AFFIDAVIT OF J. ALEX HALDERMAN

J. ALEX HALDERMAN, being duly sworn, deposes and says the following under penalty of perjury:

1. My name is J. Alex Halderman. I am a Professor of Computer Science and Engineering and the Director of the Center for Computer Security and Society at the University of Michigan in Ann Arbor, Michigan. I submit this Affidavit in support of Jill Stein’s Petition for a hand recount of all ballots in Wisconsin.

2. I have a Ph.D., a Master’s Degree, and a Bachelor’s Degree in Computer Science, all from Princeton University.

3. My research focuses on computer security and privacy, with an emphasis on problems that broadly impact society and public policy. Among my areas of research are software security, data privacy, and electronic voting.

4. I have authored more than seventy articles and books. My work has been cited in more than 4,700 scholarly publications. I have served on the program committees for thirty research conferences and workshops, and I co-chaired the USENIX Election Technology Workshop, which focuses on electronic voting security. I received the John Gideon Award for Election Integrity from the Election Verification Network, the Alfred P. Sloan Foundation Research Fellowship, the IRTF Applied Networking Research Prize, and the University of Michigan College of Engineering 1938 E Award for teaching and scholarship.

5. I have published peer-reviewed research analyzing the security of electronic voting systems used in Wisconsin, other U.S. states, and other countries. I was part of a team of experts commissioned by the California Secretary of State to conduct a “Top-to-Bottom” review of the
state’s electronic voting systems. I have also investigated methods for improving the security of
electronic voting, such as efficient techniques for testing whether electronic vote totals match
paper vote records.

6. My full curriculum vitae, including a list of honors and awards, research projects, and
publications, is attached as Exhibit A.

**Context: Cyberattacks and the 2016 Presidential Election**

7. The 2016 presidential election was subject to unprecedented cyberattacks apparently
intended to interfere with the election. This summer, attackers broke into the email system of the
Democratic National Committee and, separately, into the email account of John Podesta, the
chairman of Secretary Clinton’s campaign. Exhibits B and C. The attackers leaked private
messages from both hacks. Attackers also infiltrated the voter registration systems of two states,
Illinois and Arizona, and stole voter data. Exhibit D. The Department of Homeland Security has
stated that senior officials in the Russian government commissioned these attacks. Exhibit E.
Attackers attempted to breach election offices in more than 20 other states. Exhibit F.

8. Russia has sophisticated cyber-offensive capabilities, and it has shown a willingness to
use them to hack elections elsewhere. For instance, according to published reports, during the
2014 presidential election in Ukraine, attackers linked to Russia sabotaged Ukraine’s
vote-counting infrastructure, and Ukrainian officials succeeded only at the last minute in
defusing vote-stealing malware that could have caused the wrong winner to be announced.
Exhibit G. Countries other than Russia also have similarly sophisticated cyberwarfare
capabilities.
9. If a foreign government were to attempt to hack American voting machines to influence the outcome of a presidential election, one might expect the attackers to proceed as follows. First, the attackers might probe election offices (or the offices of election service vendors) well in advance to find ways to break into the computers. Next, closer to the election, when it was clear from polling data which states would have close electoral margins, the attackers might spread malware into voting machines in some of these states, manipulating the machines to shift a few percent of the vote to favor their desired candidate. One would expect a skilled attacker’s work to leave no visible signs, other than a surprising electoral outcome in which results in several close states differed from pre-election polling.

**The Vulnerability of American Voting Machines to Cyberattack**

10. As I and other experts have repeatedly documented in peer-reviewed and state-sponsored research studies, American voting machines have serious cybersecurity problems. Voting machines are computers with reprogrammable software. An attacker who can modify that software by infecting the machines with malware can cause the machines to provide any result of the attacker’s choosing. As I have demonstrated in laboratory tests, in just a few seconds, anyone can install vote-stealing malware on a voting machine that silently alters the electronic records of every vote.¹

11. Whether voting machines are connected to the Internet is irrelevant. Sophisticated attackers such as nation-states have developed a variety of techniques for attacking non-Internet-connected systems.² Shortly before each election, poll workers copy the ballot

¹ A video documenting this result is publicly available at [https://youtu.be/aZws98jw67g](https://youtu.be/aZws98jw67g).
² A well known example of this ability, which is known as “jumping an airgap”, is the Stuxnet computer virus, which was created to sabotage Iran’s nuclear centrifuge program by attacking factory equipment that was not directly connected to the Internet: [https://www.wired.com/2014/11/countdown-to-zero-day-stuxnet/](https://www.wired.com/2014/11/countdown-to-zero-day-stuxnet/).
design from a regular desktop computer in a government office (or at a company that services the
voting machines) and use removable media (akin to the memory card in a digital camera) to load
the ballot design onto each machine. That initial computer is almost certainly not well enough
secured to guard against attacks by foreign governments. If technically sophisticated attackers
infect that computer, they can spread vote-stealing malware to every voting machine in the area.
Most voting machines also have reprogrammable software ("firmware") that can in many cases
be manipulated well in advance of the election to introduce vote-stealing malware. Technically
sophisticated attackers can accomplish this with ease.

12. While the vulnerabilities of American voting machines have been known for some time,
states’ responses to these vulnerabilities have been patchy and inconsistent at best. Many states,
including Wisconsin, continue to use out-of-date machines that are known to be insecure.

13. Procedural safeguards used by Wisconsin and other states to protect their voting
equipment are inadequate to guard against manipulation of the election outcome via cyberattack.
These inadequate safeguards include tamper evident seals, protective counters, and test decks.
Tamper evident seals do not protect against remote electronic attackers, and may not even defend
against local attackers. 3 Malware installed on a voting machine can subvert the protective
counter by changing its value in the machine’s computer memory. Malware can subvert test
decks by refraining from cheating when only a small number of ballots have been scanned (as is
the case when a test deck is used), or by only cheating at a specified time of day (electronic
voting machines typically have internal clocks).

3 The types of seals commonly used on voting equipment have been shown to be easily defeated in tests. For a
14. The companies that provide and service election equipment for municipalities are another possible target for attackers. An example of such as a vendor is Command Central Elections, a small business in Minnesota that provides voting machines to approximately 1000 municipalities in Wisconsin. In many municipalities, Command Central is responsible for updating voting machine software and programming ballot designs prior to the election. Such companies provide an attractive target for attackers, since compromising their computer systems would allow an attack to spread to voting machines over much of the state. An attack on Command Central could affect election in hundreds of jurisdictions statewide by altering the software or election media in malicious ways that could go detected absent a manual examination of the ballots.

Examining the Paper Record Is the Only Way to Ensure the Integrity of the Result

15. Paper ballots are the best and most secure technology available for casting votes. Optical scan voting allows the voter to fill out a paper ballot that is scanned and counted by a computer. Electronic voting machines with voter-verified paper audit trails allow the voter to review a printed record of the vote he has just cast on a computer. Only a paper record documents the vote in a manner that cannot later be modified by malware or other forms of cyberattacks.

16. One explanation for the results of the 2016 presidential election is that cyberattacks influenced the result. This explanation is plausible, in light of other known cyberattacks intended to affect the outcome of the election; the profound vulnerability of American voting machines to cyberattack; and the fact that a skilled attacker would leave no outwardly visible evidence of an attack other than an unexpected result.

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4 http://ccelelections.com/
5 http://elections.wi.gov/elections-voting/voting-equipment/voting-equipment-use
17. The only way to determine whether a cyberattack affected the outcome of the 2016 presidential election is to examine the available physical evidence—that is, to count the paper ballots and paper audit trail records, and review the voting equipment, to ensure that the votes cast by actual voters match the results determined by the computers.

18. More than 70% of American voters, and all Wisconsin voters, have their votes recorded on some form of paper, which provides permanent evidence of their intent in the event of a post-election recount. Wisconsin’s paper vote records will not serve as a defense against cyberattacks unless they are inspected by human beings.

**Recounting Ballots With Optical Scan Tabulators Will Not Reliably Detect Manipulation**

19. For ballots cast through optical scanners, a manual recount of the paper ballots, without relying on the electronic equipment, is necessary to reliably detect possible hacking. Using optical scan machines to conduct the recount, even after first evaluating the machines through a test deck, is insufficient to detect potential cyberattacks. Attackers intending to commit a successful cyberattack could, and likely would, create a method to undermine any pre-tests.⁶

20. If the scanners were attacked by infecting them with malware, such malware might still be active in the scanners during the recount. Recounting the ballots using an infected scanner would likely yield the same results as the original count, despite the results being wrong.

