UNDER THE HOOD

The West Virginia Mobile Voting Pilot

Abstract

In 2018, West Virginia's Secretary of State Mac Warner launched the nation's first mobile voting pilot for UOCAVA voters. For the first time, on their own Apple or Android smartphone, an authenticated registered voter was able to receive, mark and submit a secret ballot of the correct style from virtually anywhere in the world. Every ballot submitted was encrypted and stored on a geographically distributed and redundant network of blockchain servers managed by the two largest providers of cloud infrastructure. Once stored on the blockchain, the voter could review his/her ballot, request that it be spoiled if necessary and vote a second ballot on his/her smartphone. At the close of polls, every ballot was printed at the county and tabulated on federally certified tabulation equipment. Post-election audits were performed on every ballot submitted by smartphones.

This paper describes the Secretary's goals, the lessons learned, and how the system worked under the hood. At the end, there are some Fun Facts for Election Geeks.

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When West Virginia Secretary of State Mac Warner took office in 2017, he instructed his staff to explore ways to make voting more convenient for military personnel, their families and civilians stationed or working abroad (UOCAVA voters). As an officer in the Army, Sec. Warner experienced first-hand how difficult it is for soldiers and civilians abroad to vote and return a ballot in time to be counted. In 2016, the estimated voting participation rate for U.S. citizens living overseas was 6.9% compared to the 72% for voting age citizens living in the U.S.[i]

After an arduous process of researching firms that offered solutions for UOCAVA[ii] voters, Sec. Warner's staff ultimately signed a memorandum of understanding to conduct a pilot in two counties for the May 2018 Primary election.

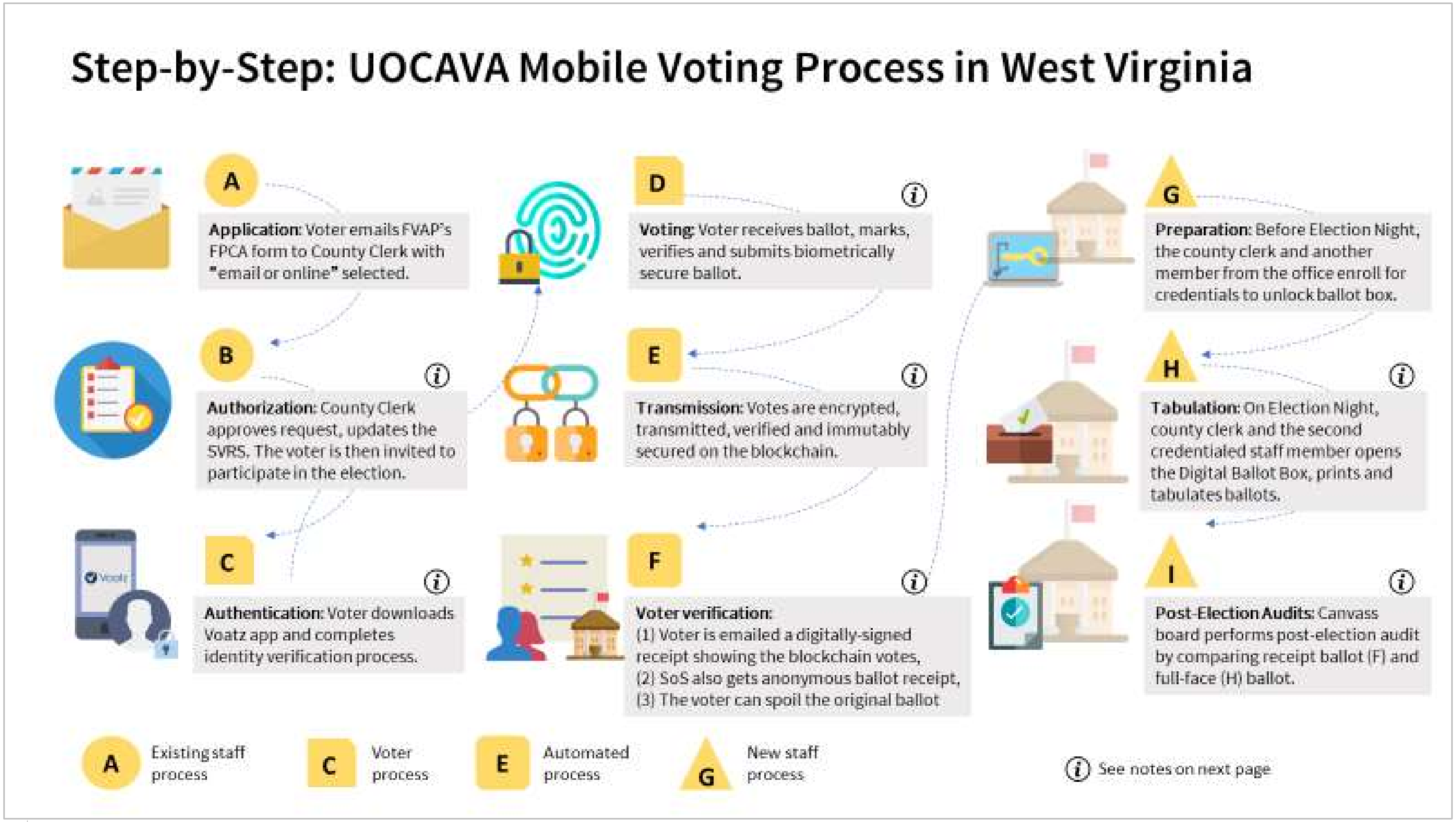
The 2018 Primary Pilot: Goals, Recommendations, & Process Flow

