Software Independence and Accessibility

A report from the

Human Factors & Privacy (HFP)
Security and Transparency (STC)

Subcommittees

The complete report is available on the NIST/TGDC web site:
http://vote.nist.gov/meeting-03222007/SI-n-access-031207.pdf

This work is in response to the TGDC Resolution #6-06

... To provide auditability and proactively address the increasing difficulty of protecting against all prospective threats, the TGDC directs STS to write requirements for the next version of the VVSG requiring the next generation of voting systems to be software independent. **The TGDC directs STS and HFP to draft usability and accessibility requirements to ensure that all voters can verify the independent voting record**...

HAVA 301(A) (3)(a) describes an accessible system as follows

"Accessibility for individuals with disabilities.--The voting system shall--

(A) be accessible for individuals with disabilities, including non-visual accessibility for the blind and visually impaired, in a manner that provides the same opportunity for access and participation (including privacy and independence) as for other voters;"

We analyzed 4 approaches to creating an accessible, software independent system

- Established definitions to use for
  - Software Independence (SI)
  - Voter Verification (VV)
  - Independent Dual Verification (IDV)
  - Observational Testing
- Described 4 approaches that have been proposed
- Analyzed each approach for its characteristics for
  - Software Independence
  - Voter Verification
  - Accessibility (and voter usability)
  - Auditability (and audit usability)

Software Independence (SI)

A global property of the system such that no purely technological problem can go undetected in the election as a whole. That detection might occur as a direct result of voters' observations, or during a subsequent audit.

By definition, no system that relies entirely on technology can be SI. Some human-performed checking is a necessary condition.

Voter Verification

The capability of *individual* voters to verify a record of their ballot choices. Two properties of that record have been up for discussion: its *independence* and its *permanence*. The TGDC resolution refers to an "independent" record; "permanent" is usually understood to imply non-electronic.

VV has two roles:
1) as one way (among others) for achieving SI and
2) as a way of building confidence for individual voters.

Independent Dual Verification

A less stringent system property than SI.

It requires that a second "independent" system (whether automated or human) be used to check on the first. Thus, purely automated solutions are possible, accepting the risk that the two systems might not really be independent or might otherwise mask failure.

Observational Testing

The use of voters without disabilities to observe the correct operation of the accessible voting system (e.g. does the printed record correspond to the audio review or playback?)

Review vs. Verification

For electronic voting systems review and verification are different

- Review – Voter action to view/hear all ballot choices on a single list, from the computer memory, before printing ballot, starting verification step or casting ballot.

- Verification – Voter action to view/hear all ballot choices on a Software Independent medium before casting ballot.

We described four approaches

1. Paper + Audio Review (with observational testing)
2. Paper + Audio Recording
3. Paper + Readback Device (with observational testing)
4. Frog Systems (IDV)

Note that these are not **systems**, but **approaches to creating a system**. Some of these approaches do not have commercial implementations.

#1 Paper + Audio Review (with observational testing)

Step 1 Voter marks the ballot	[Independent voting record created]	Step 2 Voter verifies record	Step 3 Voter casts ballot
Voters mark ballot using either the visual or audio interface. The final step of ballot marking is a review screen.	Paper audit trail created	A: Sighted voters: Verify the printed record B: Blind, low vision, low literacy, 2nd language, non-written language: No action	Voters cast ballot on the electronic device Audit uses printed record

1. Voter marks ballot using electronic system, which presents an audio review, and prints ballot (or paper audit trail).

2. A: Sighted voter (sometimes) verifies printed paper ballot.
   B: Blind, low vision, low literacy, second language, or non-written language voter: No action on the part of the voter, because the paper audit trail is not accessible.

