

The Importance of Data Visualization

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Figure 1: Dashboard with warning lights.

In 1915, a piece was published in the *New Orleans Item* newspaper by Arthur Brisbane containing a very famous adage, “A picture is worth ten thousand words.”¹ By making this statement, Brisbane aimed to express how easily complicated information can be expressed through the form of a visual aid and how quickly information can be conveyed without the use of words. In 2024, the concept of visualizing information in the form of a picture remains ever so relevant. A prime example of this relevance can be seen above in Figure 1. Specifically, the check engine light on the dashboard quickly conveys that there is an issue with the vehicle’s engine that must be checked by a mechanic. Can you imagine if instead the dashboard included a paragraph explaining the potential issues with the engine which resulted in a crash while the driver was reading the messages? Rather, the light allows the driver to glance at the dash and immediately understand the situation. Researchers at the Massachusetts Institute of Technology reported, “the human brain can process entire images that the eye sees for as little as 13

¹ quoteresearch. “A Picture Is Worth Ten Thousand Words.” *Quote Investigator*, 22 July 2022, quoteinvestigator.com/2022/07/22/picture-words. Accessed 30 May 2024.

milliseconds.”² Since the human brain is optimized for image processing, visually presenting data makes sense for all areas requiring reporting, including the voting process in local, state, and federal elections.

Visual Reporting and the Voting Process

Social cohesion, gross domestic product, and overall well-being are linked to trust in government institutions through positive correlations in studies run by the Organization for Economic Co-operation and Development.³ However, recent polling data shows a significant portion of Americans lack faith in the voting process.⁴ To help ensure trust in the voting process, transparency must be prevalent within it. One way to ensure transparency is to use real-time visual reporting. While a picture is worth ten thousand words, real-time visual reports are worth many more. Validation Architectures (VA) redundantly process data in multiple data centers so that they can be compared and validated in real-time to protect data integrity. In the case of an election, a VA may be used to tally submitted ballots at two or more separate data centers. Database updates at these data centers should always be exact matches of each other. If not, an election director receives real-time alerts if ballot tallies at a data center are hacked by an unauthorized individual. Contemporaneous information about data center problems enables authorities to act immediately to prevent an attack from progressing.

² Trafton, Anne. “In The Blink of an Eye MIT Neuroscientists Find the Brain Can Identify Images Seen for as Little as 13 Milliseconds.” *MIT News on Campus and Around the World*, 16 Jan. 2014, news.mit.edu/2014/in-the-blink-of-an-eye-0116. Accessed 31 May 2024.

³ Organization for Economic Co-operation and Development. “Trust in Government: Assessing the Evidence, Understanding the Policies.” 47th Session of the Public Governance Committee. Paris, France: Organization for Economic Co-operation and Development, 2013. [Microsoft Word - GOV-PGC\(2013\)1 Trust in Government assessing the evidence, understanding the policies CANCEL AND REPLACE 15 Ap \(oecd.org\)](https://www.oecd.org/gov/2013/11/trust-in-government-assessing-the-evidence-understanding-the-policies-CANCEL-AND-REPLACE-15-Ap-oecd.org)

⁴ Gallup Inc. “Confidence in Election Integrity Hides Deep Partisan Divide.” Gallup.com, 2022. <https://news.gallup.com/poll/404675/confidence-election-integrity-hides-deep-partisan-divide.aspx>; Ipsos/ABC News. “Ipsos/ABC News Poll `December 27 – December 29, 2021).” Ipsos, 2022. https://www.ipsos.com/sites/default/files/ct/news/documents/2022-01/Topline%20ABC_Ipsos%20Poll%20January%206%202022.pdf; Murray, Patrick. “National: Public Supports Both Early Voting and Requiring Photo ID to Vote.” Monmouth University, 2021. https://www.monmouth.edu/polling-institute/documents/monmouthpoll_us_062121.pdf; Pew Research Center. “Two Years After Election Turmoil, GOP Voters Remain Skeptical on Elections, Vote Counts.” Pew Research Center, 2022. <https://www.pewresearch.org/politics/2022/10/31/views-of-election-administration-and-confidence-in-vote-counts/>; Trafalgar Group. “Nationwide Issues Survey.” Trafalgar Group, 2022. <https://www.thetrafalgargroup.org/wp-content/uploads/2022/11/COSA-ElectionTrust-Full-Report-1123.pdf>.



Figure 2 shows the architecture of a pair of VA-protected data centers.⁵ After the polls close, ballot images are securely uploaded from local precincts to the redundant data centers.