The Secretary's goals were ambitious: Enable UOCAVA voters to use their smartphones to improve the convenience and security of voting and to lower the burden on county clerks. Specifically, he wanted to demonstrate easy integration with the state's voter registration system, biometrically secure authentication, electronic ballot delivery to smartphones, an intuitive voting experience that required no voter training, the secure return of voted ballots and the redundant, immutable storage of ballots on a blockchain infrastructure and an easy way to tabulate and consolidate the results. Having many voters participate was a not a goal; in fact, there were under 20 voters in the first of the two pilots.

While the goals were largely met, the first pilot identified some improvements that the Secretary's office and the clerks asked to be implemented in time for the second pilot. These included:

- **Independent security evaluation & post-election audits** – four independent security auditors were retained to conduct penetration testing, review the iOS and Android source code, blockchain infrastructure and the vendor's corporate procedures. With a voter-centric model in mind, the voters' confidence in the privacy and security of their ballots and the auditability of the process and results were key focal points. Accordingly, the vendor was asked to propose a method of performing post-election audits.
- **Scalable election definition** – in the Primary, the ballot styles were programmed manually. Going into the General election with an uncertain number of participating counties, creating the ballot styles had to be done programmatically. In time for the General Election pilot, ballot definition files of the 999 ballot styles from the primary voting system were produced programatically.
- **Blockchain infrastructure** – to increase performance and security, the number of blockchain servers doubled from 16 to 32 evenly split over multiple geographical locations across the U.S. between the two largest cloud infrastructure providers.
- **Ability to spoil a ballot** – while the voter could verify his/her ballot in the first pilot, the ability to spoil a ballot was not available. A process was devised for the second pilot whereby a second ballot could be issued to a voter and only his/her last ballot would be counted.
- **Automatic preparation of tabulatable ballots** – in the first pilot, ballots had to be manually transcribed which worried the clerks. An additional capability was developed to automatically print ballots, which could be inserted directly into ballot tabulating machines.

On the next page, Fig. 1 shows the process that was used in both pilots.



Step-by-Step: UOCAVA Mobile Voting Process in West Virginia

A **Application:** Voter emails FVAP's FPCA form to County Clerk with "email or online" selected.

