The 2024 Senate Selection Case Study on heain-core

Identity, Votes and Evidence: Three Separate Lanes
A Three-Level Selection on 32 Nodes: Sealed Ballots, a Verifiable Lottery, Collusion Detection and Inquiry under P5, with Core Rounds C10 and C11

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Repository: github.com/JakkritB/heain-core (casestudies/senate/)

Abstract

Thailand's 2024 Senate selection was a self-selection at district, provincial and national level, two rounds each. 43,818 candidates reported at district level, and it produced 200 senators and 100 reserves [2][7]. Allegations of organized voting from slips followed; on 14 September 2026 the Election Commission (EC) resolved to take 77 people, 26 of them senators, to the Supreme Court and criminal prosecution [13][16]. No case has a verdict yet. This paper judges no allegation and names no person or party.

The author simulated all three levels on heain-core with 32 nodes in 4 tiers (3 fictional provinces, 6 districts and a national venue). The work runs in three lanes. The identity lane issues one token per person per round; the vote lane seals each ballot at once with core's key and counts only under approval through P5; the evidence lane draws lots by commit-reveal, signs every result, and checks anonymous ballots for collusion (the watch) and sends findings to a commission through P5.

Two core rounds followed. C10 added recusal to P5, sealed data opened only under a recorded grant, and public tree heads; C11 added public statements anyone can check without a certificate. All 152 checks passed in rounds 0–5 and 2b. At national scale, 3,000 people with a 30% bloc, the watch flagged 193 of 200 targets 1.15 seconds after round 1 closed and 200 of 200 after round 2, with no one outside the bloc flagged. An analyst of published counts wrongly flagged 29 on the bloc day and 40 with no bloc. With full counts published, as under current law, a buyer could check whether hired voters followed the slip with 95% accuracy in round 1; bands or names only cut that to 0–6%. Both need legal change and conflict with open counting, so they are offered only as policy options. All figures are simulated.

Keywords: *HEAIN Framework, heain-core, Senate Selection, Thailand 2024, Vote Buying, Collusion Detection, Sealed Ballots, Commit-Reveal Lottery, Recusal, Transparency Log, Public Verifiability, Unlinkable Lanes, Legal Hold*

1. Introduction

1.1 Background

Earlier case studies of the HEAIN Framework [21] tested heain-core on disasters and the southern border, where the main problems were working on when the network is cut, authority by tier, and warning without alert fatigue. The Senate selection poses a different problem: data that must exist but must not be read (individual votes); data that must be readable but not tied to a person (voters and ballots); deciders who may have an interest in what they decide; and evidence that must survive more than two years while a case proceeds.

The starting point was the author's document HEAIN Senate Node Map [22], which proposed a five-tier structure and three lanes. Before designing, the author checked its figures and claims against news reports and compared the proposed mechanisms with heain-core as it then stood (C8). Three corrections mattered. First, occupational-group slots in a district are scopes of data, not machines, so the layout has 4 tiers. Second, what lets a buyer check hired voters is publishing each candidate's count alongside a slip, not the size of a slot, since the national level had about 150 voters per group yet still drew allegations. Third, core had no recusal for interested parties and no store that opens only on approval, which led to core round C10.

1.2 Facts checked

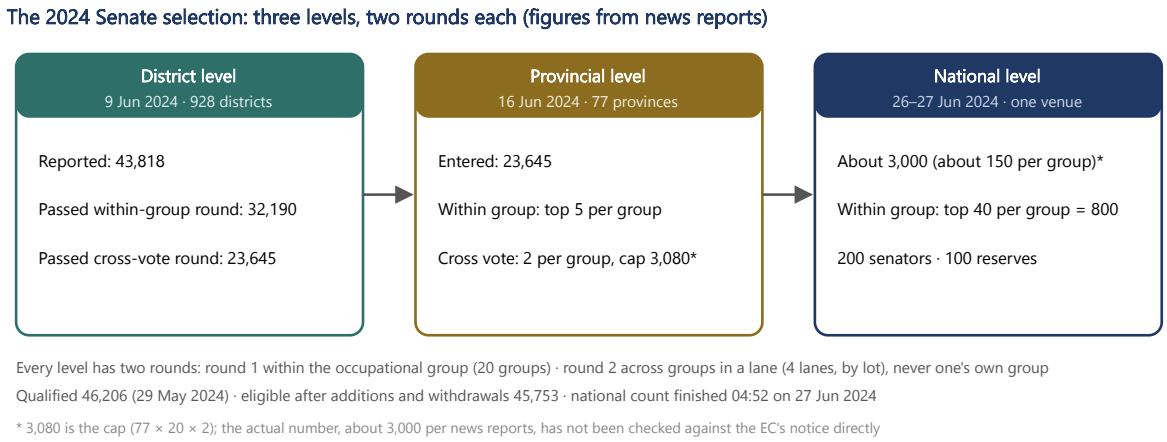


Figure 1 — The 2024 Senate selection: three levels, two rounds each; figures from news reports [2][5][7][8]

