Notes:

(1) "Ballots identified as requiring adjudication may be provided to an election official who may confirm, correct, or appropriately change one or more votes recorded for the particular ballot based on their review of the ballot optical image." (Lines 46-50 of Section 8.)

(2) "Votes requiring adjudication may be identified, in some examples, by a central server computer system, or by an optical scan ballot system, with adjudication of the votes performed with an adjudication system that is located either locally or remotely." (Lines 31-33 of Section 14.)

US009202113B2

(12) **United States Patent**
Hoover et al.

(10) **Patent No.: US 9,202,113 B2**
(45) **Date of Patent: *Dec. 1, 2015**

(54) **BALLOT ADJUDICATION IN VOTING SYSTEMS UTILIZING BALLOT IMAGES**

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(73) Assignee: **Dominion Voting Systems, Inc.**, Denver, CO (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

This patent is subject to a terminal disclaimer.

(21) Appl. No.: **14/539,684**

(22) Filed: **Nov. 12, 2014**

(65) **Prior Publication Data**

US 2015/0071501 A1 Mar. 12, 2015

Related U.S. Application Data

(63) Continuation of application No. 13/470,091, filed on May 11, 2012, now Pat. No. 8,913,787.

(51) **Int. Cl.**

G06K 9/00	(2006.01)
G07C 13/00	(2006.01)
G06T 11/60	(2006.01)

(52) **U.S. Cl.**
CPC ***G06K 9/00442*** (2013.01); ***G06T 11/60*** (2013.01); ***G07C 13/00*** (2013.01); *G06T 2207/10004* (2013.01)

(58) **Field of Classification Search**
None
See application file for complete search history.

(56) **References Cited**

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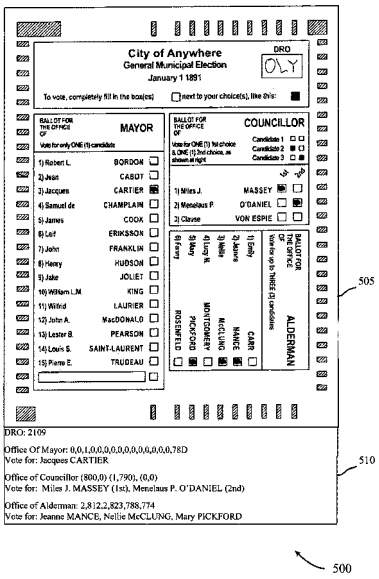
* cited by examiner

Primary Examiner — Nirav G Patel
(74) *Attorney, Agent, or Firm* — Holland & Hart LLP

(57) **ABSTRACT**

Methods, systems, and devices are described for adjudicating votes made on voter-marked paper ballots. Voter-marked paper ballots may be scanned to obtain optical image data of the voter-marked paper ballots. The optical image may be analyzed to determine the votes contained in the ballot for tabulation purposes. One or more votes on the ballot may be identified as requiring adjudication by an election official. Adjudication information, according to various embodiments, is appended to the optical images of the voter-marked paper ballots such that the image of the ballot and the image of the adjudication information may be viewed in an optical image. The optical image may be stored in a file format that allows the ballot image and the appended adjudication information to be viewed using readily available image viewers.

