device (RTD) [16].

2. METHODS

2.1 Research Question

Research question for improving election process in this preliminary study were:

1. What is a simple and familiar voting technology to be implemented for Indonesian people?
2. How to streamline the process of voting and counting votes and increasing the capacity of the number of voters in one polling station?

2.2 Research Steps

The research began by studying the electoral system used in the 2019 elections. Focus, how to vote, count and recapitulate votes at the polling station and sub-district levels which the most time-consuming process. One of the most critical issues is finding a new ballot format to reduce average transaction time [14].

Step 1 was trying to find a weakness of the election system and looking the room for improvement. We reviewed some election systems implemented by either both developing and developed country. We searched existing technology in the Indonesian market that can be adopted for improving the election system to be more efficient and effective from the current condition.

Step 2, in collaboration with PT. Codena, who holds patent and marketing for DMR software, developed new ballots just like a computer answer sheet with a superior feature, QR Code (see Figure 6). The QR code is a vital feature due to avoid forgery such as double print or double recording when tabulation. QR Code is a key feature to control originality and the number of ballots accordingly. Voters can trace QR Code number in KPU system whether their vote is existed and correctly recorded in the system.

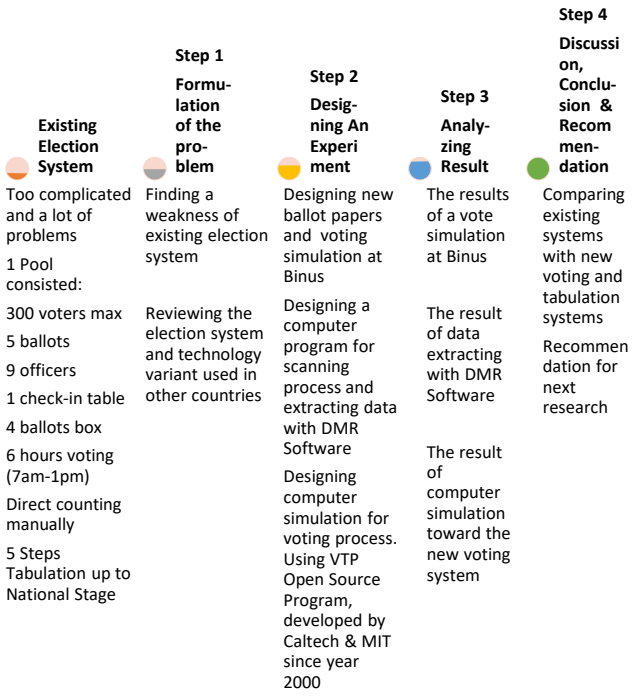

Figure 5: Research method

DMR is an application developed at the Laboratory of Graphics and Artificial Intelligence, Bandung Institute of Technology (ITB) Department of Informatics Engineering, leaded by Prof. Dr.Ing.Ir. Iping Supriana, DEA together with the ITB Flagship Research Team in 2002/2003 [17].

This DMR study was originally a digital-themed Optical Mark Recognition (OMR) research by utilizing a low-cost digital document scanner to read the Computer Answer Sheet (CAS). The main challenge of a form that enters the scanner is the occurrence of geometric distortion in the form of shear and rotation which are sometimes invisible to the eye but greatly affect the accuracy of the reading.

Figure 6: New ballot paper layout design 0.12474-meter square, the function just like a computer answer sheet. It is a combined 5 type ballot used before. And equipped with QR Code feature to avoid a forgery (double print or double recording)

With a simple digital image scanner and after undergoing various experiments, the DMR-Extractor was developed, which has a scanning, extraction, and report generation module. To be able to store up to improve image quality so that the readings are accurate, the DMR ITB Development Team also implemented several sophisticated algorithms that allow the reading of all types of CAS, including CAS OMR.

The latest DMR can check up to 12,000 CAS per minute without reducing its accuracy. Besides checking the answers, the DMR is also equipped with an analysis of exam answers and the results of the questionnaire statistics. When using the DMR, participants can use markers or pens when filling out answers, in contrast to OMR which requires the use of 2B pencils in filling CAS. Test administrators can use photocopy paper, single-color answer sheets, or even print with a normal printer, the size of the paper is not restricted from A3 to A5.