B **Authorization:** County Clerk approves request, updates the SVRS. The voter is then invited to participate in the election. ⓘ

C **Authentication:** Voter downloads Voatz app and completes identity verification process. ⓘ

D **Voting:** Voter receives ballot, marks, verifies and submits biometrically secure ballot. ⓘ

E **Transmission:** Votes are encrypted, transmitted, verified and immutably secured on the blockchain. ⓘ

F **Voter verification:**
(1) Voter is emailed a digitally-signed receipt showing the blockchain votes,
(2) SoS also gets anonymous ballot receipt,
(3) The voter can spoil the original ballot ⓘ

G **Preparation:** Before Election Night, the county clerk and another member from the office enroll for credentials to unlock ballot box.

H **Tabulation:** On Election Night, county clerk and the second credentialed staff member opens the Digital Ballot Box, prints and tabulates ballots. ⓘ

I **Post-Election Audits:** Canvass board performs post-election audit by comparing receipt ballot (F) and full-face (H) ballot. ⓘ

A Existing staff process

C Voter process

E Automated process

G New staff process

ⓘ See notes on next page

Fig. 1: Mobile voting process flow

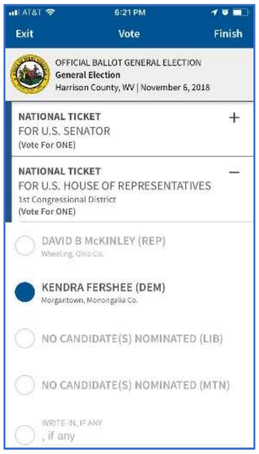
Notes to Figure 1:

B. **Authorization** – Participating counties use the State’s voter registration system (SVRS) to designate which voters are eligible to participate. In West Virginia, UOCAVA voters are required to submit a Federal Post Card Application (FPCA) each year. Voters who fill out the FCPA and choose to receive their ballots via email or online are, after verification as an eligible voter, invited to participate in the mobile voting pilot.

C. **Voter authentication** – The voter starts the process by downloading the smartphone application from the Apple or Google Play store. Voters authenticate themselves first by using their smartphone’s camera to scan both sides of their West Virginia driver’s license or state ID or the photo ID page of their passport. Next, they take a video “selfie” where they must blink or slightly move their head. The app employs facial recognition to compare the government issued photo ID with the “selfie.” In the last step, they tie their biometric identity to the unique ID of their cell phone via a fingerprint or a “selfie.” This ensures that a voter can only vote on one device and that a device can only be used by one voter.

D. **Ballot delivery / voting experience** – Once the application is downloaded and the voter authenticates him-self/herself, ballot delivery is automatic. The voter is notified upon receipt of their ballot.

Using gestures familiar to every smartphone user — like “swipe” to navigate, and “tap” to select — all participating voters use their personal Apple or Android smartphones to mark their ballots. Many voters finish in under three minutes. Additional measures have been put in place to enhance security as the application requires the voter to confirm their identity by a fingerprint or facial recognition prior to submitting their ballot.



OFFICIAL BALLOT GENERAL ELECTION
General Election
Harrison County, WV | November 6, 2018

NATIONAL TICKET
FOR U.S. SENATOR
(Vote For ONE)

NATIONAL TICKET
FOR U.S. HOUSE OF REPRESENTATIVES
1st Congressional District
(Vote For ONE)

○ DAVID B McKINLEY (REP)
Wheeling, Ohio Co.

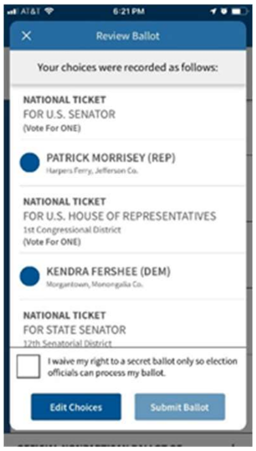
● KENDRA FERSHEE (DEM)
Morgantown, Monongalia Co.

○ NO CANDIDATE(S) NOMINATED (LIB)

○ NO CANDIDATE(S) NOMINATED (MTN)

○ WRITE-IN, IF ANY
, if any

Fig. 2: Contest list showing blue progress bar and a selected candidate.



Your choices were recorded as follows:

NATIONAL TICKET
FOR U.S. SENATOR
(Vote For ONE)

● PATRICK MORRISEY (REP)
Harpers Ferry, Jefferson Co.