19 Claims, 16 Drawing Sheets



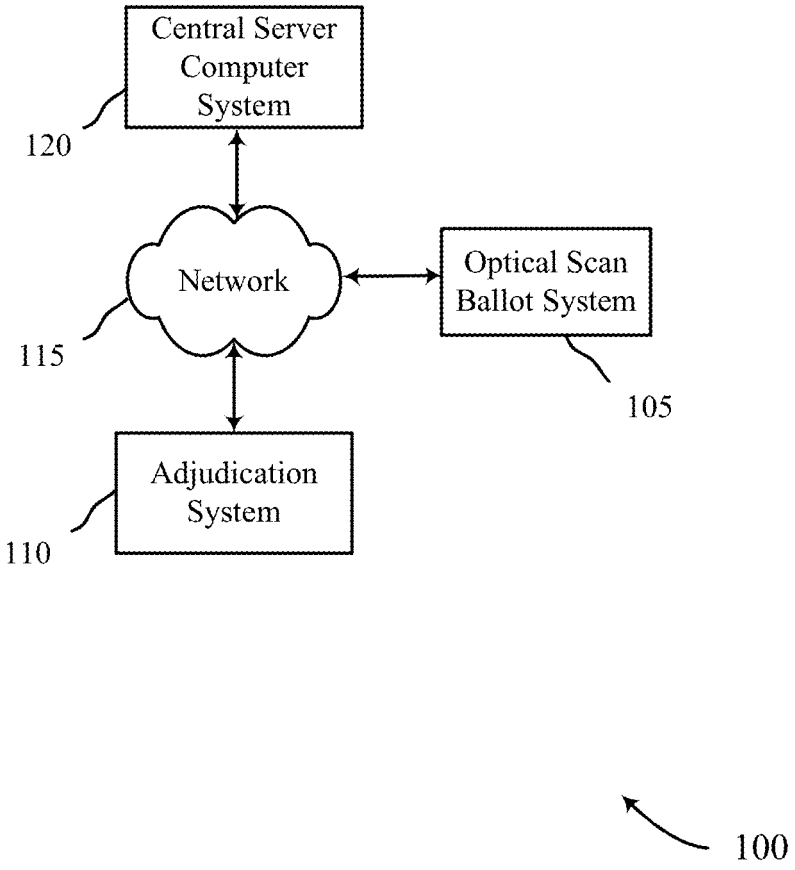

Central Server Computer System
120
Network
115
Optical Scan Ballot System
105
Adjudication System
110
100