21. If attackers managed to compromise the count during election day but in a manner that did not persist on the machines, machine recounts would still be insufficient. Attackers who were able to infect the machines before the election likely would be able to attack them again, perhaps using the same methods, prior to the recount. The dates and the procedures of the

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⁶ Volkswagen used a similar strategy to conceal the way its circumvent EPA emissions tests: http://www.reuters.com/article/us-volkswagen-emissions-audi-idUSKBN1370Q3
recount are widely publicized, so attackers would know when to strike. This would result in the
scanners producing the same incorrect results when the ballots were scanned again.

22. In contrast to machine recounts, a manual recount, where the paper ballots are inspected
by humans, can reliably detect any cyberattack that might have altered the election outcome on
the optical scanners. A manual recount is the best way, and indeed the only way, to ensure public
confidence that the results are accurate, authentic, and untainted by interference.

23. Manual recounts are not necessarily more time-consuming than recounting using optical
scanners, particularly when only one race is being counted. A manual recount focuses on a
single contest, and human observers typically proceed by sorting the ballots into stacks according
to the chosen candidate and then counting the ballots in each stack. This is an efficient and
straightforward process. If scanners are used, the scanners must be programmed and tested, new
removable media must be located and programmed, and the ballots must be fed into the scanner
by humans. These steps are not necessary when hand counting is used.

24. The paper ballots used in Wisconsin can be counted much more easily and reliably than
the punched card paper ballots that were recounted in Florida during the 2000 presidential
election. Punched card ballots are fragile, so each time they are counted, the record of voters’
intent may be inadvertently altered. They are also difficult to interpret, sometimes requiring a
magnifying glass to discern whether the voter intended to make a mark. Wisconsin’s optically
scanned paper ballots are a completely different technology. They create a persistent and readily
interpretable record of voters’ intent that does not suffer from these problems, and they can be
counted efficiently and accurately in a manual recount.
25. A manual recount will also set a precedent that will provide an important deterrent against cyberattacks on future elections. By performing a rigorous recount now in a method that would detect cyberattacks affecting the outcome (that is, a manual recount), we send a strong signal to attackers that any future computer-based tampering efforts are likely to be caught.

This affidavit was executed on the 28th day of November, 2016 in Newtown, Pennsylvania.

\[Signature\]

J. ALEX HALDERMAN

Sworn to before me this 28th day of November, 2016.

\[Signature\]

Notary Public

My Commission Expires: 08-05-2020
Exhibit A
J. Alex Halderman
Professor, Computer Science and Engineering
University of Michigan
November 4, 2016

Research Overview

My research focuses on computer security and privacy, with an emphasis on problems that broadly impact society and public policy. Topics that interest me include software security, network security, data privacy, anonymity, surveillance, electronic voting, censorship resistance, digital rights management, computer forensics, ethics, and cybercrime. I’m also interested in the interaction of technology with law, regulatory policy, and international affairs.

Selected Projects

'16: Let’s Encrypt HTTPS certificate authority
'15: Weak Diffie-Hellman and the Logjam attack
'14: Understanding Heartbleed’s aftermath
'14: Security problems in full-body scanners
'14: Analysis of Estonia’s Internet voting system
'13: ZMap Internet-wide network scanner
'12: Widespread weak keys in network devices
'11: Anticensorship in the network infrastructure
'10: Hacking Washington D.C.’s Internet voting
'10: Vulnerabilities in India’s e-voting machines
'10: Reshaping developers’ security incentives
'09: Analysis of China’s Green Dam censorware
'09: Fingerprinting paper with desktop scanners
'08: Cold-boot attacks on encryption keys
'07: California’s “top-to-bottom” e-voting review
'07: Machine-assisted election auditing
'06: The Sony rootkit: DRM’s harmful side effects
'03: Analysis of MediaMax “shift key” DRM

Positions

- University of Michigan, Ann Arbor, MI
  Department of Electrical Engineering and Computer Science, Computer Science and Engineering Division
  Professor … (2016–present)
  Associate Professor … (2015–2016)
  Assistant Professor … (2009–2015)
  Director, Center for Computer Security and Society (2014–present)

Education

- Ph.D. in Computer Science, Princeton University, June 2009
  Advisor: Ed Felten
  Doctoral committee: Andrew Appel, Adam Finkelstein, Brian Kernighan, Avi Rubin
- M.A. in Computer Science, Princeton University, June 2005
- A.B. in Computer Science, summa cum laude, Princeton University, June 2003
Honors and Awards

- Pwnie Award in the category of “Best Cryptographic Attack” for “DROWN: Breaking TLS using SSLv2,” Black Hat 2016
- Finalist for 2016 Facebook Internet Defense Prize for “DROWN: Breaking TLS using SSLv2”
- Named one of Popular Science’s “Brilliant 10” (2015) (“each year Popular Science honors the brightest young minds reshaping science, engineering, and the world”)
- Pwnie Award in the category of “Most Innovative Research” for “Imperfect Forward Secrecy: How Diffie-Hellman Fails in Practice,” Black Hat 2015
- IRTF Applied Networking Research Prize for “Neither Snow Nor Rain Nor MITM... An Empirical Analysis of Email Delivery Security” (2015)
- Alfred P. Sloan Research Fellowship (2015)
- University of Michigan College of Engineering 1938 E Award (2015) (“recognizes an outstanding teacher in both elementary and advanced courses, an understanding counselor of students who seek guidance in their choice of a career, a contributor to the educational growth of his/her College, and a teacher whose scholarly integrity pervades his/her service and the profession of Engineering”)
- Morris Wellman Faculty Development Assistant Professorship (2015) (“awarded to a junior faculty member to recognize outstanding contributions to teaching and research”)
- Best Paper Award of the 21st USENIX Security Symposium for “Mining Your Ps and Qs: Detection of Widespread Weak Keys in Network Devices” (2012)
- Runner-up for 2012 PET Award for Outstanding Research in Privacy Enhancing Technologies for “Telex: Anticensorship in the Network Infrastructure” (2012)
- John Gideon Memorial Award from the Election Verification Network for contributions to election verification (2011)
- Pwnie Award in the category of “Most Innovative Research” for “Lest We Remember: Cold Boot Attacks on Encryption Keys,” Black Hat 2008
- Charlotte Elizabeth Procter Honorific Fellowship, Princeton University (2007) (“awarded in recognition of outstanding performance and professional promise, and represents high commendation from the Graduate School”)
- National Science Foundation Graduate Research Fellowship (2004–2007)
- Best Paper Award of the 8th International Conference on 3D Web Technology
  for “Early Experiences with a 3D Model Search Engine” (2003)
- Princeton Computer Science Department Senior Award (2003)
- Accenture Prize in Computer Science, Princeton University (2002)
- Martin A. Dale Summer Award, Princeton University (2000)

Refereed Conference Publications

   Zakir Durumeric, Zane Ma, Drew Springall, Richard Barnes, Nick Sullivan, Elie Bursztein,
   Michael Bailey, J. A. Halderman, and Vern Paxson
   Acceptance rate: 16%, 68/423.

   Luke Valenta, David Adrian, Antonio Sanso, Shaanan Cohney, Joshua Fried, Marcella Hastings,
   J. A. Halderman, and Nadia Heninger
   Acceptance rate: 16%, 68/423.

   Ariana Mirian, Zane Ma, David Adrian, Matthew Tischer, Thasphon Chuenchujit, Tim Yardley,
   Robin Berthier, Josh Mason, Zakir Durumeric, J. A. Halderman and Michael Bailey

[4] Implementing Attestable Kiosks
   Matthew Bernhard, J. A. Halderman, and Gabe Stocco

   Drew Springall, Zakir Durumeric, and J. A. Halderman
   To appear in Proc. 16th ACM Internet Measurement Conference (IMC), Santa Monica, Nov. 2016.
   Acceptance rate: 25%, 46/184.

   Benjamin VanderSloot, Johanna Amann, Matthew Bernhard, Zakir Durumeric, Michael Bailey,
   and J. A. Halderman
   To appear in Proc. 16th ACM Internet Measurement Conference (IMC), Santa Monica, Nov. 2016.
   Acceptance rate: 25%, 46/184.
Proc. 25th USENIX Security Symposium, Austin, TX, August 2016.
Acceptance rate: 16%, 72/463.
**Tied for highest ranked submission.**
Pwnie award for best cryptographic attack.
Facebook Internet Defense Prize finalist.

[8] FTP: The Forgotten Cloud
Drew Springall, Zakir Durumeric, and J. A. Halderman
Acceptance rate: 22%, 58/259.

Earlence Fernandes, Qi Alfred Chen, Justin Paupore, Georg Essl, J. A. Halderman, Z. Morley Mao, and Atul Prakash
Proc. 20th International Conference on Financial Cryptography and Data Security (FC), Barbados, February 2016.

