End-to-End (E2E) Verifiable Protocols for Voting Systems

Andy Regenscheid – Voting Security Team, NIST

NIST NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY U.S. DEPARTMENT OF COMMERCE

U.S. Election Assistance Commission

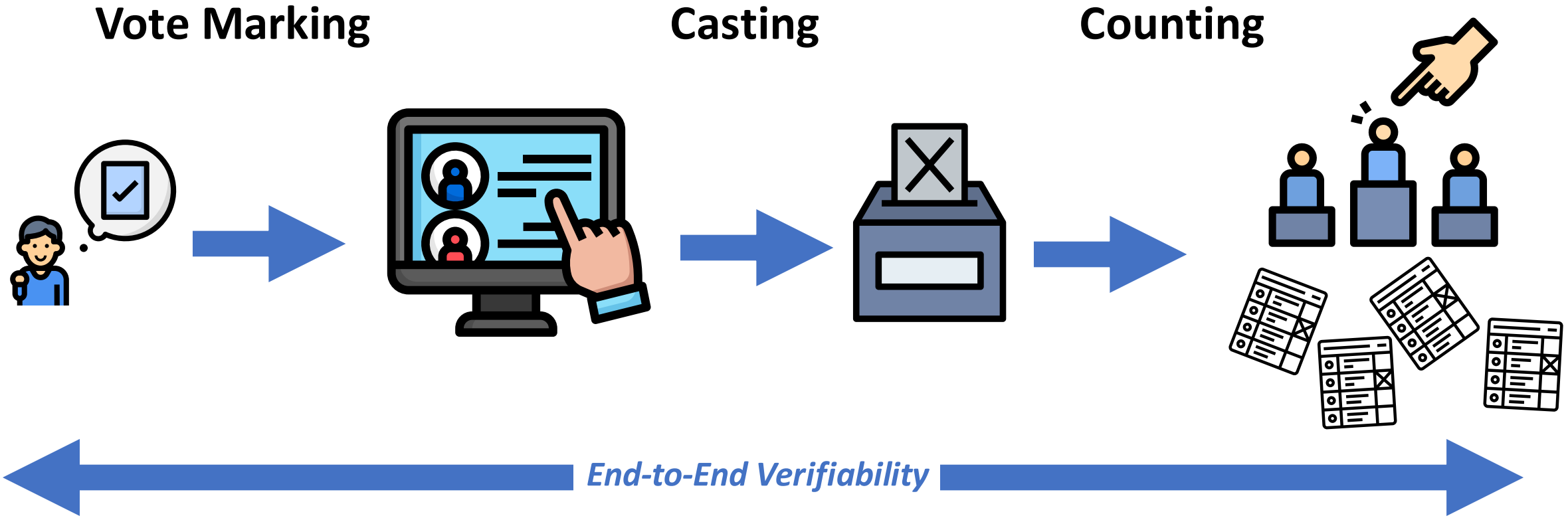
E2E Verifiability in the VVSG 2.0

Principle 9: AUDITABLE
The voting system is auditable and enables evidence-based elections.

- Two paths for software independence (9.1.1-A):
  - Paper-based System architectures
  - E2E Verifiable System Architectures
- E2E Systems must use approved cryptographic protocols (9.1.6-A)
- E2E Systems must undergo an independent evaluation of its implementation of an approved protocol (9.1.6-B)

Goal: **Establishing a public process to solicit, evaluate, and approve E2E verifiable voting protocols that could be implemented in voting systems.**

What is E2E Verifiability?