Figure	Meaning	Source
46,206	Candidates who passed the eligibility check (29 May 2024)	[2]
45,753	Eligible voters after additions and withdrawals	[2]
43,818	Candidates who reported at district level (9 Jun 2024)	[2]
32,190 / 23,645	Passed the within-group round / the cross-vote round, district level	[2]
3,080	Cap on those passing provincial level (77 provinces × 20 groups × 2)	[6][8]
About 3,000	Passed provincial level per news reports; not checked against the EC's notice directly	[5]
200 + 100	Senators (ranks 1–10 per group) and reserves (ranks 11–15)	[3][4]
≈ 20 h 52 min	Registration at 08:00 on 26 Jun 2024 to the count finishing at 04:52 on 27 Jun 2024	[7]

Table 1 — Figures of the selection process used in this paper

Some figures in the source document could not be checked against open sources and are not used here, including winners' vote counts in certain provinces and the number sent into the cross-vote round from one provincial group.

1.3 Allegations and legal steps

> This section recounts allegations and steps as reported in the news, not facts established by a court. At the time of writing (30 October 2026) there is no verdict, and no report was found that the Supreme Court has accepted the petition. This paper names no person or political party. The voting blocs in the simulation are synthetic and tied to no real province or person.

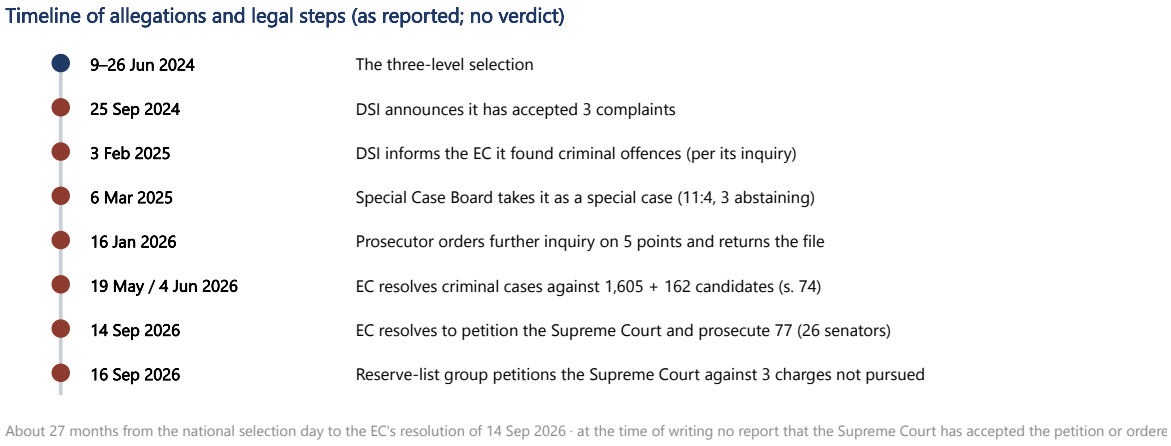


Figure 2 — Timeline of allegations and steps [9][10][11][12][13][16][17]

According to news reports, the Department of Special Investigation (DSI) announced on 25 September 2024 that it had accepted 3 complaints, and on 3 February 2025 informed the EC that its inquiry had

found criminal offences [9][10]. The Special Case Board took the matter as a special case on 6 March 2025 [9], and the prosecutor ordered further inquiry on 16 January 2026 [11]. The EC resolved to pursue criminal cases against 1,767 candidates under section 74 of the Organic Act on the Acquisition of Senators 2018, for applying while knowing they were ineligible [12], and on 14 September 2026 resolved to petition the Supreme Court and pursue criminal cases against 77 people: 26 senators, 36 voters who are not senators, and 15 others [13][16]. Some charges were not pursued [13][14], and on 16 September 2026 a group on the reserve list petitioned the Supreme Court against that decision [17]. If the Court accepts a petition, the senators concerned must stop performing their duties until it rules [18].

One fact bears directly on the design: the EC stated that bringing a slip into the venue is not an offence in itself, because the Administrative Court had revoked the ban [14]. The system therefore cannot stop people from agreeing among themselves. What it can do is stop buyers from checking hired voters, detect abnormal patterns, and keep evidence for those with authority to decide.

1.4 Research questions

1. **RQ1** Can heain-core separate identity from votes and keep ballots with no readable choice on any machine, while still counting correctly and recording who opened what?
2. **RQ2** Can the lane lottery and the published results be recomputed by observers, and by outsiders with no certificate of the system?
3. **RQ3** How does the form of disclosure (names of those passing, counts in bands, full counts) affect a buyer's ability to check hired voters?
4. **RQ4** How fast and how accurately does collusion detection on anonymous ballots catch a bloc, compared with analysis of published counts?
5. **RQ5** Does inquiry under P5 work end to end: a commission, recusal of interested parties, opening ballots under a grant, a legal hold, and deleting identity data after the objection period?

1.5 Scope

- **All three lanes are simulated,** without biometrics; identity is checked by ID card and an official as in the current system (author's decision, 28 Oct 2026).
- **Lanes 1 and 2 need the law changed,** because electronic voting and not publishing individual counts differ from the current system. Lane 3 (evidence, a verifiable lottery and pattern detection) works with the paper system. Section 6.3 separates the two.
- **The real legal process is not simulated,** only the mechanisms bodies under the law would use.
- **This deployment is the author's hypothetical design,** not a project of the EC or any agency, and no agency has reviewed it.