We performed actual voting simulation and later followed by fifty-one Binus University students, using a new ballot type then scanned and extracted the data by DMR software. After got the data from the actual simulation, we did computer simulation using an open-source program using queuing theory from Voting Technology Project (VTP) which developed by the California Institute of Technology (Caltech) and Massachusetts Institute of Technology (MIT) [18].

This computer simulation has a purpose to look any possibility merged some TPS due to ballot issue has been improved and more efficient.

Using one of The Election Management Toolkit provided ("Line Optimization"), simulation process is run 1,000 times and set some assumption as follows:

1. The number of voters in one TPS is 2800 (ten times of average voters' number in Jakarta).
2. TPS is performed voting only while counting and tabulation will be centralized in one area.
3. Average minutes to check-in and vote set is 1 minute each.
4. The poll is opened at 7 am and closed at 3 pm (8 hours).
5. Arrival pattern is Mid-Morning Peak with random based arrival.
6. Early arrival 1.2%, voters cannot check-in 2.0%.
7. Check-in desk 7 unit, voting station 7 unit.

Step 3, analyzing experiment result from step 2, Step 4 made a discussion, conclusion, and recommendation for the next research.

3. RESULT AND DISCUSSION

3.1. Actual Voting Simulation

Mean voting simulation is 43.2 second, for computer simulation rounded to 1.0 minute (considering efficiency reach 75% only) see table 1.

Table 1: Field voting simulation

N	Mean	Mode	Modus	STDEV
51	43.2 Sec	45 Sec	44 Sec	8.9

3.2. Computer Voting Simulation

Based on the simulation, the longest average waiting time occurred at 10.15 was 7 minutes totally (check-in 7 minutes and voting 0 minutes), and there are no voters on the queue that will be projected walk-offs (cancel to vote due to facing long queuing). In theory, voters took 9 minutes only (include check-in and voting time) to finish the voting process from arrival until coming out from TPS. This is far below the US upper limit standard which targeting voters in TPS are 30 minutes maximum [18].

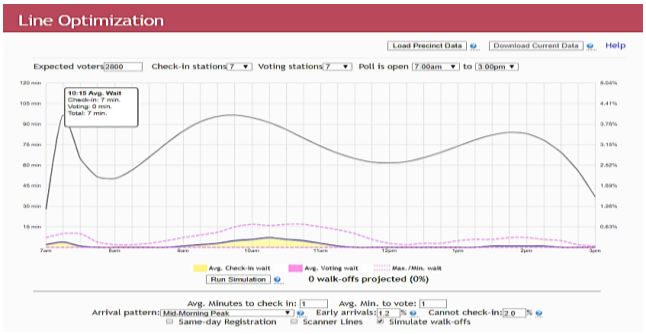

Figure 7: Voting computer simulation result. Using VTP-MIT/ CalTech open resource program.

3.3. Ballot Scanning and Extraction Result

All fifty-one ballots can be scanned and extracted with a Fujitsu 7140 scanner at a speed of 40 ballots per minute as table 2. By setting the scan quality to DPI 100, it can produce clear black/white images of only around 200 kb (Figure 8).

Figure 8: Ballot scanning in color version

One ballot with QR Code # 123464 is "error" and cannot be extracted the data and tabulated (Table 3) due to voters give thick marking for both presidential candidates instead of one as figure 9 below.

Figure 9: Error data due to voters put thick marking for both Presidential candidate

3.4. Discussion

There are some key findings base on research question made for this study:

What is a simple and familiar voting technology for Indonesian people? From four voting technology, the suitable technology is Optical Scanning System due to following reason:

1. Tens of millions of Indonesians are already familiar with the format of this ballot, like a computer answer sheet when they take the national final exam at various levels of education, starting at the elementary level (since year 2009) [20], Junior High School (since year 2006) [21], Senior High School, and University entrance selection.
2. No using expensive and special machine-like DRE System, Optical system using generic high speed scanning machine and can be used after election.
3. The DMR software was made by an Indonesian engineer, the scan results are in the form of images and can be audited with all parties participating in the election.
4. A voter can see the tabulation results of his ballots, because each ballot has an individual number that is stored in the QR Code.
5. The national tabulation process can be started from central counting through the internet network. Based on 2020 data, there are 84,038 villages / administrative areas nationally, 93.21% of areas can receive a cell phone signal; 72.65% have a strong signal, 20.56% have a weak signal, and only 6.79% without a signal [22]. This data will improve gradually until 2024.