3. Step 3: Voter casts ballot.

■ Auditing relies on paper ballots only

#2 Paper + Audio recording

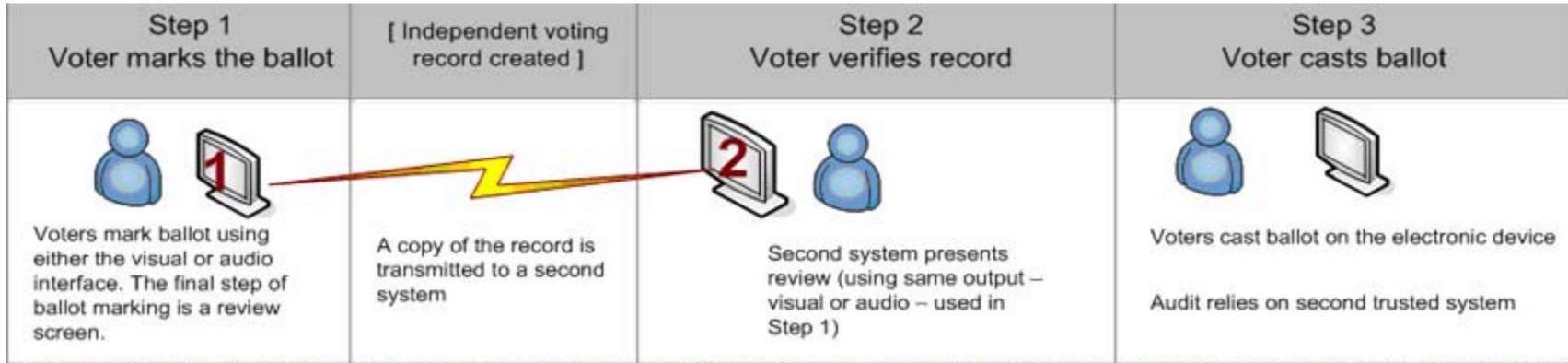| Step 1 Voter marks the ballot	[Independent voting record created]	Step 2 Voter verifies record	Step 3 Voter casts ballot
Voters mark ballot using either the visual or audio interface. The final step of ballot marking is a review screen.	Paper audit trail created when visual interface is used. OR Audio of review screen recorded when audio interface is used.	**A: Sighted voters:** Verify the printed record **B: Blind, low vision, low literacy, 2nd language, non-written language:** No additional action Audio recording serves as their permanent record	Voters cast ballot on the electronic device Audit uses printed record or audio record.

1. Voter marks ballot using electronic system, which records the audio review, and which prints ballot (or paper audit trail).

2. A: Sighted voter (sometimes) verifies printed paper ballot. B: Blind (and other) voter skips this step (audio recording serves as their permanent record).

3. Voter casts ballot.

- Auditing relies primarily on paper, can use audio records
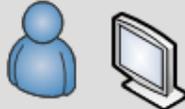
#3 Paper + Readback Device (with observational testing)

Step 1 Voter marks the ballot	[Independent voting record created]	Step 2 Voter verifies record	Step 3 Voter casts ballot
Voters mark ballot using either the visual or audio interface. The final step of ballot marking is a review screen.	Printed ballot created OR Paper audit trail created	**A: Sighted voters:** Verify the printed ballot or audit trail **B: Blind, low vision, low literacy, 2nd language, non-written language:** Second device used for OCR and then to "read back" the ballot or audit trail	**PRINTED BALLOT:** Voters cast ballot on PCOS device OR **VVPAT:** Voters cast ballot on the electronic device Audit uses printed record

1. Voter marks ballot using electronic system, and which prints ballot (or paper audit trail).

2. A: Sighted voter (sometimes) verifies printed paper ballot.
   B: Blind (and other) voter: Uses assistive device that "reads back" the ballot for verification using OCR.

3. Voter transports ballot to PCOS device to cast.

- Auditing relies on paper ballots only

#4 Frog System (IDV)

Step 1 Voter marks the ballot	[Independent voting record created]	Step 2 Voter verifies record	Step 3 Voter casts ballot
Voters mark ballot using either the visual or audio interface. The final step of ballot marking is a review screen.	A copy of the record is transmitted to a second system	Second system presents review (using same output – visual or audio – used in Step 1)	Voters cast ballot on the electronic device Audit relies on second trusted system

1. Voter marks ballot using electronic system.
2. Second system presents review (using same output (visual or audio) used in Step 1.
3. Voter casts ballot.

- Auditing relies on trusted second system.