Proc. 22nd ACM Conference on Computer and Communications Security (CCS), Denver, CO, October 2015.
Acceptance rate: 19%, 128/659.
**Best paper award. Perfect review score.**
Pwnie award for most innovative research.

Zakir Durumeric, David Adrian, Ariana Mirian, Michael Bailey, and J. A. Halderman
Proc. 22nd ACM Conference on Computer and Communications Security (CCS), Denver, CO, October 2015.
Acceptance rate: 19%, 128/659.

[12] Neither Snow Nor Rain Nor MITM... An Empirical Analysis of Email Delivery Security
Zakir Durumeric, David Adrian, Ariana Mirian, James Kasten, Elie Bursztein, Nicholas Lidzborski, Kurt Thomas, Vijay Eranti, Michael Bailey, and J. A. Halderman
Proc. 15th ACM Internet Measurement Conference (IMC), Tokyo, October 2015.
Acceptance rate: 26%, 44/169.
**IRTF Applied Networking Research Prize winner.**
J. A. Halderman and Vanessa Teague
Proc. 5th International Conference on E-Voting and Identity (VoteID), Bern, Switzerland, September 2015.

Zakir Durumeric, Frank Li, James Kasten, Johanna Amann, Jethro Beekman, Mathias Payer, Nicolas Weaver, David Adrian, Vern Paxson, Michael Bailey, and J. A. Halderman
Acceptance rate: 23%, 43/188
Best paper award.
Honorable mention for Best dataset award.

[15] Security Analysis of the Estonian Internet Voting System
Drew Springall, Travis Finkenauer, Zakir Durumeric, Jason Kitcat, Harri Hursti, Margaret MacAlpine, and J. A. Halderman
Acceptance rate: 19%, 114/585.
Highest ranked submission.

[16] Efficiently Auditing Multi-Level Elections
Joshua A. Kroll, Edward W. Felten, and J. A. Halderman
Proc. 6th International Conference on Electronic Voting (EVOTE), Lochau, Austria, October 2014.

[17] Security Analysis of a Full-Body Scanner
Keaton Mowery, Eric Wustrow, Tom Wypych, Corey Singleton, Chris Comfort, Eric Rescorla, Stephen Checkoway, J. A. Halderman, and Hovav Shacham
Acceptance rate: 19%, 67/350.

[18] TapDance: End-to-Middle Anticensorship without Flow Blocking
Eric Wustrow, Colleen Swanson, and J. A. Halderman
Acceptance rate: 19%, 67/350.

[19] An Internet-Wide View of Internet-Wide Scanning
Zakir Durumeric, Michael Bailey, and J. A. Halderman
Acceptance rate: 19%, 67/350.

[20] Elliptic Curve Cryptography in Practice
Joppe W. Bos, J. A. Halderman, Nadia Heninger, Jonathan Moore, Michael Naehrig, and Eric Wustrow
Proc. 18th Intl. Conference on Financial Cryptography and Data Security (FC), March 2014.
Acceptance rate: 22%, 31/138.
Alex Migicovsky, Zakir Durumeric, Jeff Ringenberg, and J. A. Halderman
Proc. 18th Intl. Conference on Financial Cryptography and Data Security (FC), March 2014.
Acceptance rate: 22%, 31/138.

[22] Analysis of the HTTPS Certificate Ecosystem
Zakir Durumeric, James Kasten, Michael Bailey, and J. A. Halderman
Proc. 13th ACM Internet Measurement Conference (IMC), Barcelona, Spain, October 2013.
Acceptance rate: 24%, 42/178.

[23] ZMap: Fast Internet-Wide Scanning and its Security Applications
Zakir Durumeric, Eric Wustrow, and J. A. Halderman
Acceptance rate: 16%, 45/277.

James Kasten, Eric Wustrow, and J. A. Halderman

[25] Mining Your Ps and Qs: Detection of Widespread Weak Keys in Network Devices
Nadia Heninger, Zakir Durumeric, Eric Wustrow, and J. A. Halderman
Acceptance rate: 19%, 43/222.

Best paper award.

[26] Attacking the Washington, D.C. Internet Voting System
Scott Wolchok, Eric Wustrow, Dawn Isabel, and J. A. Halderman

Election Verification Network John Gideon Memorial Award.

[27] Telex: Anticensorship in the Network Infrastructure
Eric Wustrow, Scott Wolchok, Ian Goldberg, and J. A. Halderman
Acceptance rate: 17%, 35/204.

Runner-up for 2012 PET Award for Outstanding Research in Privacy Enhancing Technologies.

[28] Internet Censorship in China: Where Does the Filtering Occur?
Xueyang Xu, Z. Morley Mao, and J. A. Halderman
Acceptance rate: 29%, 23/79.
[29] **Absolute Pwnage: Security Risks of Remote Administration Tools**  
Jay Novak, Jonathan Stibrley, Kenneth Meagher, and J. A. Halderman  
Acceptance rate: 20%, 15/74.

[30] **Security Analysis of India’s Electronic Voting Machines**  
Acceptance rate: 17%, 55/320.  
**Highest ranked submission.**

[31] **Sketcha: A Captcha Based on Line Drawings of 3D Models**  
Steve Ross, J. A. Halderman, and Adam Finkelstein  
Acceptance rate: 12%, 91/754.

[32] **Defeating Vanish with Low-Cost Sybil Attacks Against Large DHTs**  
Scott Wolchok, Owen S. Hofmann, Nadia Heninger, Edward W. Felten, J. A. Halderman, Christopher J. Rossbach, Brent Waters, and Emmett Witchel  
Acceptance rate: 15%, 24/156.

[33] **Fingerprinting Blank Paper Using Commodity Scanners**  
William Clarkson, Tim Weyrich, Adam Finkelstein, Nadia Heninger, J. A. Halderman, and Edward W. Felten  
Acceptance rate: 10%, 26/254.

[34] **Lest We Remember: Cold-Boot Attacks on Encryption Keys**  
Acceptance rate: 16%, 27/170.  
**Best student paper award.**  
Pwnie award for most innovative research.

[35] **Harvesting Verifiable Challenges from Oblivious Online Sources**  
J. A. Halderman and Brent Waters  
Acceptance rate: 18%, 55/302.
[36] Lessons from the Sony CD DRM Episode
   J. A. Halderman and Edward W. Felten
   Acceptance rate: 12%, 22/179.

[37] A Convenient Method for Securely Managing Passwords
   J. A. Halderman, Brent Waters, and Edward W. Felten

[38] New Client Puzzle Outsourcing Techniques for DoS Resistance
   Brent Waters, Ari Juels, J. A. Halderman, and Edward W. Felten
   Acceptance rate: 14%, 35/251.

[39] Early Experiences with a 3D Model Search Engine
   Patrick Min, J. A. Halderman, Michael Kazhdan, and Thomas Funkhouser
   Best paper award.

Book Chapters

[40] Practical Attacks on Real-world E-voting
   J. A. Halderman

Journal Publications

[41] Lest We Remember: Cold-Boot Attacks on Encryption Keys

[42] A Search Engine for 3D Models
   Thomas Funkhouser, Patrick Min, Michael Kazhdan, Joyce Chen, J. A. Halderman, David P. Dobkin, and David Jacobs
Refereed Workshop Publications

[43] Content-Based Security for the Web
Alexander Afanasyev, J. A. Halderman, Scott Ruoti, Kent Seamons, Yingdi Yu, Daniel Zappala, and Lixia Zhang

[44] Umbra: Embedded Web Security through Application-Layer Firewalls
Travis Finkenauer and J. A. Halderman

[45] Replication Prohibited: Attacking Restricted Keyways with 3D Printing
Ben Burgess, Eric Wustrow, and J. A. Halderman
Proc. 9th USENIX Workshop on Offensive Technologies (WOOT), Washington, DC, August 2015.

Proc. 8th USENIX Workshop on Offensive Technologies (WOOT), San Diego, CA, August 2014.

[47] Zippier ZMap: Internet-Wide Scanning at 10Gbps
David Adrian, Zakir Durumeric, Gulshan Singh, and J. A. Halderman
Proc. 8th USENIX Workshop on Offensive Technologies (WOOT), San Diego, CA, August 2014.

[48] Internet Censorship in Iran: A First Look
Simurgh Aryan, Homa Aryan, and J. A. Halderman
Proc. 3rd USENIX Workshop on Free and Open Communications on the Internet (FOCI), Washington, D.C., August 2013.