2. Selection Rules Used in the Simulation

Before writing the rules into the app, the author checked them against reports citing the EC's notices [3] [4] and sections 40–42 of the Organic Act, which set the three levels. The result is in Table 2.

Level	Round 1: within the group	Round 2: across groups in a lane
District	Up to 2 choices, self allowed, at most 1 vote per candidate; ranks 1–5 pass	Other groups in the same lane, 1 per group, never one's own group; ranks 1–3 pass
Province	As at district level; ranks 1–5 pass	As at district level; ranks 1–2 pass
National	Up to 10 choices, self allowed; ranks 1–40 pass (at least 20)	Other groups in the lane, up to 5 per group, never one's own group; ranks 1–10 senators, 11–15 reserves

Table 2 — Rules of each round enforced by the app

The 20 occupational groups are split by lot into 4 lanes of 3–5 groups. Two points have not been confirmed from the texts and serve as assumptions of the case study: ties at the cut-off are settled by lot, and groups with fewer candidates than the cut-off at district and provincial level all pass.

3. Method

3.1 Simulation layout

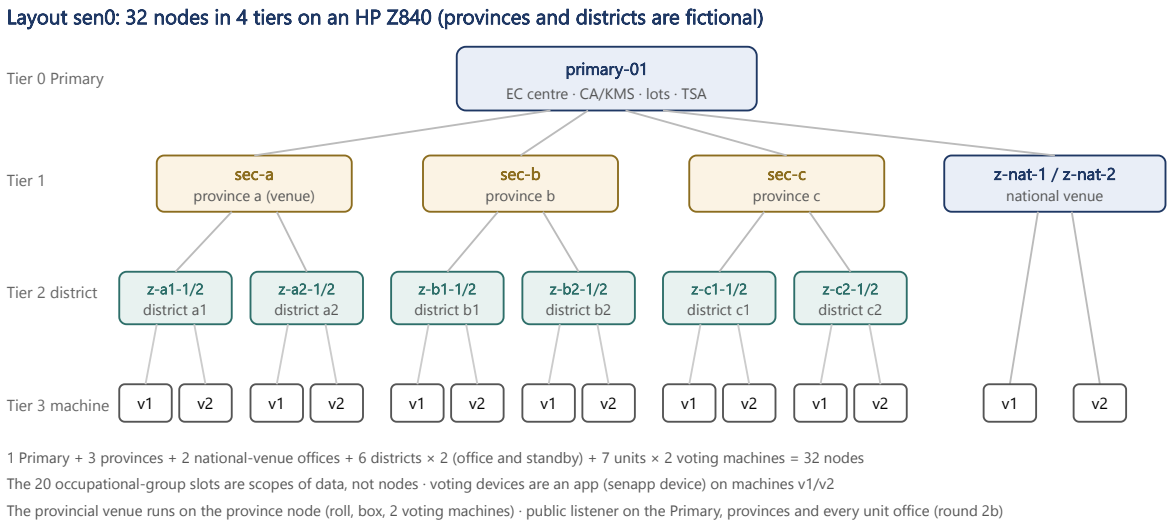


Figure 3 — Layout sen0: 32 nodes in 4 tiers

The layout has 4 tiers, as the author decided: the Primary (the EC centre), provinces, districts, and machines at the venues. The national venue is a special unit under the Primary. Each district has two machines, an office and a standby that can take over, and each unit has two voting machines (Figure 3). Every node is a container on one machine, with short-lived node certificates; voting machines' keys are wrapped by the tier above; and every node has a transparency log time-stamped by a TSA [19][20].