How do streamline the process of voting and counting votes and increase the capacity of the number of voters in one polling station?

1. Redesigned ballots from five sheets to one sheet, saving 280.7 million square meters of paper nationally.
2. From simulation it takes less than one minute to cast a ballot instead of 5 minutes previously (reduced by 80%).
3. Ballot counting process uses a high-speed scan machine that can be placed at the TPS, or ballot is transported to a central location for counting and tabulation.
4. From simulation, one polling station capacity increased and able to serve 2800 voters (increased by 930%) with 14 officers.
5. As case study, if we take Kapuk Administrative, Cengkareng Sub-District, West Jakarta has 400 TPS totally to serve 104,710 voters in 2019 Election. With the new system it needs 38 TPS only (reduced by 90.5%). The number of TPS officers in Kapuk can be drastically reduced, from 2,800 to 532 officers (81% reduction).
6. In the 2024 election, the KPU estimates that one officer will receive an honorarium of Rp. 1.5 million. The reduction of 2,268 officers in the Kapuk area alone will save the budget at the TPS level by Rp. 3.4 billion and 38,556 working hours.

3.5. Future Research

This preliminary study shows the great potential of the implementation of e-voting in Indonesian elections, and requires further studies, including:

1. It is highly recommended to conduct pilot project to scale up this method prior to implementing in 2024 Election.
2. If counting and tabulating are being centralized, it is recommended to set a protocol on how to deliver ballots to the counting center to keep the integrity of election results.

4. CONCLUSION

This study aims to improve the voting, counting and tabulation process of the National Election, which is more humane, sustainable, simple, concise, transparent, and low cost. Redesigning ballots, and using electronic counting and tabulation methods, are the key to improving Indonesia's overall electoral system. This study proposed one paper ballot with a QR code feature to replace the existing five paper ballots, the results are reducing 280.7 million square meters of paper consumption nationally, the average voting vote time from 5 minutes to below 1 minute. Using a new type of ballot, computer simulation results show that one polling station can accommodate 2,800 voters (930% the current number) with an average waiting time of 7 minutes. Election officers working hour is set for 8 hours, not 17-20 working hours as 2019 election which caused 894 officers were death.

For counting and tabulation, manual and multi-stage processes are replaced with electronic by using scanners and DMR software, the scanner can process 2,400 ballots/hours and tabulate it automatically in one stage. Currently electronic transmission data is possible nationally due to 93.21% of total villages / administrative areas has been internet signals.

Significant reductions in polling time and dramatic increases in polling station capacity will result in a significant reduction in the number of polling stations and TPS officers. That will have a significant impact by saving Rp 3.4 billion budget and 38,556 working hours in Kapuk Administrative only.

ACKNOWLEDGMENTS

We gratefully acknowledge the support of Prof. Fergyanto. E. Gunawan and this study is self-funded.