Anthony Bonkoski, Russ Bielawski, and J. A. Halderman

[50] Crawling BitTorrent DHTs for Fun and Profit
Scott Wolchok and J. A. Halderman

[51] Can DREs Provide Long-Lasting Security?
The Case of Return-Oriented Programming and the AVC Advantage
Steve Checkoway, Ariel J. Feldman, Brian Kantor, J. A. Halderman, Edward W. Felten, and Hovav Shacham

[52] You Go to Elections with the Voting System You Have:
Stop-Gap Mitigations for Deployed Voting Systems
J. A. Halderman, Eric Rescorla, Hovav Shacham, and David Wagner
[53] In Defense of Pseudorandom Sample Selection
Joseph A. Calandrino, J. A. Halderman, and Edward W. Felten

Ariel J. Feldman, J. A. Halderman, and Edward W. Felten

Joseph A. Calandrino, J. A. Halderman, and Edward W. Felten

[56] Privacy Management for Portable Recording Devices
J. A. Halderman, Brent Waters, and Edward W. Felten
Acceptance rate: 22%, 10/45.

[57] Evaluating New Copy-Prevention Techniques for Audio CDs
J. A. Halderman

Selected Other Publications

[58] The Security Challenges of Online Voting Have Not Gone Away
Robert Cunningham, Matthew Bernhard, and J. A. Halderman

[59] TIVOS: Trusted Visual I/O Paths for Android
Earlence Fernandes, Qi Alfred Chen, Georg Essl, J. A. Halderman, Z. Morley Mao, and Atul Prakash
Technical report, Computer Science and Engineering Division, University of Michigan, Ann Arbor, MI, May 2014.

[60] Tales from the Crypto Community:
The NSA Hurt Cybersecurity. Now It Should Come Clean
Nadia Heninger and J. A. Halderman
Foreign Affairs, October 23, 2013.
[61] Ethical Issues in E-Voting Security Analysis
David G. Robinson and J. A. Halderman

J. A. Halderman

[63] Analysis of the Green Dam Censorware System
Scott Wolchok, Randy Yao, and J. A. Halderman
Technical report, Computer Science and Engineering Division, University of Michigan, Ann Arbor, MI, June 2009.

[64] AVC Advantage: Hardware Functional Specifications
J. A. Halderman and Ariel J. Feldman


Edward W. Felten and J. A. Halderman

[67] Analysis of the MediaMax CD3 Copy-Prevention System
J. A. Halderman

**Selected Legal and Regulatory Filings**

[68] Request for DMCA Exemption: Games with Insecure DRM and Insecure DRM Generally
*(Outcome: Requested exemption granted in part.)*

[69] Request for DMCA Exemption for Audio CDs with Insecure DRM
*(Outcome: Requested exemption granted in part.)*
Patents

[70] Controlling Download and Playback of Media Content
  Wai Fun Lee, Marius P. Schilder, Jason D. Waddle, and J. A. Halderman

[71] System and Method for Machine-Assisted Election Auditing
  Edward W. Felten, Joseph A. Calandrino, and J. A. Halderman

Speaking

Major Invited Talks and Keynotes

- Let's Encrypt

- Elections and Cybersecurity: What Could Go Wrong?

- Internet Voting: What Could Go Wrong?

- Logjam: Diffie-Hellman, Discrete Logs, the NSA, and You

- The Network Inside Out: New Vantage Points for Internet Security
  Invited talk, China Internet Security Conference (ISC), Beijing, September 30, 2015.

- The Network Inside Out: New Vantage Points for Internet Security
  Keynote speaker, ESCAR USA (Embedded Security in Cars), Ypsilanti, Michigan, May 27, 2015.

- Security Analysis of the Estonian Internet Voting System.

- The Network Inside Out: New Vantage Points for Internet Security
  Keynote speaker, 14th Brazilian Symposium on Information Security and Computer Systems (SBSeg), Belo Horizonte, Brazil, November 4, 2014.

- Empirical Cryptography: Measuring How Crypto is Used and Misused Online
  Keynote speaker, 3rd International Conference on Cryptography and Information Security in Latin America (LatiCrypt), Florianópolis, Brazil, September 2014.

- Healing Heartbleed: Vulnerability Mitigation with Internet-wide Scanning


Verifiably Insecure: Perils and Prospects of Electronic Voting
Invited talk, Computer Aided Verification (CAV) 2012 (Berkeley, CA), July 13, 2012.

Deport on Arrival: Adventures in Technology, Politics, and Power

Electronic Voting: Danger and Opportunity

Selected Talks (2009–present)


Logjam: Diffie-Hellman, Discrete Logs, the NSA, and You. Invited talk, NYU Tandon School of Engineering, April 8, 2016 [host: Damon McCoy]; Invited talk, UIUC Science of Security seminar, February 9, 2016 [host: Michael Bailey].


Influence on Democracy of Computers, Internet, and Social Media. Invited speaker, Osher Lifelong Learning Institute at the University of Michigan, March 26, 2015.


- Internet Censorship in Iran: A First Look. 3rd USENIX Workshop on Free and Open Communications on the Internet (FOCI), Aug. 13, 2013.

- Mining Your Ps and Qs: Detection of Widespread Weak Keys in Network Devices. Invited talk, NSA, Aug. 8, 2013; Invited talk, Taiwan Information Security Center Workshop, National Chung-Hsing University (Taichung, Taiwan), Nov. 16., 2012


- Voter IDon't. Rump session talk; 21st USENIX Security Symposium (Bellevue, WA), Aug. 8, 2012; Rump session talk; EVT/WOTE ’12 (Bellevue, WA), Aug. 6, 2012 [with Josh Benaloh].


- Security Problems in India’s Electronic Voting Machines. Dagstuhl seminar on Verifiable Elections and the Public (Wadern, Germany), July 12, 2011; Harvard University, Center for Research on Computation and Society (CRCS) seminar, Jan. 24, 2011 [host: Ariel Procaccia]; U. Michigan, CSE seminar, Nov. 18, 2010 [with Hari Prasad]; MIT, CSAIL CIS Seminar, Nov. 12, 2010 [with Hari Prasad; host: Ron Rivest]; Distinguished lecture, U.C. San Diego, Department of Computer Science, Nov. 9, 2010 [with Hari Prasad; host: Hovav Shacham]; U.C. Berkeley, Center for Information Technology Research in the Interest of Society (CITRIS), Nov. 8, 2010 [with Hari Prasad; host: Eric Brewer]; Google, Inc., Tech Talk (Mountain View, CA), Nov. 5, 2010 [with Hari Prasad; host: Marius Schilder]; U.C., Berkeley TRUST Security Seminar, Nov. 4, 2010 [with Hari Prasad; host: Shankar Sastry]; Stanford University, CS Department, Nov. 3, 2010 [with Hari Prasad; host: David Dill]; Princeton University, Center for Information Technology Policy, Oct. 28, 2010 [with Hari Prasad, host: Ed Felten]; University of Texas at Austin, Department of Computer Science, Aug. 27, 2010 [host: Brent Waters].


Selected Other Speaking (2010–present)


Panelist: The Future of E-Voting Research. 5th International Conference on E-Voting and Identity (VoteID), Bern, Switzerland, Sep. 4, 2015.


Panelist: Civil Society’s Challenge in Preserving Civic Participation. The Public Voice workshop: Privacy Rights are a Global Challenge, held in conjunction with the 34th International Conference of Data Protection and Privacy Commissioners, Punta del Este, Uruguay, Oct. 22, 2012 [moderator: Lillie Coney].
Panelist: Election Technologies: Today and Tomorrow. Microsoft Faculty Summit (Redmond), July 17, 2012 [moderator: Josh Benaloh].
Panelist: Internet Voting. RSA Conference (San Francisco), Mar. 1, 2012 [moderator: Ron Rivest].
Panelist: Connecticut Secretary of State’s Online Voting Symposium (New Britain, CT), Oct. 27, 2011 [moderator: John Dankosky].
Tutorial speaker/organizer: Security Issues in Electronic Voting, ICiSS (Gandhinagar, India), Dec. 15, 2010 [canceled under threat of deportation].