FIG. 1

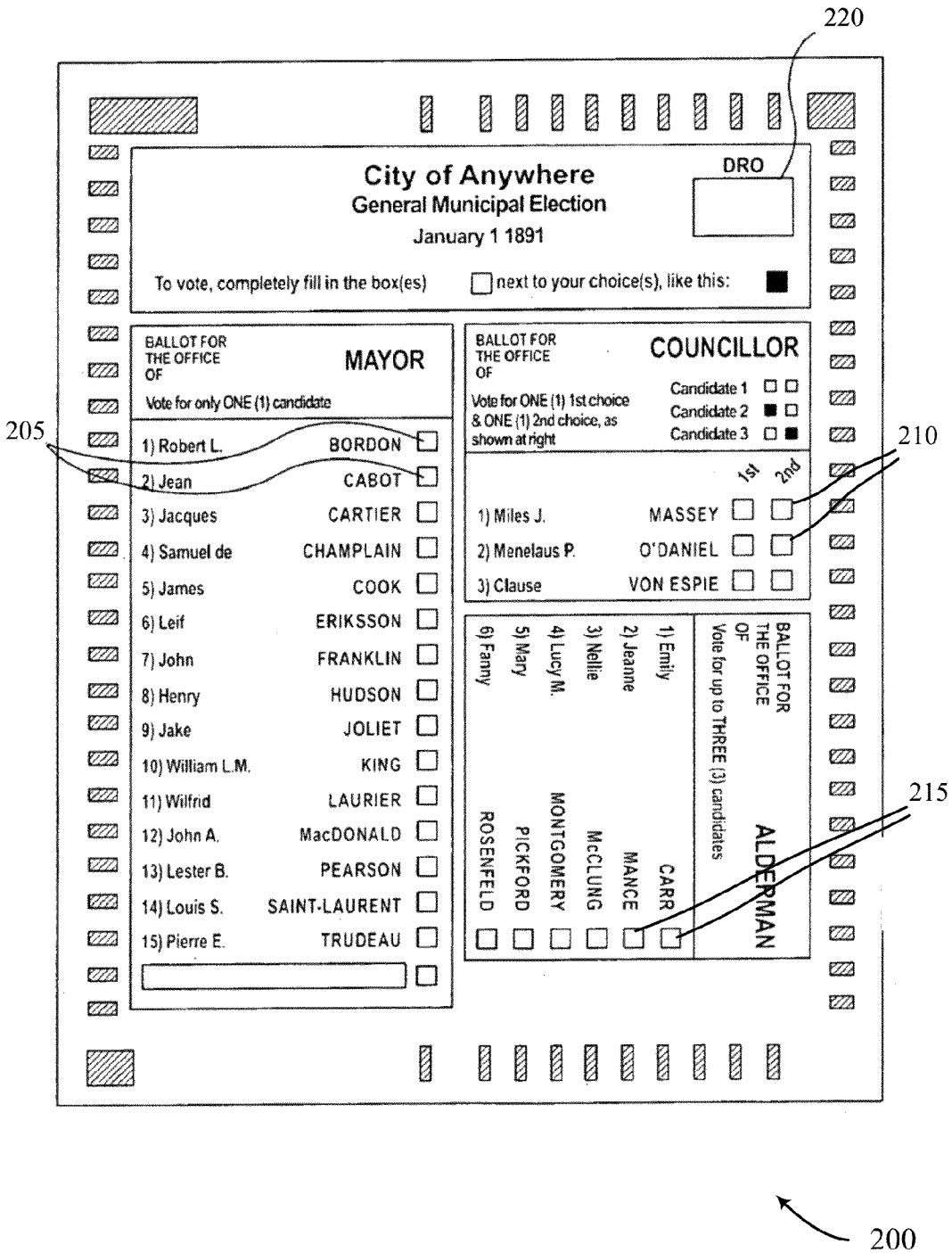
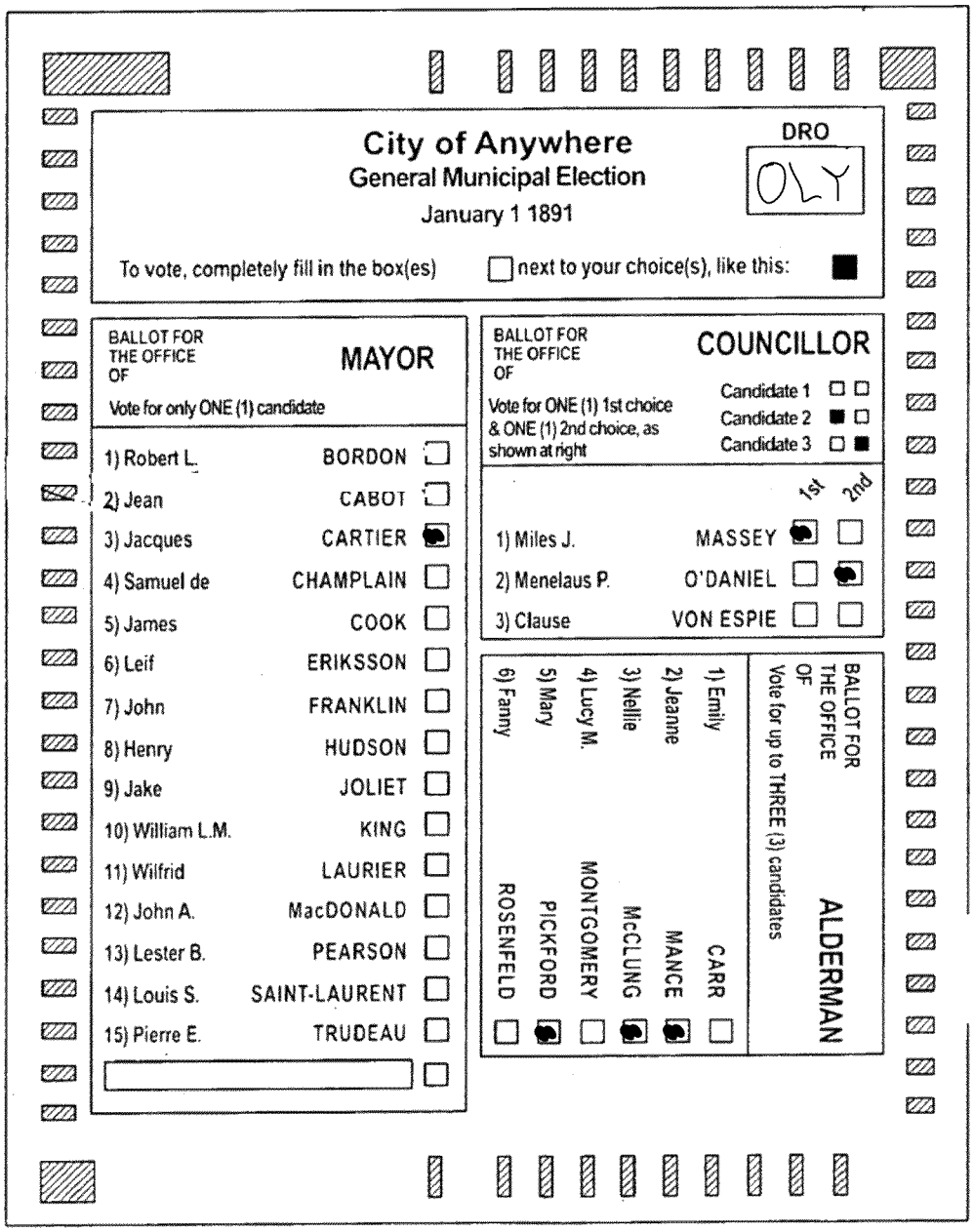