3.2 Three lanes and the senapp app

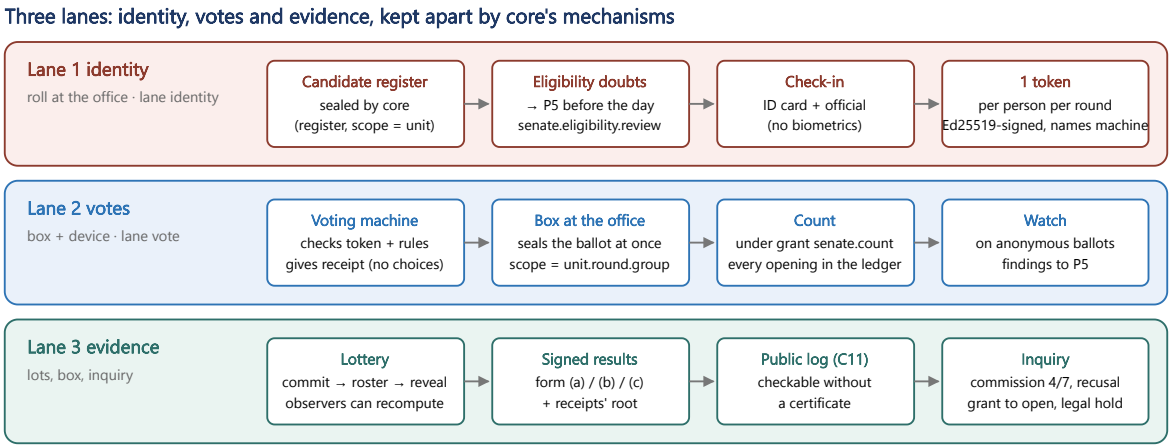


Figure 4 — The three lanes and what each keeps

Command	Lane	What it does	Core used
roll	identity	Candidate register, eligibility doubts to P5 before the day, check-in, one token per person per round; the register is on disk only in sealed form	P5, sealed data (register), lanes.unlinkable
device	votes	Voting machine: checks token and rules, gives a receipt	App certificate
box	votes	Seals ballots at once, counts under the counting grant, draws lots on ties, signs rosters, results and receipts' root	Sealed data, P5, journal, evidence, public log
lots	evidence	Commits one seed per level before the day; reveals after the roster of those reporting is signed	Evidence, public log
watch (in box)	evidence	Checks anonymous ballots for collusion at the count; findings to P5	P5 (THRESHOLD_BASED), evidence
inquiry (in box)	evidence	Proposes grants to open ballots for an inquiry, opens under a grant, crypto-shreds	Sealed data, recusal, legal hold
observe, receipts, voters, plan, buyer, analyst, compare	test	Observers, voters, synthetic blocs, buyers, and an analyst in the style of the current system	—

Table 3 — senapp commands and the core mechanisms they use

The case study's app (senapp) is written in standard Go and talks to core only through the App API. Everything specific to the selection lives in the app; core has no election-specific code (Table 3).

3.3 Synthetic data

- **Three-level flow (scaled down):** 49 candidates per district, the real average (45,753 ÷ 928), 294 in all, spread unevenly across groups; some groups have 0–1.
- **National level at full size:** 3,000 synthetic candidates, 150 per group, put straight into the national venue.
- **Synthetic bloc:** a buyer hires 30% of every group, with 10 targets per group. The round 1 slip is 9 targets plus one "marker" per hired voter: a candidate almost nobody picks, different for each hired voter. 10% of hired voters defect.
- **Control day:** the same candidates, with no bloc.
- **Time:** each level's selection day is compressed to about 20–30 minutes; the objection period to 2 minutes.

3.4 The two systems compared

Matter	asis (as it was)	heain
Identity	ID card + official	The same (no biometrics)
Eligibility	Documents; problems found later	Doubts to P5 before the day
Lane lottery	On site; cannot be recomputed	Commit-reveal; can be recomputed
Ballots	Paper, counted in the open	Sealed at once, counted under a grant
Disclosure	Each candidate's count at every level	Form (a) names, (b) bands of ten, or (c) full counts; all signed
Collusion detection	Analysis of published counts, after results	Watch on anonymous ballots at the count → P5
Inquiry	File assembled later; no record of who read what	Commission, recusal, grant, ledger, legal hold

Table 4 — The system as it was (asis) compared with heain

The asis analyst uses one explainable rule: flag candidates with at least 10 votes and at least k times MAD × 1.4826 above their group's median (k = 6 as the main setting). The heain watch flags pairs of candidates chosen together on at least 8 ballots and more than 3 times the expected $n_i \cdot n_j / B$, where n is each candidate's count and B the number of ballots; pairs linked into groups of 4 or more count as a bloc. Both are rules, not models, as the author decided.

3.5 Rounds and environment

Round	Content	Scenarios
0	32-node layout, security, rules, values inherited over 3 tiers	S0
1	Identity and vote lanes at district level; network cut; simultaneous close; district head lost	V1–V3, V5–V8
2	Commit-reveal lottery; receipts; three-level flow	V4, V9, V14
2b	Public statements and an observer with no certificate (after C11)	V2b.1–V2b.8
3	National level, 3,000 people; three forms of disclosure; buyer	V10
4	Inquiry: commission, recusal, grant to open ballots, lowering thresholds, legal hold, deletion	V11–V13, V15
5	The same national day evaluated under both systems	asis versus heain

Table 5 — Rounds of the case study

Every round ran on the HP Z840 with a script that commits only when all checks pass. Each round starts from fresh nodes, preceded by round 0. Results reported come from the final run set on core C11 (bb2f60c); rounds 3 and 5 use the figures of their first run, and later reruns passed every check.

4. Core Work Arising from This Case

Before designing, the author compared 22 requirements with core. Most were already there: P5 commissions and quorums, unlinkable lanes (lanes.unlinkable), working on when the network is cut, threshold widening flagged Overdue (C8), the audit chain and the transparency log. What was missing led to two core rounds (Table 6). Every change followed the usual process: a written proposal, the author's decision, then the full regression suite of every case study.