Advising and Mentoring

Graduate Students
- Allison McDonald (Ph.D. in progress)
- Matthew Bernhard (Ph.D. in progress)
- Benjamin VanderSloot (Ph.D. in progress)
- David Adrian (Ph.D. in progress)
- Andrew Springall (Ph.D. in progress; NSF Graduate Research Fellowship)
- Zakir Durumeric (Ph.D. in progress; Google Ph.D. Fellowship in Computer Security)
- Travis Finkenauer (M.S. 2016; went on to security position at Juniper Networks)
- Eric Wustrow (Ph.D. 2016; went on to tenure track faculty position at U. Colorado, Boulder)
- James Kasten (Ph.D. 2015; went on to software engineering position at Google)
- Scott Wolchok (M.S. 2011; went on to software engineering position at Facebook)
Post Docs
  – Colleen Swanson (2014–15)

Doctoral Committees
  – Denis Bueno (C.S. P.D. expected 2016, Michigan)
  – Eric Crockett (C.S. Ph.D expected 2016, Georgia Tech)
  – Jakub Czyz (C.S. Ph.D. 2016, Michigan)
  – Eric Wustrow (C.S. Ph.D. 2016, Michigan; chair)
  – James Kasten (C.S. Ph.D. 2015, Michigan; chair)
  – Jing Zhang (C.S. Ph.D. 2015, Michigan)
  – Katharine Cheng (C.S. Ph.D. 2012, Michigan)
  – Matt Knysz (C.S. Ph.D. 2012, Michigan)
  – Zhiyun Qian (C.S. Ph.D. 2012, Michigan)
  – Xin Hu (C.S. Ph.D. 2011, Michigan)
  – Ellick Chan (C.S. Ph.D. 2011, UIUC)

Undergraduate Independent Work
  – 2016: Ben Burgess, Noah Duncan
  – 2015: Ben Burgess, Rose Howell, Vikas Kumar, Ariana Mirian, Zhi Qian Seah
  – 2014: Christopher Jeakle, Andrew Modell, Kollin Purcell
  – 2013: David Adrian, Anthony Bonkoski, Alex Migicovsky, Andrew Modell, Jennifer O’Neil
  – 2011: Yilun Cui, Alexander Motalleb
  – 2010: Arun Ganesan, Neha Gupta, Kenneth Meagher, Jay Novak, Dhritiman Sagar, Samantha Schumacher, Jonathan Stribley
  – 2009: Mark Griffin, Randy Yao

Teaching
  – **Introduction to Computer Security**, EECS 388, University of Michigan
    Terms: Fall 2017, Fall 2016, Fall 2015, Fall 2014, Fall 2013, Fall 2011, Fall 2010, Fall 2009
    Created new undergrad security elective that has grown to reach >750 students/year. An accessible intro, teaches the security mindset and practical skills for building and analyzing security-critical systems.
  – **Computer and Network Security**, EECS 588, University of Michigan
    Redesigned core grad-level security course. Based around discussing classic and current research papers and performing novel independent work. Provides an intro. to systems research for many students.
  – **Securing Digital Democracy**, Coursera (MOOC)
    Designed and taught a massive, open online course that explored the security risks—and future potential—of electronic voting and Internet voting technologies; over 20,000 enrolled students.
Professional Service

Program Committees

- 2017 ISOC Network and Distributed Systems Security Symposium (NDSS ’17)
- 2016 ACM Internet Measurement Conference (IMC ’16)
- 2016 USENIX Security Symposium (Sec ’16)
- 2016 International Joint Conference on Electronic Voting (E-VOTE-ID ’16)
- 2016 Workshop on Advances in Secure Electronic Voting (Voting ’16)
- 2015 ACM Conference on Computer and Communications Security (CCS ’15)
- 2015 ACM Internet Measurement Conference (IMC ’15)
- 2015 USENIX Security Symposium (Sec ’15)
- 2014 ACM Conference on Computer and Communications Security (CCS ’14)
- 2014 USENIX Security Symposium (Sec ’14)
- 2013 ACM Conference on Computer and Communications Security (CCS ’13)
- Program co-chair, 2012 Electronic Voting Technology Workshop/Workshop on Trustworthy Elections (EVT/WOTE ’12)
- 2012 Workshop on Free and Open Communications on the Internet (FOCI ’12)
- 2012 IEEE Symposium on Security and Privacy (“Oakland” ’12)
- 2012 International Conference on Financial Cryptography and Data Security (FC ’12)
- 2011 Workshop on Free and Open Communications on the Internet (FOCI ’11)
- 2011 Electronic Voting Technology Workshop (EVT/WOTE ’11)
- 2010 ACM Conference on Computer and Communications Security (CCS ’10)
- 2010 USENIX/ACCURATE/IAVOSS Electronic Voting Technology Workshop (EVT ’10)
- 2010 USENIX Security Symposium (Sec ’10)
- 2010 IEEE Symposium on Security and Privacy (Oakland ’10)
- 2010 International World Wide Web Conference (WWW ’10)
- 2009 ACM Conference on Computer and Communications Security (CCS ’09)
- 2009 ACM Workshop on Digital Rights Management (DRM ’09)
- 2009 ACM Workshop on Multimedia Security (MMS ’09)
- 2009 USENIX Workshop on Offensive Technologies (WOOT ’09)
- 2009 International World Wide Web Conference (WWW ’09)
- 2008 ACM Conference on Computer and Communications Security (CCS ’08)
- 2008 ACM Workshop on Privacy in the Electronic Society (WPES ’08)
- 2008 USENIX/ACCURATE Electronic Voting Technology Workshop (EVT ’08)
- 2008 International World Wide Web Conference (WWW ’08)

Boards

- Board of Directors for the Internet Security Research Group (2014–present)
- Board of Advisors for the Verified Voting Foundation (2012–present)
– External Advisory Board for the DemTech Project, IT University of Copenhagen (2011–present)

Department and University Service
– Faculty Advisor for Michigan Hackers student group (2012–present)
– CSE Graduate Affairs Committee (member, 2014–present)
– CSE Undergraduate Program Advising (CS/ENG) (2011–present)
– Faculty Senate, Rules Committee of the Senate Assembly (member, 2011–12)
– CSE Graduate Admissions Committee (member, 2010–11)
– CSE Graduate Committee (member, 2009–10)

Broader Impact of Selected Projects
– **Let’s Encrypt: A Certificate Authority to Encrypt the Entire Web (2016)**
  Co-founded a new HTTPS certificate authority to provide free, browser-trusted, automatically validated certificates for all domains. Developed in partnership with EFF and Mozilla, Let’s Encrypt has helped secure millions of websites and is now issuing certificates at a greater rate than all other CAs combined.

  Introduced Logjam, a practical attack on TLS that affected nearly 10% of popular HTTPS websites. Our results suggest that state-level attackers can break 1024-bit Diffie-Hellman, providing the first parsimonious explanation for how NSA is decrypting widespread VPN traffic, as revealed by Snowden.

– **Security Analysis of the Estonian Internet Voting System (2014)**
  Led the first rigorous security review of world’s most significant Internet voting system. Based on code review, laboratory testing, and in-person observation, our study revealed significant shortcomings that could allow state-level attackers to upset national elections.

– **ZMap Internet-Wide Scanner Open-Source Project (2013)**
  Created ZMap, a network probing tool designed for Internet-wide measurement research that achieves up to $10,000 \times$ better performance than earlier tools. Now a thriving open-source project, ZMap is available in major Linux distros. We also maintain Scans.io, a public scan data repository.

– **Detection of Widespread Weak Keys in Network Devices (2012)**
  After conducting the largest Internet-wide survey of HTTPS and SSH hosts, we uncovered serious flaws in cryptographic public key generation affecting millions of users. We disclosed vulnerabilities to more than 60 network device makers and spawned major changes to the Linux random number generator.

– **The Telex Anticensorship System (2011)**
  Invented a fundamentally new approach to circumventing state-level Internet censorship, based on placing anticensorship technology into core network infrastructure outside the censoring country. Prototype attracted over 100,000 users, mainly in China. Now testing next-gen. schemes at partner ISP.

  Participated in the first public security trial of an Internet voting system set to be deployed in a real election. We found serious flaws that allowed us to change all votes without detection. This led to the system being scrapped, and the widespread media coverage has altered the debate on Internet voting.
- **Analysis of India’s E-Voting System (2010)**
  Participated in the first independent security review of the electronic voting machines used by half a billion voters in India. The flaws uncovered in our work were front-page news. After arresting my coauthor and threatening to deport me, officials eventually moved to adopt a paper trail nationwide.

- **Green Dam Youth Escort Censorware (2009)**
  Uncovered security problems and copyright infringement in client-side censorship software mandated by the Chinese government. Findings helped catalyze popular protest against the program, leading China to reverse its policy requiring installation on new PCs.

- **Cold-Boot Attacks (2008)**
  Developed the “cold boot” attack against software disk encryption systems, which altered widespread thinking on security assumptions about the behavior of RAM, influenced computer forensics practice, and inspired the creation of a new subfield of theoretical cryptography.

- **California “Top-to-Bottom” Review (2007)**
  Helped lead the California Secretary of State’s “top-to-bottom” review of electronic voting machines, the first public review of this technology by any state. Our reports led California to discontinue use of highly vulnerable touch-screen voting systems and altered the course of election technology in the U.S.