220
City of Anywhere
General Municipal Election
January 1 1891
DRO
To vote, completely fill in the box(es) next to your choice(s), like this:
BALLOT FOR THE OFFICE OF MAYOR
Vote for only ONE (1) candidate
1) Robert L. BORDON
2) Jean CABOT
3) Jacques CARTIER
4) Samuel de CHAMPLAIN
5) James COOK
6) Leif ERIKSSON
7) John FRANKLIN
8) Henry HUDSON
9) Jake JOLIET
10) William L.M. KING
11) Wilfrid LAURIER
12) John A. MacDONALD
13) Lester B. PEARSON
14) Louis S. SAINT-LAURENT
15) Pierre E. TRUDEAU
205
BALLOT FOR THE OFFICE OF COUNCILLOR
Vote for ONE (1) 1st choice & ONE (1) 2nd choice, as shown at right
Candidate 1
Candidate 2
Candidate 3
1st
2nd
1) Miles J. MASSEY
2) Menelaus P. O'DANIEL
3) Clause VON ESPIE
210
BALLOT FOR THE OFFICE OF ALDERMAN
Vote for up to THREE (3) candidates
1) Emily CARR
2) Jeanne MANCE
3) Nellie McCLUNG
4) Lucy M. MONTGOMERY
5) Mary PICKFORD
6) Fanny ROSENFELD
215
200