REFERENCES

[1] Lestari, M., Asikin, Z., & Risnain, M., Presidential Threshold Concept in the Democratic Perspective in Indonesia, International Journal of Scientific Research and Management, 7(06), 149-150, 2019.
[2] Yoga, S., Jusuf Kalla: The 2019 Election Will Be The Most Complicated Election In The World, Kompas.com, https://nasional.kompas.com/read/2018/06/25/15183661/jusuf-kalla-pemilu-2019-akan-jadi-pemilu-terumit-di-dunia (25 June 2018).
[3] Ben, B., Indonesia's Incredible Elections: Why Indonesian elections are unlike any other in the world, Lowy Institute, https://interactives.lowyinstitute.org/features/indonesia-votes-2019/ (7 January 2020).
[4] Rakhman, S., Evaluation of 2019 election tabulation result (Case study of Cengkareng Sub-District), AIPI XXVIII National Seminar, 2019.
[5] Sania, M., Reflection on the 2019 Election, 894 KPPS Officers Died, Kompas.com, https://nasional.kompas.com/read/2020/01/22/15460191/refleksi-pemilu-2019-sebanyak-894-petugas-kpps-meninggal-dunia (22 Jan 2020).
[6] Rezza, A. P., 2024 Election Budget Too Big, KPU Will Try Rationalization, Katadata.co.id, https://katadata.co.id/rezzaaji/berita/6149593534b1c/anggaran-pemilu-2024-terlalu-besar-kpu-akan-coba-rasionalisasi (21 September 2021)
[7] KPU Sumenep, 2019 Election Ballot Specimen, http://kpud-sumenepkab.go.id/spesimen-surat-suara-pemilu-2019/ (12 December 2019).
[8] Sekretaris Jenderal KPU, KPPS Guide: Voting and Counting Votes for the 2019 General Election, KPU, http://perludem.org/wp-content/plugins/download-attachments/includes/download.php?id=4659 (10 December 2019).
[9] Sekretaris Jenderal KPU, PPK Guide: Tabulation of Vote Count Results at the Sub-District Level, KPU, http://perludem.org/wp-content/plugins/download-attachments/includes/download.php?id=4662 (10 December 2019).
[10] Peraturan.go.id, State Gazette of The Republic No.182, 2017Law of The Republic of Indonesia Number 7 of 2017 Concerning General Elections, https://peraturan.go.id/common/dokumen/ln/2017/uu7-2017bt.pdf (December 2019).
[11] Martin, R and Ionel, Z., Digital technology in elections: Efficiency versus credibility?, European Parliament Research Service, https://www.europarl.europa.eu/RegData/etudes/BRIE/2018/625178/EPRS_BRI(2018)625178_EN.pdf (2018).
[12] The ACE Electoral Knowledge Network., Elections and Technology, Ace Project, https://aceproject.org/ace-en/topics/et/eth/eth02/eth02b/default ,(2022).
[13] Drew D., On Election Day, most voters use electronic or optical-scan ballots, Pew Research, https://www.pewresearch.org/fact-tank/2016/11/08/on-election-day-most-voters-use-electronic-or-optical-scan-ballots/ (8 November 2016).
[14] Stewart III, C., & Ansolabehere, S., Waiting to vote Election, Law Journal, 14(1), 47-53, 2015.
[15] Filipinas Heritage Library, A History of automated elections in the Philippines, https://www.filipinaslibrary.org.ph/articles/a-history-of-automated-elections-in-the-philippines/ (15 December 2019).
[16] Election Observation Mission to Iraq 2021, EU EOM Iraq 2021 Preliminary statement, European Union Election Observation Mission to Iraq 2021, https://eeas.europa.eu/election-observation-missions/eom-iraq-2021/105451/eu-eom-iraq-2021-preliminary-statement_en (12 October 2021).
[17] Hafshah, N. A., Digital Mark Reader, ITB's Phenomenal Work for the Best Examination Technology, Institut Teknologi Bandung, https://www.itb.ac.id/news/3845.xhtml (28 February 2013).
[18] Stephen, G and Rong, Y., VTP Toolkit: Line Optimization and Poll Worker Management, Voting Technology Project Caltech / MIT, http://web.mit.edu/vtp/index.html#articles (2016).
[19] Stein, R. M., Mann, C., Stewart III, C., Birenbaum, Z., Fung, A., Greenberg, J., ... & Beaulieu, E., Waiting to Vote in the 2016 Presidential Election: Evidence from a Multi-county Study, Political Research Quarterly, 1065912919832374, 2019.
[20] Mahsusi, Press Release: Ujian Nasional (UN) untuk MTs dan MA Ujian Akhir Madrasah Berstandar Nasional (UAMBN) untuk MI Tahun Pelajaran 2008/2009, https://2017.kemenag.go.id/file/dokumen/PressReleaseUNdiMadrasah.pdf, (17 April 2009)
[21] Bambang, S., The Ministry of National Education, MINISTER OF NATIONAL EDUCATION OF THE REPUBLIC OF INDONESIA NUMBER 20 OF 2005 CONCERNING THE NATIONAL EXAM FOR THE ACADEMIC YEAR 2005/2006 https://jdih.kemdikbud.go.id/arsip/permen_tahun2005_nomor20.pdf, 13 October 2005.
[22] Tri, S, et al, Telecommunication Statistics in Indonesia 2020, Catalog:8305002, Directorate of Financial, Information Technology, and Tourism Statistics BPS-Statistics Indonesia, Jakarta, October 2021.