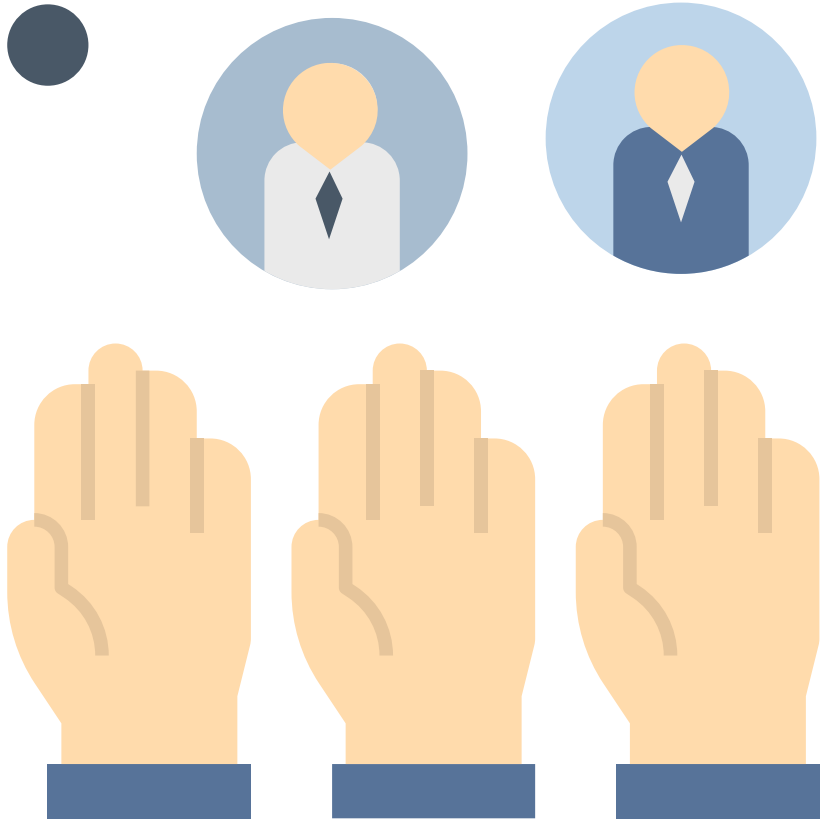


Voter Verifiability: Voters can check their ballot was correctly cast/recorded

Universal Verifiability: Anyone can verify cast ballots were correctly counted

Simple E2E Verifiability

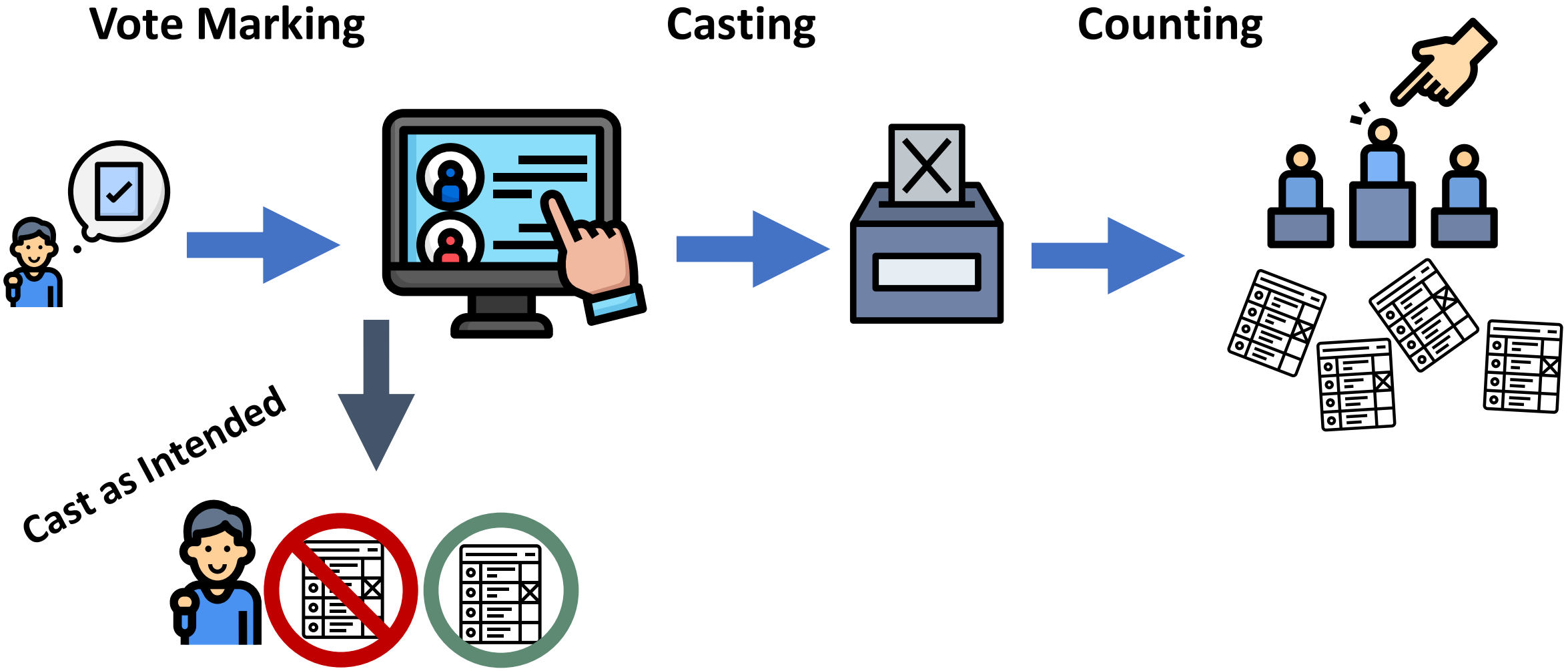
Raising Hands in a Group: Verifiable, but not private