Round	What was added	Why	Tests
C10 S1 (9d09746)	p5.recusals and p5.recusal_mode (refuse or flag): a recused member cannot approve, reject or propose the matter, or the vote counts but is marked; a quorum left short goes to the next higher authority	Deciders may have an interest in what they decide	live 33/33
C10 S2	Sealed data: the key stays in core; opens only under an approved grant naming the reader and scope; every opening in a ledger; a legal hold blocks crypto-shredding; keys escrowed to the standby	Individual votes must exist but must not be read without approval	live 9/9
C10 S3	A public listener (-public-addr) serving signed tree heads with no certificate needed	Outside observers	round 0
C10 (found during work)	A proposal can no longer carry its own votes or expiry	An app had attached forged votes and core counted them	unit

C11 S1 (bb2f60c)	A value looser than the tier above returns 403 looser_than_parent, as documented (was 400)	Found in round 4	unit, E4, round 4
C11 S2	Public statements: an app may publish only the kinds and lanes public.statements (P5) allows, never the identity lane; leaves bind the content's hash; heads are signed, time-stamped and recorded in the audit chain (public.head)	Outsiders could see that records exist, but not what they say	live 30/30, round 2b
App (43b1f63)	The roll's identity register sealed by core (identity lane); after a restart it needs a grant; shredded after the objection period	Core's retention does not cover the app's files	round 4 V15

Table 6 — Core changes from the Senate case

heain-sdk 1.3 and 1.4 added app-side functions for sealed data (Seal, OpenSealed, SealOpenings, DestroySealKey) and for public statements (PublishStatement, VerifyPublicStatement, CheckPublicStatement). Both rounds ran the full regressions of every earlier case study, the southern border, CineNexus, disasters and the E1–E4 trials, with every result unchanged.

5. Results

5.1 District level: identity separate from votes (round 1)

Scenario	Result
V1 eligibility	12 doubts went to P5 before the day; the round could not open (409) while they waited; district commissioners cleared 1 and excluded 1 per district; an excluded candidate could not check in
V2 token	All 48 per district voted; refused a reused token (409), a wrong machine (403), a choice outside the group (400) and a second token (409); core refused the same trace on both lanes (409 lane_link_refused)
V3 sealed ballots	No choice in the clear in the files of 32 nodes and 24 app states; a grant still awaiting approval could not open ballots; counts equalled the votes cast one by one; the ledger recorded 48 ballots opened per district
V5 cross vote	4 lanes drawn; choosing one's own group refused (400); at most 3 per group
V6 network cut	District a1 was cut from its province all round; it voted and counted alone; its journal reached the province on reconnection
V7 simultaneous close	5 districts counted at once in 0.54 seconds; results reached the provinces and were acknowledged; ties at the cut-off were drawn by lot in 11 groups
V8 district head lost	The standby took over and received all 12/12 sealing keys; counting from the sealed copies on the voting machines gave the same result

Table 7 — Round 1 results (25/25 passed)

Sealing happens at the office, not on the voting machine, because C10's escrow passes keys only from the office to the standby. If the key were on the voting machine, it would be lost with the machine. Scenario V8 confirms that when the district head is lost, the sealed ballots can still be counted in full without opening anything outside a grant.

5.2 The lottery and verifiable evidence (round 2)

lots at the Primary commits one seed per level before the day; the seed cannot be read before the reveal (404), and the commitment reaches district offices relayed over 2 tiers. A forged reveal whose seed does not match the commitment (a simulated insider) is refused. Each unit's seed mixes the revealed seed with the level, unit, round and the hash of the roster signed before the reveal, so no one knows the draw in advance. An observer recomputed every unit correctly from the signed statements alone: the lanes of 6 districts and 30 tie-break draws. When an insider swapped a group between lanes in district c2's box after the count, the observer caught it.

The three-level flow passed 194 at district level, 101 at provincial level and 101 at national level. Each level took its roll from the signed results of the level below. Every receipt verified against its signed root; a receipt the box never saw got 404, and the answer reveals no choice; and the receipts matched the ballots the ledger shows opened under the counting grant, every one.

A limit found in this round was that an outsider without a certificate could see only the public tree heads, which prove records exist and cannot be deleted, but not their content. This limit led to C11 (Section 5.6).

5.3 Full scale and three forms of disclosure (round 3)

At national level with 3,000 people, round 1 voting took 27 seconds; 800 passed round 1, giving 200 senators and 100 reserves, with counts equal to the votes cast. On the bloc day, the bloc got 198 of its 200 targets selected.

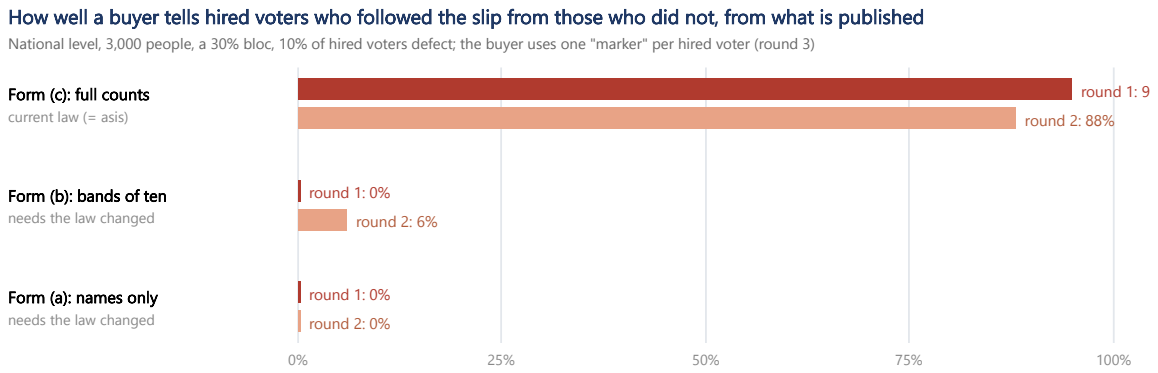


Figure 5 — A buyer's accuracy at telling hired voters who followed the slip, by form of disclosure