- **DMCA Exemptions for Security (2006 and 2010)**
  Worked with legal teams to successfully petition the U.S. Copyright Office to create exemptions to the Digital Millennium Copyright Act (which prohibits circumventing DRM) in order to allow the public to investigate and repair security problems caused by certain DRM. One of only six exemptions granted.

- **Sony DRM Rootkit (2005)**
  Discovered dangerous security side-effects in the design of copy protection software used for music CDs. Resulted in the recall of millions of discs, class action lawsuits, and an investigation by the U.S. Federal Trade Commission in which I served as a technical expert on DRM’s harm to consumers’ security.

- **The Art of Science (2004)**
  Co-founded an interdisciplinary art competition at Princeton University that showcases images and videos produced in the course of scientific research as well as creative works that incorporate tools and ideas from science. Following international attention, the concept has spread to many other campuses.
Outreach and Press Coverage

I’m a regular contributor to Freedom-to-Tinker, a blog hosted by Princeton’s CITP. My posts discuss current issues in security and public policy or announce new research results, aiming to communicate findings to nonspecialists.

I’m happy to speak to the press when I believe the topic is important for the public to understand. Much of my research has received significant media attention.

Selected media outlets  

References

Edward W. Felten  
Professor  
Princeton University  
ACM Fellow, NAE Member  
felten@cs.princeton.edu

Farnam Jahanian  
Provost  
Carnegie Mellon University  
AAAS, ACM, & IEEE Fellow  
farnam@andrew.cmu.edu

Ronald L. Rivest  
Professor  
MIT  
A.M. Turing Award Winner  
rivest@mit.edu

Michael Bailey  
Associate Professor  
UIUC  
mdbailey@illinois.edu

Matt Blaze  
Professor  
University of Pennsylvania  
mab@crypto.com

Avi Rubin  
Professor  
Johns Hopkins University  
rubin@jhu.edu

Doug Tygar  
Professor  
U. C. Berkeley  
doug.tygar@gmail.com

Dan Wallach  
Professor  
Rice University  
dwallach@cs.rice.edu

David Wagner  
Professor  
U. C. Berkeley  
daw@cs.berkeley.edu
Exhibit B
As the Democratic National Convention continues its week-long stay in Philadelphia, accusations of Russian hacking continue to cloud the proceedings. At this point, it seems likely that Russia is responsible. What’s less clear is what that will mean going forward.

It’s been a bad stretch for the Democratic National Committee. Hackers broke into its servers months ago, stealing private emails, opposition research, and campaign correspondence. Last Friday, Wikileaks made nearly 20,000 of those private emails public, revealing embarrassing details of the political machine’s inner workings. DNC officials allege that the Russian government is behind the breach. The New York Times reports that US intelligence agencies increasingly share that opinion. According to a number of top cybersecurity researchers, they’re probably right.

A Brief History of a Hack
News of the hack of the Democratic National Committee first broke in mid-June. That’s when Crowdstrike, a firm that analyzes threats to network security, revealed that the DNC had called it in to inspect the party’s servers, where it found “two separate Russian intelligence-affiliated adversaries present in the DNC network.” Crowdstrike released a comprehensive report of its findings on June 14, which accompanied a Washington Post article detailing the attacks. One of the hacking groups, Crowdstrike found, had access to the DNC servers for almost a year.

A day after that report, someone calling themselves Guccifer 2.0 (an allusion to notorious hacker Guccifer) claimed responsibility for the hack in a blog post. Through the blog and an accompanying Twitter account, Guccifer 2.0 refuted Crowdstrike’s claims that this was a Russian operation, instead calling himself a “lone hacker.” He also claimed to have handed much of the DNC bounty to Wikileaks.

The following week, two cybersecurity firms, Fidelis Cybersecurity and Mandiant, independently corroborated Crowdstrike’s assessment that Russian hackers infiltrated DNC networks, having found that the two groups that hacked into the DNC used malware and methods identical to those used in other attacks attributed to the same Russian hacking groups.

But some of the most compelling evidence linking the DNC breach to Russia was found at the beginning of July by Thomas Rid, a professor at King’s College in London, who discovered an identical command-and-control address hardcoded into the DNC malware that was also found on malware used to hack the German Parliament in 2015. According to German security officials, the malware originated from Russian military intelligence. An identical SSL certificate was also found in both breaches.

The evidence mounts from there. Traces of metadata in the document dump reveal various indications that they were translated into Cyrillic. Furthermore, while Guccifer 2.0 claimed to be from Romania, he was unable to chat with Motherboard journalists in coherent Romanian. Besides which, this sort of hacking wouldn’t exactly be outside of Russian norms.

“It doesn’t strain credulity to look to the Russians,” says Morgan Marquis-Boire, a malware expert with CitizenLab. “This is not the first time that Russian hackers has been behind intrusions in US government, and it seems unlikely that it will be the last.” Last year Russian hackers were able to breach White House and State
Department email servers, gleaning information even from President Obama’s Blackberry.

Meanwhile, the Kremlin has denied Russian involvement in the DNC breach. But the reverberations continue; DNC Chairwoman Debbie Wasserman Schultz will resign at the end of the week, after emails revealed what many view as the unfair treatment of Bernie Sanders.

**From Russia With Love**

As compelling as the evidence is, there’s still a small amount of room to argue that Guccifer 2.0 was a lone actor, an individual motivated by hacktivist ideals of dismantling state power. He wouldn’t be the first. And in a recent interview on NBC, Julian Assange of Wikileaks gave a soft disavowal of claims that his whistleblowing organization is in cahoots with Russian intelligence, “Well, there is no proof of that whatsoever,” he said. “We have not disclosed our source, and of course, this is a diversion that’s being pushed by the Hillary Clinton campaign.”

This is, of course, the same Assange who boasts responsibility for helping find Snowden a home in Russia and Wikileaks publicly criticized the Panama Papers for implicating Putin in financial misdeeds. He’s also an outspoken frequent critic of Hillary Clinton’s time at the State Department. A damning document dump the weekend before Clinton’s nomination arguably aligns with both Russian interests and his own.

If the allegations do prove correct, this is an unprecedented step for Russia. Hacking is nothing new, but publicizing documents to attempt to sway an election certainly is. Putin would clearly prefer a Trump presidency. The billionaire Republican candidate is a longtime admirer of Putin’s, and has publicly stated that he wouldn’t necessarily defend NATO allies against a Russian invasion. To top it all off, Trump’s campaign manager, Paul Manafort, formerly worked as an advisor to Viktor Yanukovych, the Russian-backed President of Ukraine before he was ousted in 2014.

“Due to the nature and timing of this hack, it all seems very political,” says Marquis-Boire.

And there’s a whole lot of election left—and likely more leaks to come with it. On Sunday, a Twitter user asked Wikileaks if more DNC leaks were on their way. The reply: “We have more coming.”
Update: In a press conference Wednesday, Republican presidential candidate Donald Trump invited Russia to retrieve “missing” emails from Hillary Clinton’s campaign and release them. Cybersecurity experts described the remarks as “unprecedented” and “possibly illegal.”
Exhibit C
Private Security Group Says Russia Was Behind John Podesta’s Email Hack

By NICOLE PERLROTH and MICHAEL D. SHEAR  OCT. 20, 2016

SAN FRANCISCO — At the start of 2014, President Obama assigned his trusted counselor, John D. Podesta, to lead a review of the digital revolution, its potential and its perils. When Mr. Podesta presented his findings five months later, he called the internet’s onslaught of big data “a historic driver of progress.” But two short years later, as chairman of Hillary Clinton’s presidential campaign, Mr. Podesta would also become one of the internet’s most notable victims.

On Thursday, private security researchers said they had concluded that Mr. Podesta was hacked by Russia’s foreign intelligence service, the GRU, after it tricked him into clicking on a fake Google login page last March, inadvertently handing over his digital credentials.

For months, the hackers mined Mr. Podesta’s inbox for his most sensitive and potentially embarrassing correspondence, much of which has been posted on the WikiLeaks website. Additions to the collection on Thursday included three short
email exchanges between Mr. Podesta and Mr. Obama himself in the days leading up to his election in 2008.

Mr. Podesta’s emails were first published by WikiLeaks earlier this month. The release came just days after James R. Clapper Jr., the director of national intelligence, and the Department of Homeland Security publicly blamed Russian officials for cyberattacks on the Democratic National Committee, in what they described as an effort to influence the American presidential election.

To date, no government officials have offered evidence that the same Russian hackers behind the D.N.C. cyberattacks were also behind the hack of Mr. Podesta’s emails, but an investigation by the private security researchers determined that they were the same.