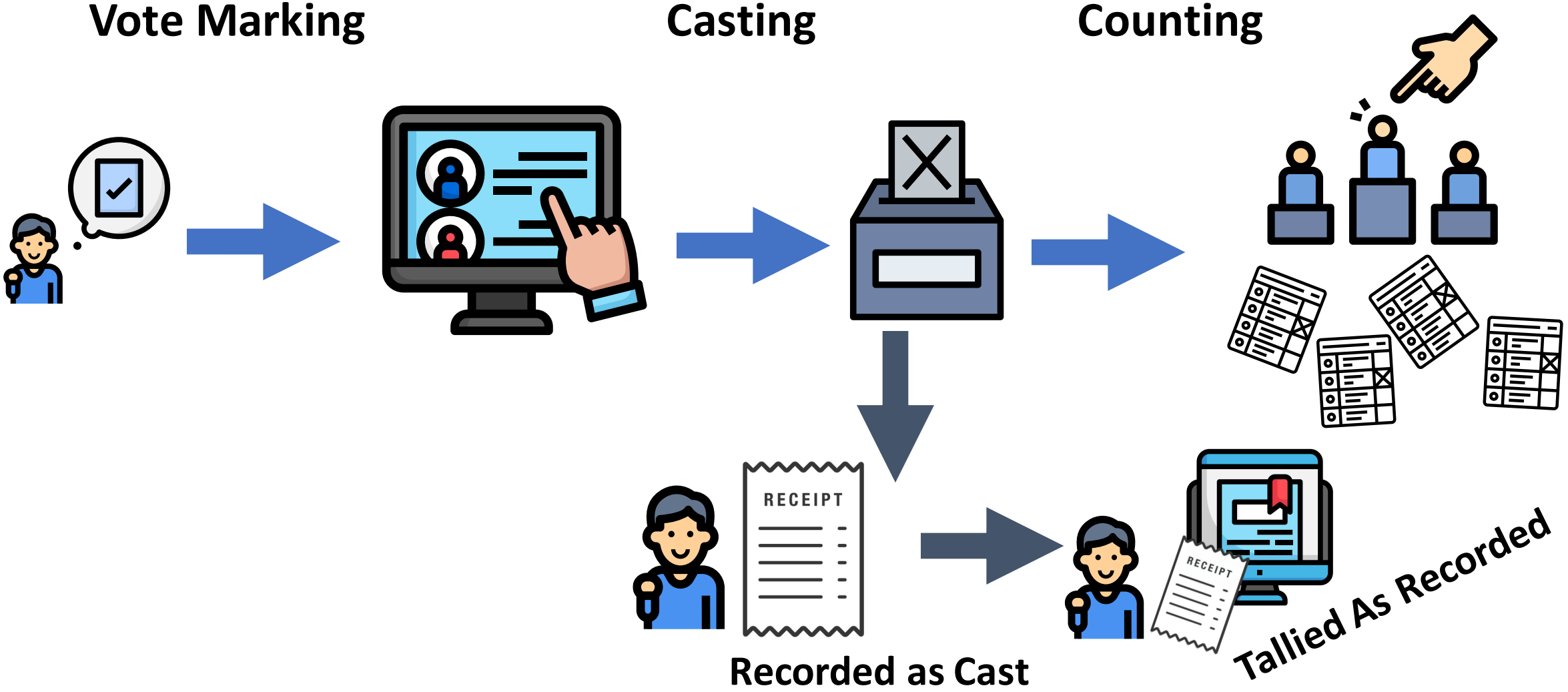
E2E-V Properties

- Cryptographically auditable voting protocols
  - ***Cast as Intended***: Voters have confidence that the their cast vote selections reflect intent
  - ***Recorded as Cast***: Voters can confirm their cast ballot was included in the results
  - ***Tallied as Recorded***: Vote counts are publicly verifiable
- Software Independent by design
  - *Paper-Based Systems*: Auditability achieved through voter-verifiable paper records and election procedures
  - *E2E Systems:* Auditability achieved through mathematical proofs; may **also** use paper records
- E2E protocols must provide these properties while also supporting usability, accessibility, security, privacy and functional requirements

What is E2E Verifiability?



What is E2E Verifiability?



Evaluation Challenges

- **Lack of Standards**
  - E2E protocols are application-specific
  - Use non-standard cryptographic algorithms
- **Security Analysis**
  - Protocol and algorithm evaluations require careful review by subject matter experts
- **Accessibility**
  - New voter verification/auditing processes present unique accessibility challenges
- **Testing Implementation in Voting Systems**
  - Systems must properly implement protocols to be software independent
  - Protocols must be securely implemented to avoid errors and preserve ballot secrecy

E2E-V Workshop

The Path to E2E Verifiable Protocols for Voting Systems

Purpose: Bring stakeholders together to begin the process of:

- Building a community of interest
- Identifying what is needed from E2E verifiable voting protocols and systems
- Establishing a public evaluation process for protocols
- Discussing requirements and evaluation criteria for a call for proposals

Oct. 6-7, 2022
Agenda

Opening Remarks: Chairman Hicks, EAC

Keynote- E2E Verifiability- Ben Adida, VotingWorks

Overview Of E2E Eval. Process- Andy Regenscheid, NIST

Panel 1: Integrity and Voter Confidence

Panel 2: Security

Panel 3: Accessibility and Human Factors

Panel 4: Implementation and Testing

Next Steps- Jon Panek, EAC

Closing Remarks: Chairman Hicks, EAC

E2E-V Workshop Feedback

- **E2E-V Voting Systems have unique and valuable characteristics**
  - Improve voter confidence/trust
  - Facilitate development of new voting system architectures
- **Significant challenges remain**
  - Complexity may reduce voter acceptance and trust – communication will be key
  - Technical evaluation of protocols and systems is difficult
  - Accessibility of voting and verification methods is critical
- **Move deliberately and thoughtfully**
  - "Nothing erodes trust more than getting it wrong with voter"
- **Open and transparent processes are critical**
  - Involve a diverse group of stakeholders
  - Allow public to see, analyze, and contribute to the process, provide open documentation
- **Learn through incremental progress**
  - Consider encouraging/facilitating pilot projects to learn from real-world systems