With full counts published, the buyer looked at each hired voter's marker and told those who followed the slip from those who did not with 95% accuracy in round 1 and 88% in round 2. With bands of ten, the marker's single votes vanish and accuracy fell to 0% and 6%; with names only it was 0% in both

rounds (Figure 5). This confirms the second correction in Section 1.1: what matters is publishing individual counts, not the size of a slot.

5.4 Pattern detection: the watch against analysis of published counts (rounds 3 and 5)

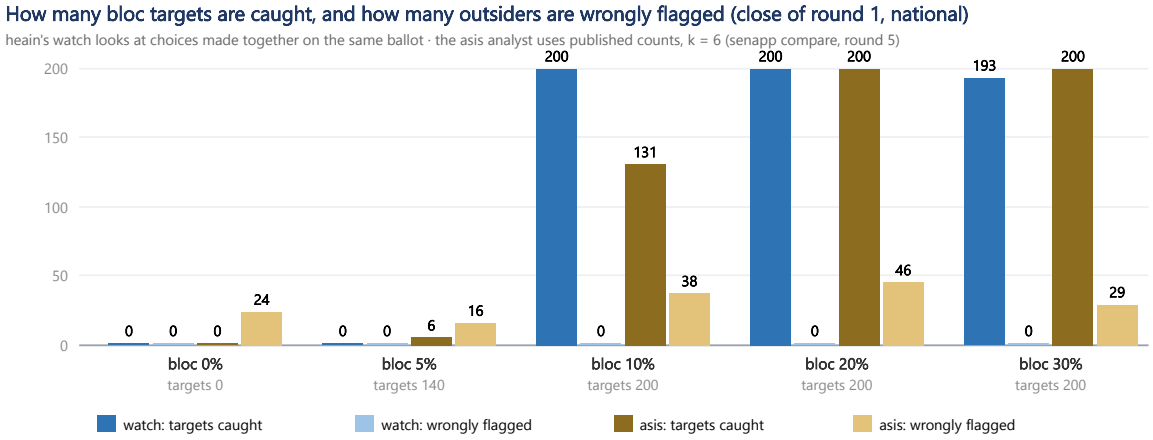


Figure 6 — Blocs caught and wrong flags by bloc size, at the close of round 1

Measure	asis	heain
Targets caught at the close of round 1	200/200 from published counts, after publication	193/200 by the watch, 1.15 s after the close
Targets caught at the close of round 2	13/200	200/200
Outsiders flagged (bloc day)	29	0
Flagged with no bloc at all (control day)	40	0
Buyer tells hired voters apart (rounds 1/2)	95% / 88%	form (b) 0% / 6%; form (a) 0% / 0%; form (c) as asis
Record of who read ballots	None	Every opening in the ledger (7,600 ballots in 38 openings, under approved grants)
When the EC acts	After the selection, from documents	A case proposed at the close of round 1, with the watch's explanation
Choices in readable form	Every paper ballot at the count	None on any node or app file

Table 8 — The same national day evaluated under both systems (30% bloc and control day)

The asis analyst catches a large bloc in round 1, because its targets get abnormally high counts, but cannot tell genuinely popular candidates from targets, so it wrongly flags people even on a day with no bloc. A stricter threshold (k = 8) cuts wrong flags to 6–15, but catches only 61 of 200 in a 10% bloc; and in round 2, where cross votes are spread out, the analyst catches no more than 10 of 200. The watch

makes no wrong flags at any bloc size, because it looks at who is chosen together on the same ballot, not at who scores high (Figure 6).

Bloc	Threshold 8 (used)	Threshold 6	Threshold 5
0%	No one flagged	No one flagged	Round 2: 30 wrongly flagged
2%	Escapes both rounds (bloc got 8 of 19 selected)	Escapes	Round 2: 3/19 caught (+13)
5%	Escapes round 1; all caught in round 2 (122/122)	Round 1: 9/140	Round 1: 112/140 (+1)
10–30%	All or nearly all caught in both rounds; no wrong flags	0–2 wrong flags	0–10 wrong flags

Table 9 — Trade-offs of the watch threshold (senapp sweep in memory, the same code): targets caught (wrong flags)

Small blocs (2–5%) can escape the round 1 threshold. Lowering the threshold catches more but starts flagging innocent candidates, so it is a decision for the commission through P5, not for the system (Section 5.5, scenario V13). A 2% bloc still got only 8 of its 19 targets selected, meaning a bloc small enough to escape is usually too small to get what it wants.