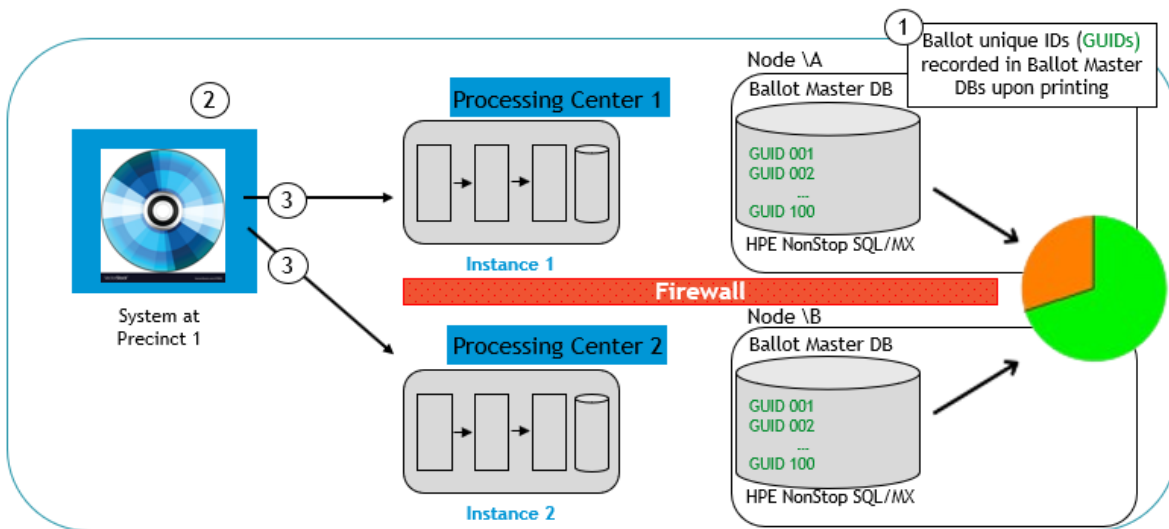


Figure 2: Two data centers in a VA shown redundantly processing ballot images and comparing tabulations in real-time.

The power of data visualization is seen in the image sequence below, which shows snapshots of a simulated hacker attack on a data center protected with a VA. Figure 3 is a real-time report showing inter-data center comparison results before an attack, taken when ballot image batches at the local precincts were still being uploaded and processed at the data centers. One data center received the ballot image batches quicker than the other, resulting in the pie chart showing temporary instances of late ballots (orange).

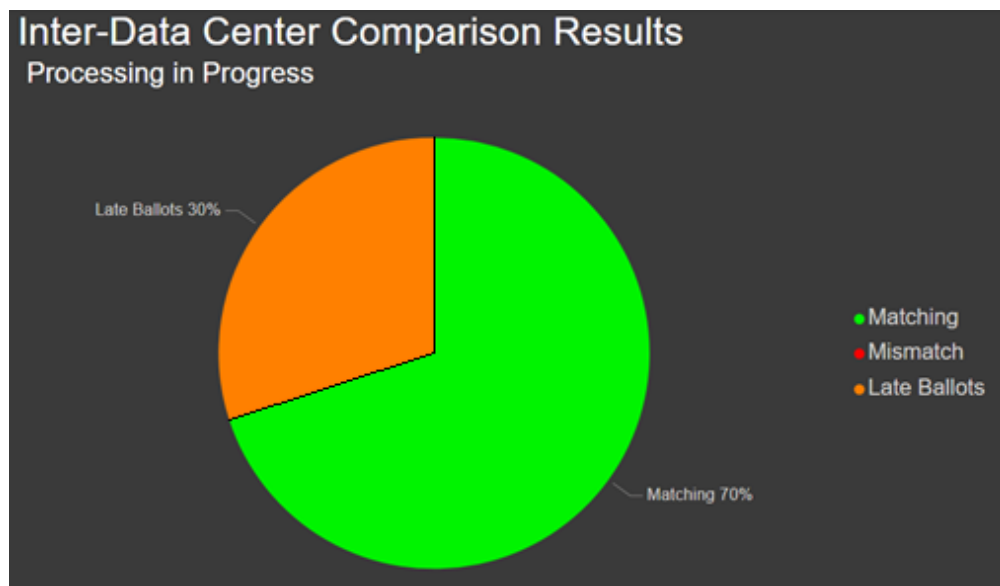


Figure 3: Ballot images are still being uploaded and processed.

⁵ Holenstein, Bruce, and Victor Berutti. "A Proof of Concept Study to Increase the Data Integrity of Voting Systems via Redundant Processing." *Remark Innovations*, 10 July 2023, remarkinnovations.com/wp-content/uploads/2023/07/Remark-Innovations-POC-Whitepaper-2023.pdf. Accessed 12 June 2024.



Figure 4 was taken when all of the ballot image batches were uploaded and processed by the data centers before the hacker attacks. All of the late batches of ballots are resolved. The pie chart contains only matching cases (green).