Threat researchers at Dell SecureWorks, an Atlanta-based security firm, had been tracking the Russian intelligence group for more than a year. In June, they reported that they had uncovered a critical tool in the Russian spy campaign. SecureWorks researchers found that the Russian hackers were using a popular link shortening service, called Bitly, to shorten malicious links they used to send targets fake Google login pages to bait them into submitting their email credentials.

The hackers made a critical error by leaving some of their Bitly accounts public, making it possible for SecureWorks to trace 9,000 of their links to nearly 4,000 Gmail accounts targeted between October 2015 and May 2016 with fake Google login pages and security alerts designed to trick users into turning over their passwords.

Among the list of targets were more than 100 email addresses associated with Hillary Clinton’s presidential campaign, including Mr. Podesta’s. By June, 20 staff members for the campaign had clicked on the short links sent by Russian spies. In June, SecureWorks disclosed that among those whose email accounts had been targeted were staff members who advised Mrs. Clinton on policy and managed her travel, communications and campaign finances.
Two security researchers who have been tracking the GRU’s spearphishing campaign confirmed Thursday that Mr. Podesta was among those who had inadvertently turned over his Google email password. The fact that Mr. Podesta was among those breached by the GRU was first disclosed Thursday by Esquire and the Motherboard blog, which published the link Russian spies used against Mr. Podesta.

“The new public data confirming the Russians are behind the hack of John Podesta’s email is a big deal,” Jake Sullivan, Mrs. Clinton’s senior policy adviser, said Thursday. “There is no longer any doubt that Putin is trying to help Donald Trump by weaponizing WikiLeaks.”

The new release of Mr. Podesta’s email exchange with Mr. Obama from 2008 made clear that Mr. Obama’s team was confident he would win.

In one of the emails, Mr. Podesta wrote Mr. Obama a lengthy memo in the evening on Election Day recommending that he not accept an invitation from President George W. Bush to attend an emergency meeting of the Group of 20 leaders.

“Attendance alongside President Bush will create an extremely awkward situation,” the memo said. “If you attempt to dissociate yourself from his positions, you will be subject to criticism for projecting a divided United States to the rest of the world. But if you adopt a more reserved posture, you will be associated not only with his policies, but also with his very tenuous global standing.”

The White House did not respond to questions about the email.

**Correction: October 22, 2016**

An article on Friday about suspected email hacking by Russia’s foreign intelligence service misstated the name of one organization that first disclosed that a presidential counselor, John D. Podesta, was among those whose accounts were breached. The blog is Motherboard, not VICE Motherload.

Nicole Perlroth reported from San Francisco, and Michael D. Shear from Washington.

Follow The New York Times’s politics and Washington coverage on Facebook and Twitter, and sign up for the First Draft politics newsletter.
A version of this article appears in print on October 21, 2016, on page A14 of the New York edition with the headline: Private Security Group Says Russia Was Behind Hack of Clinton Campaign Chairman.

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Exhibit D
Hackers based in Russia were behind two recent attempts to breach state voter registration databases, fueling concerns the Russian government may be trying to interfere in the U.S. presidential election, U.S. intelligence officials tell NBC News.

The breaches included the theft of data from as many as 200,000 voter records in Illinois, officials say.

The incidents led the FBI to send a "flash alert" earlier this month to election officials nationwide, asking them to be on the lookout for any similar cyber intrusions.

One official tells NBC News that the attacks have been attributed to Russian intelligence agencies.

"This is the closest we've come to tying a recent hack to the Russian government," the official said.

That person added that "there is serious concern" that the Kremlin may be seeking to sow uncertainty in the U.S. presidential election process.

Two other officials said that U.S. intelligence agencies have not yet concluded that the Russian government is trying to do that, but they are worried about it.
They said the Russians have long conducted cyber espionage on political targets. The question now is whether they are moving into a covert intelligence operation designed to destabilize the U.S. political process.

The alert, first reported by Yahoo News, provided IP addresses associated with the hack attempts, though it did not mention Russia.

One of the IP addresses was involved in both breaches, the FBI alert said.

"The FBI is requesting that states contact their Board of Elections and determine if any similar activity to their logs, both inbound and outbound, has been detected," the alert said.

The bulletin does not identify the targeted states, but officials told NBC News they were Illinois and Arizona. Illinois officials said in July that they shut down their state's voter registration after a hack. State officials said Monday the hackers downloaded information on as many 200,000 people.

State officials told the Chicago Tribune they were confident no voter record had been deleted or altered.

In Arizona, officials said, hackers tried to get in using malicious software but were unsuccessful. The state took its online voter registration down for nine days, beginning in late June, after malware was discovered on a county election official's computer. But the state concluded that the system was not successfully breached.

Those incidents led Homeland Security Secretary Jeh Johnson to host a call earlier this month with state election officials to talk about cybersecurity and election infrastructure.

Johnson said DHS isn't aware of any specific cyber threat against election-related networks, but he urged officials to examine how to better secure their systems, according to a summary of the call put out by the department.

U.S. intelligence officials have previously said Russian intelligence agencies were behind hacks into the Democratic National Committee and related organizations. There has been a long running debate among intelligence analysts about what Russia is up to.

Voting systems have not been considered "critical infrastructure," by the Department of Homeland Security, so they are not subject to federal government protections.

Independent assessments have found that many state and local voting systems are extremely vulnerable to hacking.
Russians Hacked Two U.S. Voter Databases, Officials Say - NBC News

More to Explore

A Solution That Puts Snoring to Bed
My Snoring Solution

Tiny Device Transforms Old Computer into a Blazingly Fast PC
Xtra-PC

You Don't Need to Remember You Passwords Anymore Thanks to This Device
Everykey

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Your Warrington Grocery Store is 70% More... Blue Apron

Harry's Releases New Blade Keeos
Exhibit E
Joint Statement from the Department Of Homeland Security and Office of the Director of National Intelligence on Election Security

Release Date: October 7, 2016

For Immediate Release
DHS Press Office
Contact: 202-282-8010

The U.S. Intelligence Community (USIC) is confident that the Russian Government directed the recent compromises of e-mails from US persons and institutions, including from US political organizations. The recent disclosures of alleged hacked e-mails on sites like DCLeaks.com and WikiLeaks and by the Guccifer 2.0 online persona are consistent with the methods and motivations of Russian-directed efforts.
These thefts and disclosures are intended to interfere with the US election process. Such activity is not new to Moscow—the Russians have used similar tactics and techniques across Europe and Eurasia, for example, to influence public opinion there. We believe, based on the scope and sensitivity of these efforts, that only Russia’s senior-most officials could have authorized these activities.

Some states have also recently seen scanning and probing of their election-related systems, which in most cases originated from servers operated by a Russian company. However, we are not now in a position to attribute this activity to the Russian Government. The USIC and the Department of Homeland Security (DHS) assess that it would be extremely difficult for someone, including a nation-state actor, to alter actual ballot counts or election results by cyber attack or intrusion. This assessment is based on the decentralized nature of our election system in this country and the number of protections state and local election officials have in place. States ensure that voting machines are not connected to the Internet, and there are numerous checks and balances as well as extensive oversight at multiple levels built into our election process.

Nevertheless, DHS continues to urge state and local election officials to be vigilant and seek cybersecurity assistance from DHS. A number of states have already done so. DHS is providing several services to state and local election officials to assist in their cybersecurity. These services include cyber “hygiene” scans of Internet-facing systems, risk and vulnerability assessments, information sharing about cyber incidents, and best practices for securing voter registration databases and addressing potential cyber threats. DHS has convened an Election Infrastructure Cybersecurity Working Group with experts across all levels of government to raise awareness of cybersecurity risks potentially affecting election infrastructure and the elections process. Secretary Johnson and DHS officials are working directly with the National Association of Secretaries of State to offer assistance, share
information, and provide additional resources to state and local officials.

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Last Published Date: October 7, 2016
Exhibit F
U.S. official: Hackers targeted voter registration systems of 20 states

Hackers have targeted the voter registration systems of more than 20 states in recent months, a Homeland Security Department official said Friday.

The disclosure comes amid heightened concerns that foreign hackers might undermine voter confidence in the integrity of U.S. elections. Federal officials and many cybersecurity experts have said it would be nearly impossible for hackers to alter an election’s outcome because election systems are very decentralized and generally not connected to the internet.
The official who described detecting the hacker activity was not authorized to speak publicly on the subject and spoke to The Associated Press on condition of anonymity. It was unclear, the official said, whether the hackers were foreign or domestic, or what their motives might be. ABC News earlier reported that more than 20 states were targeted.

The FBI last month warned state officials of the need to improve their election security after hackers targeted systems in Illinois and Arizona. FBI Director James Comey told lawmakers this week that the agency is looking "very, very hard" at Russian hackers who may try to disrupt the U.S. election.