5.5 Inquiry under P5 (round 4)

The Primary set up an EC commission of 7 needing 4 votes to open a case, in flag mode, because the law makes the EC decide; a recused member's vote therefore counts but is marked for checking. It also set up an inquiry subcommittee of 3 needing 2 votes to grant the opening of ballots, in refuse mode. Every value went through P5 at the Primary and was inherited below.

Scenario	Result
V11 opening a case	The watch flagged 193; the strongest pair was chosen together on 31 ballots, beyond the automatic-dismissal range 0–7, so core did not dismiss it, and the case went to the commission with an explanation (rule, 20 blocs, strongest pairs). A commissioner declared a recusal at once; a commissioner could not impose one on another (403); the admin could. 4 commissioners opened the case; the recused member's vote counted and was recorded as recused_vote
V12 opening ballots	Before approval the grant opened nothing; the recused subcommittee member could not vote; the other 2 approved. The inquirer opened group 1's 150 ballots and found 37 sharing 9 of 10 choices (the slip), with no voter on any. Another group's ballots, an unnamed reader and a recused reader were refused. The ledger shows 1 opening of 150 ballots. With 2 of 3 subcommittee members recused, group 2's grant could not reach quorum and went to the next higher authority, who voted instead

V13 lowering the threshold	A province widening the automatic-dismissal range beyond the Primary's was refused when proposed (403 looser_than_parent after C11); stricter was allowed. The Primary widened it to 0–60 (which would dismiss this bloc automatically); it was recorded as a widening and the policy went Overdue
V15 after the objection period	The 3,000-person register was on disk only sealed; after a restart it stayed closed (503) until a grant passed. A legal hold kept the case's records and group 1's ballots. Retention deleted the content of 6,003 app events (all check-ins and tokens) while the audit chain still verified. Crypto-shredding destroyed the ballot keys of 19 groups; the held group was refused (409) and still opened under its grant; once the hold was lifted it was destroyed. A register whose key is destroyed can no longer be opened, though its file remains

Table 10 — Round 4 results (28/28 passed)

5.6 Outsiders can check for themselves without a certificate (C11 and round 2b)

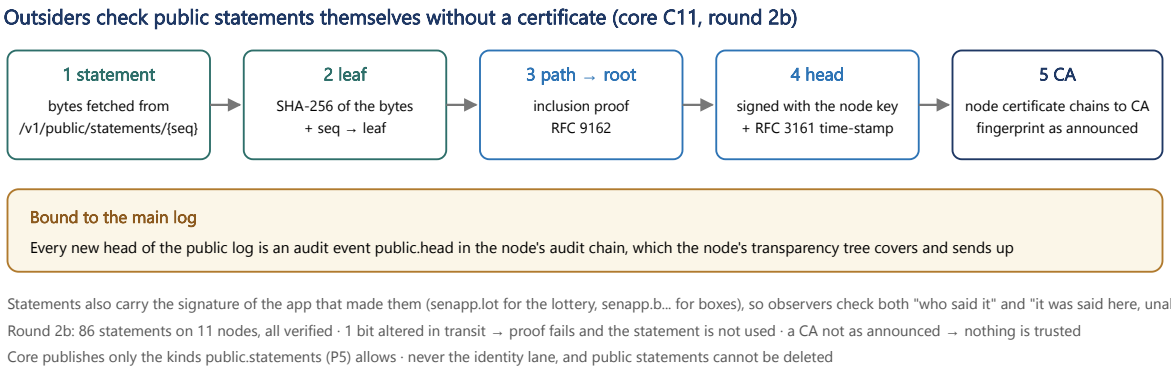


Figure 7 — The five checks of a public statement and its binding to the main log

After C11, senapp publishes signed statements through core: the lottery's commitments and reveals, rosters of those reporting, each round's candidate lists, results (form (a)) and receipts' roots. Statements still carry the app's signature, and core adds the binding to the node's log. Round 2b passed 24/24.

- **Off by default:** the public listeners on all 11 nodes answered 404 until the Primary set public.statements through P5 and the value reached every node over 3 tiers. A value letting the identity lane publish was refused when proposed.
- **Selection day unchanged:** round 2 with publishing on still passed all 25/25 original checks, and no statement was refused.
- **Observer:** a container on the networks only, with no certificate and no key, checked the CA's fingerprint against the announced one; checked that the heads of all 11 nodes were signed with that node's key and time-stamped; checked that all 86 statements were in their node's head; and then checked every unit from the public statements alone: 100 app signatures, 20 rosters, 10 lane draws, 52 tie-break draws and 20 receipts' roots. Results matched the observer holding a certificate for every unit.
- **Refused and recorded:** kinds P5 had not allowed (full counts, form (c)) and anything from an identity-lane capability (403).

- **Altered in transit:** with 1 bit changed in one statement, the proof failed, the observer did not use that statement and reported that district as missing data, while the other 9 units still verified. Given a CA not as announced, the observer trusted nothing.
- **Bound to the main log:** every head of the public log is in the node's audit chain (public.head), and its time-stamp verifies with openssl ts.