Takeaways

- **More research and community engagement is needed before initiating a call for proposals**
- **Protocols and system designs continue to change to support new properties and features, e.g.,**
  - Support different voting variations
  - Back-end optimizations
  - Quantum resistance
- **Stability needed to make evaluation/certification practical and cost-effective**
  - E2E verified voting protocol evaluation
  - Protocol implementation evaluation
  - System-level certification
- **NIST continues to believe an open and public process should be used to evaluate protocols**

Previously-Proposed Plan

Community Building	• Detail the plan - process, scope, etc. • Establish public feedback mechanisms
Call for Proposals	• Draft and seek input on evaluation criteria • Release CFP to formally initiate process
Evaluation *(Multiple Rounds)*	• Publish complete submissions publicly • Engage stakeholders in public events
Selection Decisions	• Analyze public feedback and make selections • Publish decision rationale
Maintenance	• Maintain specifications for protocols • Review any new research/findings
Testing and Certification	• Determine testing and evaluation methods for E2E protocol implementations

Needed Research Areas

- **Accessibility and usability of E2E verifiable voting systems**
  - For voters, pollworkers, and election officials using these systems
  - Address full process – system setup, voting, verification, and auditing
- **Impact on election management and pollworker responsibilities**
  - E2E verifiable voting systems introduce new steps to the process
  - New system components, e.g., verification website
- **Public transparency and trust in E2E verifiable voting protocols**
  - Study perceptions and trust in E2E verified voting protocols and systems
  - Communicating E2E verifiability to the public/voters
- **New methods/designs for E2E verifiable voting systems**
  - Front-end: Different protocols/designs to support different interfaces and voter interaction-
  - Back-end: New cryptographic protocol/designs to support voting variations and quantum resistance
- **Use of E2E verifiable protocols as an incremental tool**
  - Consider different usage scenarios where E2E verifiability could add to the voting process

Questions

- **Are there other research areas or questions that NIST and the EAC should investigate?**
- **How can NIST and the EAC facilitate incremental progress in E2E verifiable systems?**
  - What pilot projects or studies could be done?
  - How could/should we address usage of E2E verifiable voting protocols in otherwise software independent systems?
- **How and where can we bring the election officials, technologists, manufacturers, and advocates together to discuss challenges, needs, and solutions?**

Q&A/Discussion

Jon Panek – EAC Testing and Certification Director
Andrew Regenscheid - NIST

Email: Andrew.Regenscheid@nist.gov

NIST NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY U.S. DEPARTMENT OF COMMERCE

U.S. Election Assistance Commission

Background: *Crypto Standards Processes*

- NIST has been developing cryptographic standards since the Data Encryption Standard in the 1970s
- Similar challenges to vetting E2E protocols:
  - Difficult, multi-layered security evaluation process
  - Need to build confidence and trust to facilitate adoption
- Public evaluation processes valuing openness and transparency
  - Establish a community of interest with researchers, industry and practitioners
  - Develop open Calls for Proposals with clear requirements and evaluation criteria
  - Submissions open for public view, typically over multiple rounds
  - Rationale for decisions are publicly documented

Example: *PQC Selection Process*

Community Building
- Foundational research
- Workshops
- Participation in academic events

<2015

2016

Call for Proposals
- Public comments on requirements and evaluation criteria
- Formal Call for Submissions

First Round
- 82 Submissions Received
- 69 accepted as complete and proper

2017

2018

Public Evaluation
- 1st PQC Conference
- Ongoing communication with researcher

Second Round
- 26 candidates selected for Round 2
- Rationale published in NISTIR 8240
- 2nd PQC Conference

2019

2020

Third Round
- 7 finalists and 8 alternates selected for Round 3
- Rationale published in NISTIR 8309