Last month, Donald Trump, the GOP nominee for president, suggested that he feared the general election "is going to be rigged."

The Homeland Security Department has stepped up its outreach to states and localities, but it is up to them to ask for help. So far, 19 states have expressed interest in a general "cyber hygiene" scan of key websites — akin to ensuring that windows in a home are properly closed, according to another Homeland Security official directly involved in securing local elections who also was not authorized to speak publicly about ongoing efforts.

The FBI has detected a variety of "scanning activities" that are early indications of hacking, Comey told the House Judiciary Committee this week.

The FBI held a conference call on Friday with the local officials who run elections in the battleground state of Florida. Meredith Beatrice, a spokeswoman for Secretary of State Ken Detzner, called it an "informational call related to elections security," but a person on the call who was not authorized to discuss it and requested anonymity said authorities had seen evidence of someone probing a local elections website.

Homeland Security Secretary Jeh Johnson spoke to state election officials by phone last month, encouraging them to implement existing technical recommendations to secure their election systems and ensure that electronic voting machines are not connected to the internet.

DHS is offering states more comprehensive, on-site risk and vulnerability checks. Only four states have expressed interest in the assessment, and because the election is only weeks away, the department will likely only be able to conduct an assessment of one state before Election Day on Nov. 8, the official said.

Two of the hacking attempts involved efforts to mine data from the Arizona and Illinois voter registration systems, according to Kay Stimson, a spokeswoman for the National Association of Secretaries of State. She said in Arizona a hacker tried to probe voter registration data, but never infiltrated the system, while in Illinois hackers got into the system, but didn't manipulate any data.
These systems have "nothing to do with vote casting or counting," Stimson said in an email. "While it is theoretically possible to disrupt an election by infiltrating a voter registration system, their compromise would not affect election results" and there are system controls in place to catch any fraud.

Rep. Henry Johnson, D-Ga., introduced two bills earlier this month that would require voting systems be designated as critical infrastructure and limit purchases of new voting systems that don't provide paper ballots, among other measures. It's unlikely the bills will be passed before the election.

The Homeland Security Department is already considering designating voting systems as critical infrastructure in the future, though it is unlikely to happen before the election, the second official said.

A presidential directive released in 2013 details 16 sectors that are considered critical infrastructure, including energy, financial services, healthcare, transportation, food and agriculture, and communications. The designation places responsibilities on the Homeland Security secretary to identify and prioritize those sectors, considering physical and cyber threats. The secretary is also required to conduct security checks and provide information about emerging and imminent threats.

Associated Press

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This article is related to: Jeh Johnson, James Comey
Exhibit G
A three-pronged wave of cyber-attacks aimed at wrecking Ukraine's presidential vote – including an attempt to fake computer vote totals – was narrowly defeated by government cyber experts, Ukrainian officials say.

The still little-known hacks, which surfaced May 22-26, appear to be among the most dangerous cyber-attacks yet deployed to sabotage a national election – and a warning shot for future elections in the US and abroad, political scientists and cyber experts say.

National elections in the Netherlands, Norway, and other nations have seen hackers probe Internet-tied election systems, but never with such destructive abandon, said experts monitoring the Ukraine vote.

"This is the first time we've seen a cyber-hacktivist organization act in a malicious way on such a grand scale to try to wreck a national election "

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That wanton destruction began four days ahead of the national vote, when CyberBerkut, a group of pro-Russia hackers, infiltrated Ukraine’s central election computers and deleted key files, rendering the vote-tallying system inoperable. The next day, the hackers declared they had “destroyed the computer network infrastructure” for the election, spilling e-mails and other documents onto the web as proof.

A day later, government officials said the system had been repaired, restored from backups, and was ready to go. But it was just the beginning.

Only 40 minutes before election results were to go live on television at 8 p.m., Sunday, May 25, a team of government cyber experts removed a “virus” covertly installed on Central Election Commission computers, Ukrainian security officials said later.

If it had not been discovered and removed, the malicious software would have portrayed ultra-nationalist Right Sector party leader Dmytro Yarosh as the winner with 37 percent of the vote (instead of the 1 percent he actually received) and Petro Poroshenko (the actually winner with a majority of the vote) with just 29 percent, Ukraine officials told reporters the next morning.

Curiously, Russian Channel One aired a bulletin that evening declaring Mr. Yarosh the victor with 37 percent of the vote over Mr. Poroshenko with 29 percent, Ukrainian officials said.

“Offenders were trying by means of previously installed software to fake election results in the given region and in such a way to discredit general results of elections of the President of Ukraine,” the Ukrainian Security Service (SBU) said in a statement.

Still, there was more to come.

In the wee hours of the morning after polls closed, as results flowed in from Ukrainian election districts, Internet links feeding that data to the vote tally system were hit with a barrage of fake data packets – known as distributed denial of service (DDoS) attacks. So from about 1 to 3 a.m. on May 26, election results were blocked, delaying the finally tally until the early
morning, a preliminary report by international election observers recounted.

An analysis of the DDoS attack by Arbor Networks, a Burlington, Mass., cyber-security company, ties it to CyberBerkut.

In the end, international observers declared Ukraine’s vote “a genuine election.” But US researchers say it’s clear that Ukraine dodged a major cyber-bullet.

“We’ve seen vote fraud before in Ukraine, including a rigged computer system in 2004,” says Peter Ordeshook, a California Institute of Technology political scientist. “But this wasn’t an effort to steal the election outcome, so much as to steal the election itself – by entirely discrediting it in the eyes of key segments of the population in Ukraine and in Russia, too.”

While it was well understood across most of Ukraine and internationally that the far-right candidate Yarosh had little political support, the faked results would have lent credibility to Russian-inspired accounts that the popular revolt last fall against the Ukraine government was fomented by ultra-nationalists.

“In that light, the cyber fakery looks incredibly clumsy from the outside because no one there would have believed it,” Dr. Ordeshook says. “But these faked results were geared for a specific audience in order to feed the Russian narrative that has claimed from the start that ultra-nationalists and Nazis were behind the revolution in Ukraine.”

If the virus with the faked computer results had not been discovered, it would have fomented unrest across the volatile ethnic-Russian Donetsk region now under the shadow of Russian forces on the border with Ukraine, he says. Such spurious results also would have undermined the credibility of the new Ukraine government and could have paved the way for Russian military action, say political scientists who monitor Ukraine elections.

The Ukraine hack is a stark warning for the US and other democracies that use the Internet for tabulation and even direct voting, election security experts say. One clear lesson, they say, is to always have paper ballots to back up election results – like Ukraine – and to avoid Internet voting.

“The Ukraine attack story demonstrates there is no shortage of methods which a determined adversary will make use of to sabotage an election,” says Pamela Smith, president of the Verified Voting Foundation, a US group that has researched US election systems security.

In the runup to the election, President Obama on May 2 warned Russia not to interfere or the US “will not have a choice but to move forward with additional, more severe sanctions.”

Since then, US officials appear reluctant to make too much of the attacks. References to the cyber-attacks have been brief and oblique. With anonymity cloaking cyber-attacks across the Internet it’s difficult to tell
cyber-attacks on the Central Election Commission of the kind that generally would require outside support,” Victoria Nuland, assistant secretary of State for European affairs, acknowledged in a May 27 interview on the Charlie Rose show. Mark Green, a former congressman, said in Senate testimony June 6 that he had been told by a US diplomat of a failed Russian cyber-attack on the election.

Ukrainian officials have been unabashed in throwing blame at Russia, saying that arrests were made in the case, although no names have yet been made public.

“It was prepared in advance and stored on Russian (Internet) re-sources,” Volodymyr Zverev, head of the Ukraine’s Administration of Public Service of Special Communication and Protection of Information said of the malware that was intended to deliver the fake election results, according to Interfax-Ukraine. "They wanted to, and made the preparations, but they did not succeed."

While Russian hacktivists appear to be linked to at least some of the attacks, not everyone agrees the Russian government had a hand in the most devious element. Internet security expert Mr. Kiniry, for instance, says there is no solid proof yet to back the Ukrainian government claim of a virus carrying fake election results.

Others say Russia’s paw prints are all over the attack.

“Did Russia attempt to sway the Ukrainian Presidential Election? I honestly don’t know the answer to that,” says Jeffery Stutzman, CEO of Red Sky Alliance, a cyber-security group in New Hampshire.

But, he adds, "the idea that these guys were trying to poison the election result by compromising the election commission computers is amazing to me – and this coincidence with the Russian channel showing the same fake results – is just too much. If it walks like a duck and quacks like one, maybe it’s a duck."

Next up

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