5.7 System correctness

Set	Result
Round 0 (run before every round, 6 times)	30/30 each time
Rounds 1, 2, 2b, 3, 4, 5	25, 25, 24, 9, 28, 11, with no failure
Live tests of core C10 and C11	33/33, 9/9 and 30/30
Regressions of earlier case studies	Southern border 10 rounds, CineNexus 5 rounds, disasters 7 rounds, E1–E4 trials: all passed, results unchanged
Audit chain	Verified on all 32 nodes in every round
Values that must be zero	Ballots counted twice or lost, ballots opened without a grant, recused votes counted in refuse mode, reusable tokens: all zero

Table 11 — Checks of the final run set on core C11 (Z840, 30 Oct 2026)

6. Discussion

6.1 Answers to the research questions

- **RQ1:** Yes. The identity and vote lanes cannot be linked (core refuses with 409); ballots are sealed at once at the office; no readable choice is on any node's or app's disk; counting happens only under a grant; and every opening is in the ledger. The limit is that tokens are issued the simple way, so secrecy at the moment of issue depends on reviewing the app's code (Section 6.4).
- **RQ2:** Yes. Both the lottery and the results can be recomputed from signed statements, and after C11 outsiders with no certificate can check everything themselves. The one condition is knowing the CA's fingerprint from another channel.
- **RQ3:** The form of disclosure decides whether a buyer can check hired voters. Full counts let the buyer check with 88–95% accuracy; bands or names cut that to 0–6%.
- **RQ4:** The watch catches blocs of 10% and above within seconds of the round 1 close, with no wrong flags, but it needs per-ballot data opened under the counting grant. Analysis of published counts catches large blocs but always makes wrong flags, and barely catches the cross-vote round.
- **RQ5:** Yes, all of it after C10. The commission decides seeing who has an interest; a recused subcommittee member cannot vote; a quorum left short goes up a tier; opening ballots is limited

by reader, scope and number; the case's evidence survives under a legal hold; and identity data is destroyed after the objection period.

6.2 Transparency against vote-buying protection

Round 3 shows this case's sharpest trade-off. Open counting and candidates' right to object call for visible counts, but individual counts published alongside slips are exactly what let a buyer check hired voters. heain does not make this trade-off disappear. What it does is make individual counts exist and provably unaltered (sealed ballots, receipts' roots, signatures and the public log) while opening them only to those with authority as P5 approves. Choosing between forms (a), (b) and (c) is a matter for the law, not the system, and forms (a) and (b) need the law changed.

6.3 Possible under current law versus requiring legal change

Part	Usable with the current system	Requires legal change
Verifiable commit-reveal lane lottery	yes	—
Signed rosters and results published on a public log	yes	—
Eligibility doubts to a commission before the day	yes (an administrative step)	—
Commission, recusal, grants to open evidence, legal hold	yes, for digital evidence	—
Machine voting, sealed ballots	—	needed
Watch on individual ballots	—	needs digital ballots (paper must first be transcribed per ballot)
Disclosure form (a) or (b)	—	needed, and conflicts with open counting

Table 12 — Parts usable with the current paper system, separated from parts that need legal change

6.4 Limitations

- **Synthetic data and one machine:** all figures come from simulation on an HP Z840; a real network of 928 districts was not measured.
- **The buyer uses one strategy:** one marker per hired voter. A real buyer might photograph ballots or use other methods this system does not prevent.
- **Fixed slips:** a bloc that randomizes slips or spreads targets may evade the watch more, and small 2–5% blocs already escape round 1 in this simulation.
- **The asis analyst is one rule:** other methods may give different results.
- **Simple tokens:** the roll issues a token and drops the link at once; core blocks linking through ids on the two lanes but cannot see the app's memory. Blind signatures can close this gap but were not

yet done here.

- **Seed secrecy:** the seed stays in the lots app at the Primary until reveal; the commitment prevents later changes but not an early leak.
- **Reader names come from the app:** core checks that the name is in the grant and not recused, but authenticating the reader is the app's job.
- **Data in memory:** the register is open in the app's memory while running, a matter for app code review.
- **Public statements cannot be deleted:** core cannot inspect content, so it publishes only kinds approved through P5; allowing a new kind needs care about personal data.
- **Scale:** core has been tested up to 330 nodes; the real layout of 1 + 77 + 928 + venue machines has not been tested, nor bringing up and retiring thousands of nodes in one day.

7. Conclusion and Recommendations

The 2024 Senate selection case tested heain-core where earlier cases did not reach: data that must exist but must not be read, deciders who may have an interest, and evidence outsiders must be able to check for themselves. Core needed two rounds (C10 and C11). After them every check passed with no election-specific code in core, and every earlier case study gave the same results. The most important finding is not technical but a fact the simulation made measurable: publishing individual counts is what lets buyers check hired voters, a policy decision the system cannot make on anyone's behalf.

1. **Pilot lane 3 first,** because it works with the paper system without legal change: the verifiable lottery, signed results on a public log, and an inquiry procedure with a commission, recusal and a ledger.
2. **Treat the disclosure decision separately** as a policy question, using round 3's results as data, not as a conclusion.
3. **If digital ballots are to be used,** add blind signatures to tokens and test at real scale first, including thousands of temporary nodes in one day.
4. **Test the watch against adaptive blocs,** such as randomized slips or targets spread across groups, before using its findings as grounds to open a case.

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