NATIONAL TICKET
FOR U.S. HOUSE OF REPRESENTATIVES
1st Congressional District
(Vote For ONE)

● KENDRA FERSHEE (DEM)
Morgantown, Monongalia Co.

NATIONAL TICKET
FOR STATE SENATOR
12th Senatorial District

□ I waive my right to a secret ballot only so election officials can process my ballot.

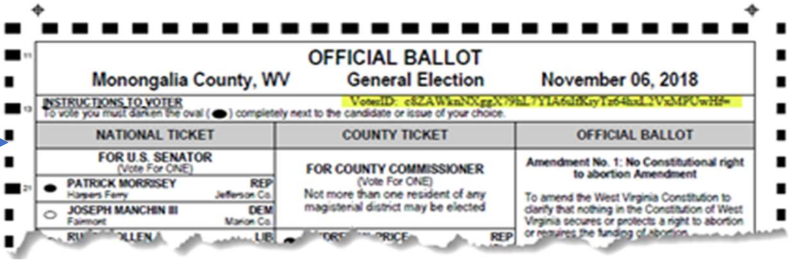
Fig. 3: The review screen showing the W.V. required privacy waiver.

E & F **Voter history, voter privacy, secure storage and ballot spoiling** – Once the voter submits their ballot, four things happen under the hood.

a. *Voter history* – to fulfill the state’s requirement to capture voter history, the smartphone automatically notifies the state’s voter registration system that the voter has submitted a ballot.
b. *Preserve privacy* – a unique anonymous voter ID is generated that hereafter preserves the privacy of the voter and enables ballot spoiling and post-election audits (see note G below).
c. *Secure the aggregate vote* – Each vote, joined with the voter’s anonymous ID, is submitted to the blockchain. When added to the blockchain, the encrypted vote is redundantly distributed across 32 servers residing in highly secure data centers managed by the two largest cloud services .
d. *Voter verified ballot* – two anonymous ballot receipts are sent showing the voter’s selections along with the voter’s anonymous ID - one to the voter and one to the Secretary of State’s (SoS) office.

The SoS receipt enables a post-election audit. The voter receipt enables the voter to verify their selections and, if desired, spoil their ballot. A voter may spoil their ballot with a request to the SoS’s Office with the anonymous ID from their initial receipt. The original ballot is spoiled, their smartphone voting session is opened again, and the voter can cast a second ballot. Since the blockchain is immutable, both ballots are recorded, but only the last ballot submitted is counted. In the second pilot, spoiling a ballot necessitated the loss of voter privacy.

H. **Ballot preparation and tabulation** – When the polls close, members of each county clerk's staff insert two cryptographically secure thumb drives into the vendor's administrative portal laptop. Once the two thumb drives are verified, votes on the blockchain are automatically assembled as PDF files for each county. The Secretary of State's office sends each county one PDF file containing all the marked ballots submitted by voters of that county. The clerk's staff prints the ballots on cardstock with a ballot printer capable of printing up to 20" two-sided ballots (see Fig. 4). Each printed ballot contains the anonymous ID of the voter (see highlight in Fig. 5). Tabulation and the consolidation of results is done automatically by scanning the paper ballot into the precinct tabulator of the primary voting system (see Fig. 6).



OFFICIAL BALLOT

Monongalia County, WV General Election November 06, 2018

INSTRUCTIONS TO VOTER VoterID: c8ZAWknNXggX79hL7YIA6dfKryTz64hxL2VxMPUwHf=
To vote you must darken the oval (●) completely next to the candidate or issue of your choice.