	Step 1 Voter marks the ballot	[Independent voting record created]	Step 2 Voter verifies record	Step 3 Voter casts ballot
1 AUDIO REVIEW + OBSERVATION TESTING	Voters mark ballot using either the visual or audio interface. The final step of ballot marking is a review screen.	Paper audit trail created	**A: Sighted voters:** Verify the printed record **B: Blind, low vision, low literacy, 2nd language, non-written language:** No action	Voters cast ballot on the electronic device Audit uses printed record
2 AUDIO RECORDING	Voters mark ballot using either the visual or audio interface. The final step of ballot marking is a review screen.	Paper audit trail created when visual interface is used. **OR** Audio of review screen recorded when audio interface is used.	**A: Sighted voters:** Verify the printed record **B: Blind, low vision, low literacy, 2nd language, non-written language:** No additional action Audio recording serves as their permanent record	Voters cast ballot on the electronic device Audit uses printed record or audio record.
3 AUDIO + SCANNED PAPER RECORD	Voters mark ballot using either the visual or audio interface. The final step of ballot marking is a review screen.	Printed ballot created **OR** Paper audit trail created	**A: Sighted voters:** Verify the printed ballot or audit trail **B: Blind, low vision, low literacy, 2nd language, non-written language:** Second device used for OCR and then to "read back" the ballot or audit trail	**PRINTED BALLOT:** Voters cast ballot on PCOS device **OR** **VVPAT:** Voters cast ballot on the electronic device Audit uses printed record
4 FROG SYSTEM	Voters mark ballot using either the visual or audio interface. The final step of ballot marking is a review screen.	A copy of the record is transmitted to a second system	Second system presents review (using same output – visual or audio – used in Step 1)	Voters cast ballot on the electronic device Audit relies on second trusted system

Analysis of characteristics of the four approaches

Approach	SI	VV	Accessible	Auditable
1 – Paper + Audio review	Yes	No	Yes	Yes *
2 - Paper + Audio recording	Yes	Yes	Yes *	No
3 - Paper + readback device	Yes *	Yes	Yes *	Yes *
4 - Frog system (IDV)	No	No	Yes	Yes

* Footnotes are included in the full paper

Discussion points

- Which approaches should be considered?

- Use of assistive technology in verification?

- Others?

Discussion:
Which approaches should be considered?

- The Frog System approach is IDV, but not SI

- The Audio Recording approach has raised questions about its feasibility for audit, the usability/accessibility of handling the recording media and playback device.

- Recommendation:
  These two approaches should not be considered as meeting the requirements for a system to be both SI and accessible.

Discussion
Use of assistive technology in verification

- The audio + scanned paper approach relies on assistive technology to read the printed record back (using OCR or other technology). Does this violate the principles for Software Independence

- Recommendation:
  Allow assistive technology in verification. These devices can be checked through the observational defense and pre/post election testing.

Discussion:
Ballot privacy and assistance

- All systems must maintain ballot privacy (12.2.7: Privacy)

- Any approach that requires the record or ballot to be handled by the voter reduces independence for voters who lack the use of their hands, and may require them to have assistance.

- Discussion:
  What assistance can be used within the VVSG guidelines on dexterity and ballot submission?

Current requirements language in VVSG 2005 and the current draft

- **VVSG 2005: 3.2.3 e (Dexterity)**
  If the normal procedure is for voters to submit their own ballots, then the accessible voting station <u>shall</u> provide features that enable voters who lack fine motor control or the use of their hands to perform this submission.

- **DRAFT: 12.3.4-C (Dexterity) Ballot Submission**
  If the voting station supports ballot submission for non-disabled voters, then it <u>shall</u> also provide features that enable voters who lack fine motor control or the use of their hands to perform this submission.

Possible requirement:
Accessibility of Paper-based Vote Verification

If the Acc-VS generates a paper record (or some other durable, human-readable record) for the purpose of allowing voters to verify their ballot choices, then the system should provide a mechanism that can read that record and generate an audio representation of its contents. The use of this mechanism should be accessible to voters with dexterity disabilities.

Other questions?

Annex: Comparison of Voter Verification characteristics for blind and sighted voters

Scenario	Can voter verify contents?	Does independent record exist?	Can voter verify existence of record?
Sighted voter + screen	Yes	No	No
Blind voter + generated audio	Yes	No	No
Sighted voter + paper	Yes	Yes	Yes
Blind voter + Braille	Yes	Yes	Yes
Blind voter + audio recording	Yes	Yes	Not easily