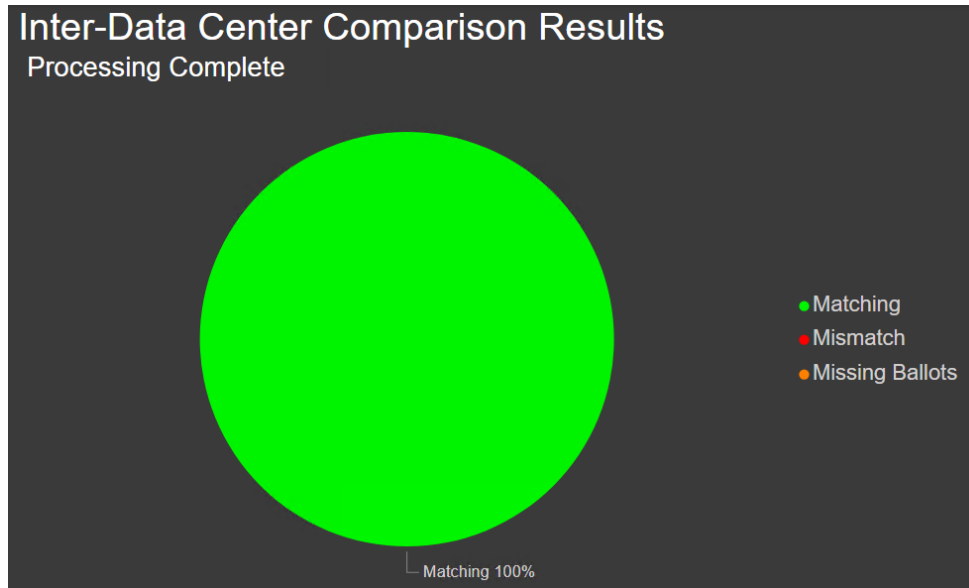


Figure 4: All ballot images have been successfully uploaded, processed, and compared at the two data centers.

In the third snapshot, Figure 5, a simulated hacker had unauthorized access to one of the data centers, changed ballot tallies in some of the ballot batches (red), and destroyed some ballots, preventing them from being processed (orange). The ballot batches did not balance between the data centers, which is seen because the pie chart now contains mismatch cases in red and missing ballot cases in orange.

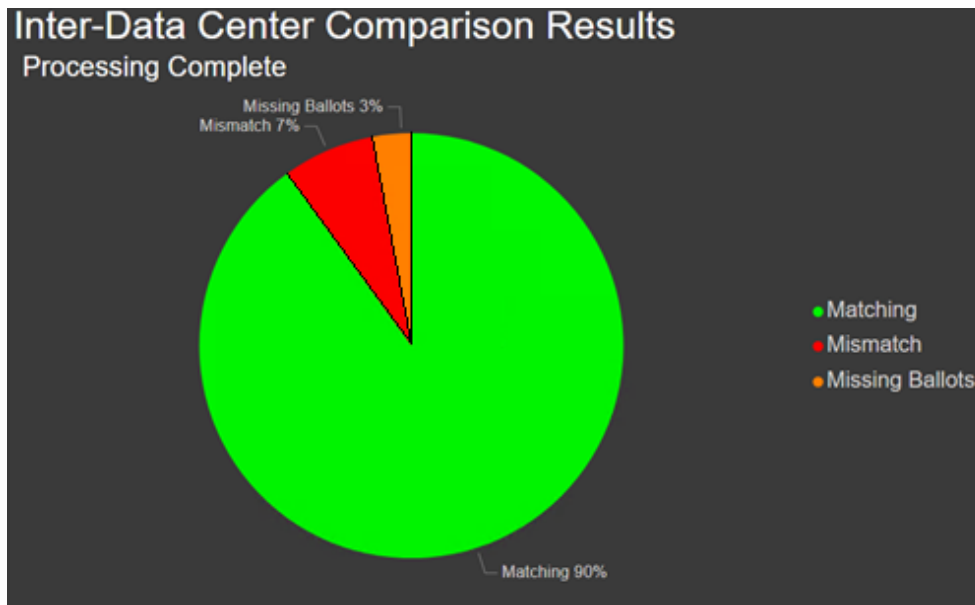


Figure 5: ALERT: Simulated hacker successfully gained access to the remote data center, changed ballot tallies (red), and destroyed some ballots preventing them from being processed (orange).



Conclusion

Citizens' trust in government institutions is extremely important to the overall well-being of a nation. The use of real-time visual reports can help improve government transparency and response time to balloting issues. A picture may be worth ten thousand words, and the value of the voters' trust gained through the resulting transparency is immeasurable.

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For more information on a proof of concept implementation of a Validation Architecture for balloting, contact Remark Innovations at information@remarkinnovations.com.

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- [Voting Systems as Mission-Critical Systems](#)
- [Ensuring Government Data Integrity: A Case for Dual Redundant Processing](#)
- [A Proof of Concept Study to Increase the Data Integrity of Voting Systems via Redundant Processing](#)