NATIONAL TICKET	COUNTY TICKET	OFFICIAL BALLOT
FOR U.S. SENATOR (Vote For ONE)	FOR COUNTY COMMISSIONER (Vote For ONE) Not more than one resident of any magisterial district may be elected	Amendment No. 1: No Constitutional right to abortion Amendment To amend the West Virginia Constitution to clarify that nothing in the Constitution of West Virginia secures or protects a right to abortion or requires the funding of abortion.
● PATRICK MORRISEY REP Harpers Ferry Jefferson Co.		
○ JOSEPH MANCHIN III DEM Fairmont Marion Co.		
RU[illegible]LLEN LIB	● [illegible]PRICE REP	

Fig. 5: Automatically marked ballot showing anonymous voter ID (just below the date)

Fig. 4: Ballot printer

Fig. 6: Precinct tabulator

I. **Post-Election Audit** – During the canvass the county clerk's staff can perform several audit checks on the mobile voting system. These include comparisons between the:

- number of voters submitting ballots and the number of ballots printed
- ballot style intended for the voter and the ballot style recorded for the voter
- number of receipts received by the SoS, and the number of ballots printed.

Finally, for any given anonymous voter ID, the votes recorded on the voter-verified receipt should match perfectly with the votes on the tabulated ballot.

The 2018 General Election Pilot: Participation results & Recommendations

Participation results

Every year West Virginia UOCAVA voters must return a Federal Post Card Application (FCPA) which asks, among other things, how they wish to receive their ballot. The three choices are: by "mail", by "email or online", or by "fax." The Secretary's staff were keenly interested in the rates at which the eligible voters downloaded the app, completed the authentication process and then voted.

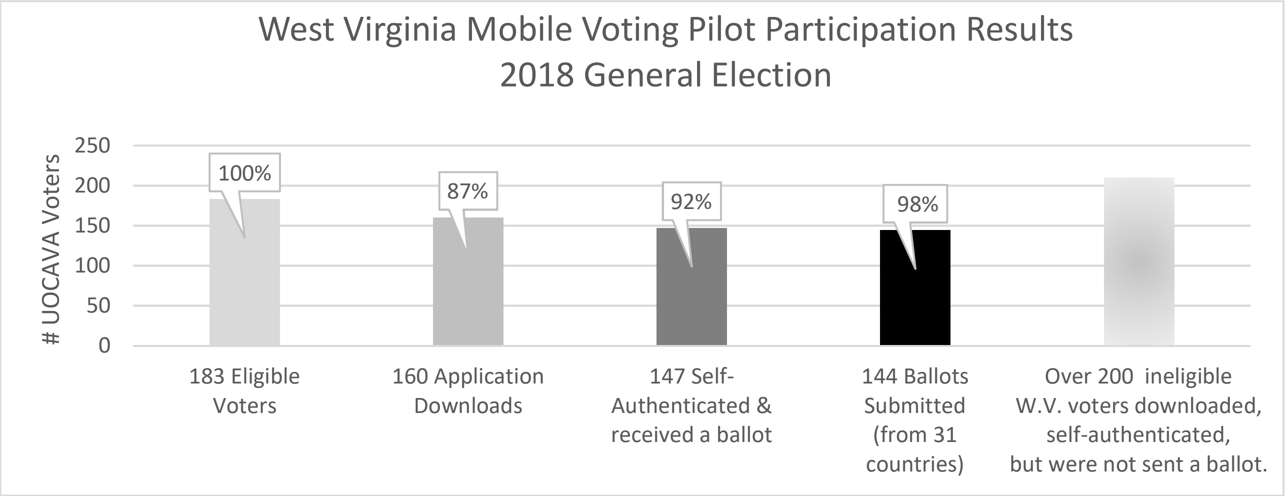


Figure 2: 2018 General Election Participation Breakdown

In the 24 participating counties, 183 voters submitted FCPA forms requesting by "email or online" and, of those, 160 (87%) completed the application download. While no data was collected on the 23 (13%) voters who requested but did not download, the possible explanations include: did not have a qualifying smartphone, chose email instead, was in a country that was not enabled in the Apple or Google Play stores.

Of the 160 voters who completed the download, 147 (92%) completed the authentication process. Since this one-time process is the voter's most difficult step, the Secretary's staff and the vendor's team were pleased at this key measure of ease-of-use. Voters do not need to authenticate themselves again.

Of the 147 that completed the one-time authentication process, 98% submitted their ballot; every submitted ballot was counted.