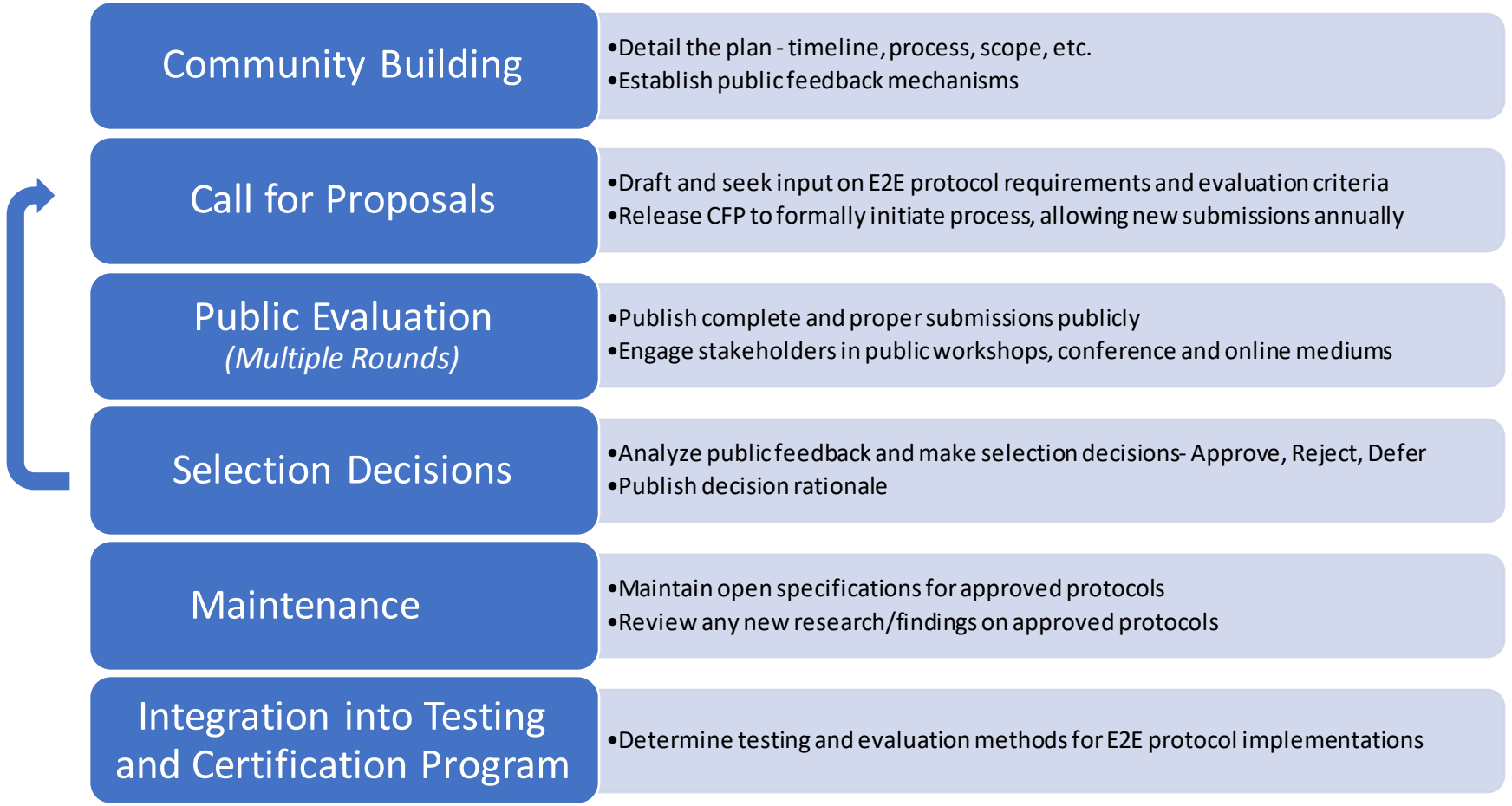
Public Evaluation
- 3rd PQC Conference
- Analysis of research results

2021

2022

Standards
- Initial selections announced
- Drafting standards

Previously-Proposed Process



What is E2E Verifiability?