Finally, as evidence of demand, more than 200 West Virginians outside the eligibility criteria (UOCAVA and 24 counties) downloaded the app and authenticated themselves, only to find out they were not eligible. They had likely heard of the pilot and thought they would be able to participate.

Recommendations (partial listing)

1. Eliminate manual ballot spoiling process by the Secretary of State by allowing the voter to self-spoil their own ballot and count only the last ballot submitted.
2. Improve the overall voter engagement. For example, have the app automatically issue a reminder if the voter hasn't voted by Election Day.

Fun Facts for Election Geeks

Demographics

Age Distribution of West Virginia's Mobile Voters				
Generation	Born on or after	Born on or before	#	%
Boomers	1944	1964	18	13%
Gen X	1965	1980	41	28%
Millennials	1981	1996	76	53%
Gen Z	1997	2012	9	6%
Total			144	100%

Note: Generations defined by Pew Center for the States[iii]

Random facts

Youngest / oldest voters	
Youngest voter	18
Oldest voter(s)	73 (2)
Voting by gender	
Females	60 (42%)
Males	84 (58%)
Time between biometric authentication and voting:	
Longest:	43 days
Shortest:	10 min.

Geography

Voters submitted ballots from the U.S. and 30 countries:

Canada, Israel, UK, New Zealand, Philippines, Turkey, Mexico, Japan, Australia, France, Spain, Germany, Bahamas, Peru, Ireland, Netherlands, Denmark, Italy, Switzerland, Finland, Armenia, Kuwait, Guinea, Uganda, Taiwan, Belgium, Albania, Egypt, Botswana, Cambodia.

Technology

Minimum hardware and software smartphone requirements are: iPhone 5s or later (running IOS 10+); Android phones running Android OS version 6+ (including KNOX support).

Note, only Android phones that run specific distributions of Google's Android operation system can use the application to submit a ballot. Accordingly, voters with certain Android phones from firms like ZTE and Huawei could not use the application to submit a ballot.

Distribution of smartphones used: 105 iPhones (73%); 39 Android (27%)

Blockchain infrastructure: 32 identically configured verifying servers distributed 50% across the cloud providers. Each server runs an identical copy the open source Hyperledger blockchain software.

Blockchain technology has been well-vetted by major organizations[iv] like the National Institute of Standards and Technology (NIST), the World Economic Forum, and the Federal Reserve Board.

Election Administration

999 ballot styles from the 24 participating counties were automatically formatted for use on a smartphone; 118 styles were returned by 144 voters.

Number of ballots spoiled: 1

Number of ballots transcribed by hand: Primary – approx. 20; General– none.

Endnotes – all last accessed on Jan 20, 2019:

[i] Federal Voting Assistance Program (FVAP) Sept, 2018; Pg. 1, "2016 Overseas Citizen Population Analysis Report, 2016" https://www.fvap.gov/uploads/FVAP/Reports/FVAP-2016-OCPA-FINAL-Report.pdf

[ii] Uniformed and Overseas Citizens Absentee Voting Act (UOCAVA)

[iii] Pew Center for the States, FactTank, "Defining generations: Where Millennials end and Generation Z begins", http://www.pewresearch.org/fact-tank/2019/01 /17/where-millennials-end-and-generation-z-begins/

[iv] Major organizations have studied blockchain technology (also called distributed ledger technology), including:

NIST article, Jan. 24, 2018 "Report on Blockchain Technology Aims to Go Beyond the Hype"
https://www.nist.gov/news-events/news/2018/01/nist-report-blockchain-technology-aims-go-beyond-hype

NIST study, "Draft NIST Interagency Report (NISTIR) 8202: Blockchain Technology Overview"
https://csrc.nist.gov/CSRC/media/Publications/nistir/8202/draft/documents/nistir8202-draft.pdf

World Economic Forum, "The future of financial infrastructure"
http://www3.weforum.org/docs/WEF_The_future_of_financial_infrastructure.pdf

Federal Reserve Board, 2016-095, "Distributed ledger technology in payments, clearing, and settlement"
https://www.federalreserve.gov/econresdata/feds/2016/files/2016095pap.pdf