FIG. 2


City of Anywhere
General Municipal Election
January 1 1891
DRO
OLY
To vote, completely fill in the box(es) next to your choice(s), like this:
BALLOT FOR THE OFFICE OF
MAYOR
Vote for only ONE (1) candidate
1) Robert L. BORDON
2) Jean CABOT
3) Jacques CARTIER
4) Samuel de CHAMPLAIN
5) James COOK
6) Leif ERIKSSON
7) John FRANKLIN
8) Henry HUDSON
9) Jake JOLIET
10) William L.M. KING
11) Wilfrid LAURIER
12) John A. MacDONALD
13) Lester B. PEARSON
14) Louis S. SAINT-LAURENT
15) Pierre E. TRUDEAU
BALLOT FOR THE OFFICE OF
COUNCILLOR
Vote for ONE (1) 1st choice & ONE (1) 2nd choice, as shown at right
Candidate 1
Candidate 2
Candidate 3
1st
2nd
1) Miles J. MASSEY
2) Menelaus P. O'DANIEL
3) Clause VON ESPIE
BALLOT FOR THE OFFICE OF
ALDERMAN
Vote for up to THREE (3) candidates
1) Emily CARR
2) Jeanne MANCE
3) Nellie McCLUNG
4) Lucy M. MONTGOMERY
5) Mary PICKFORD
6) Fanny ROSENFELD

300

FIG. 3

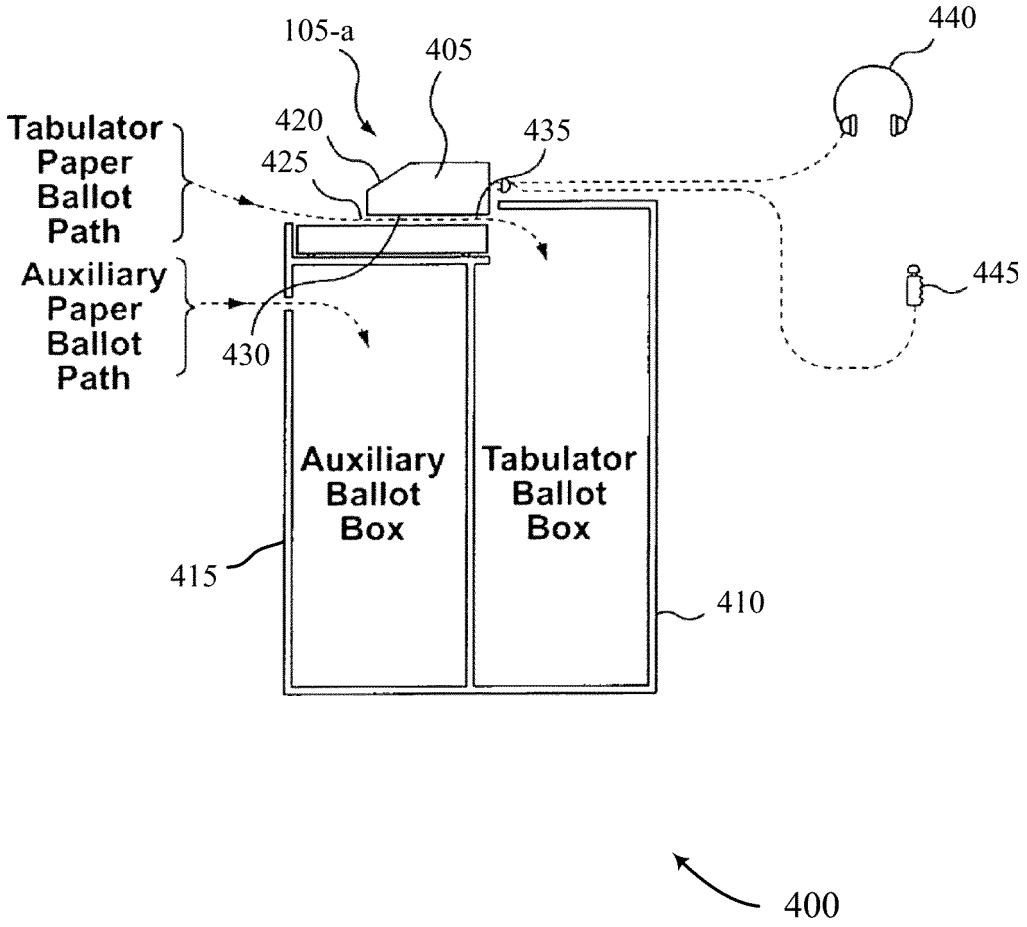
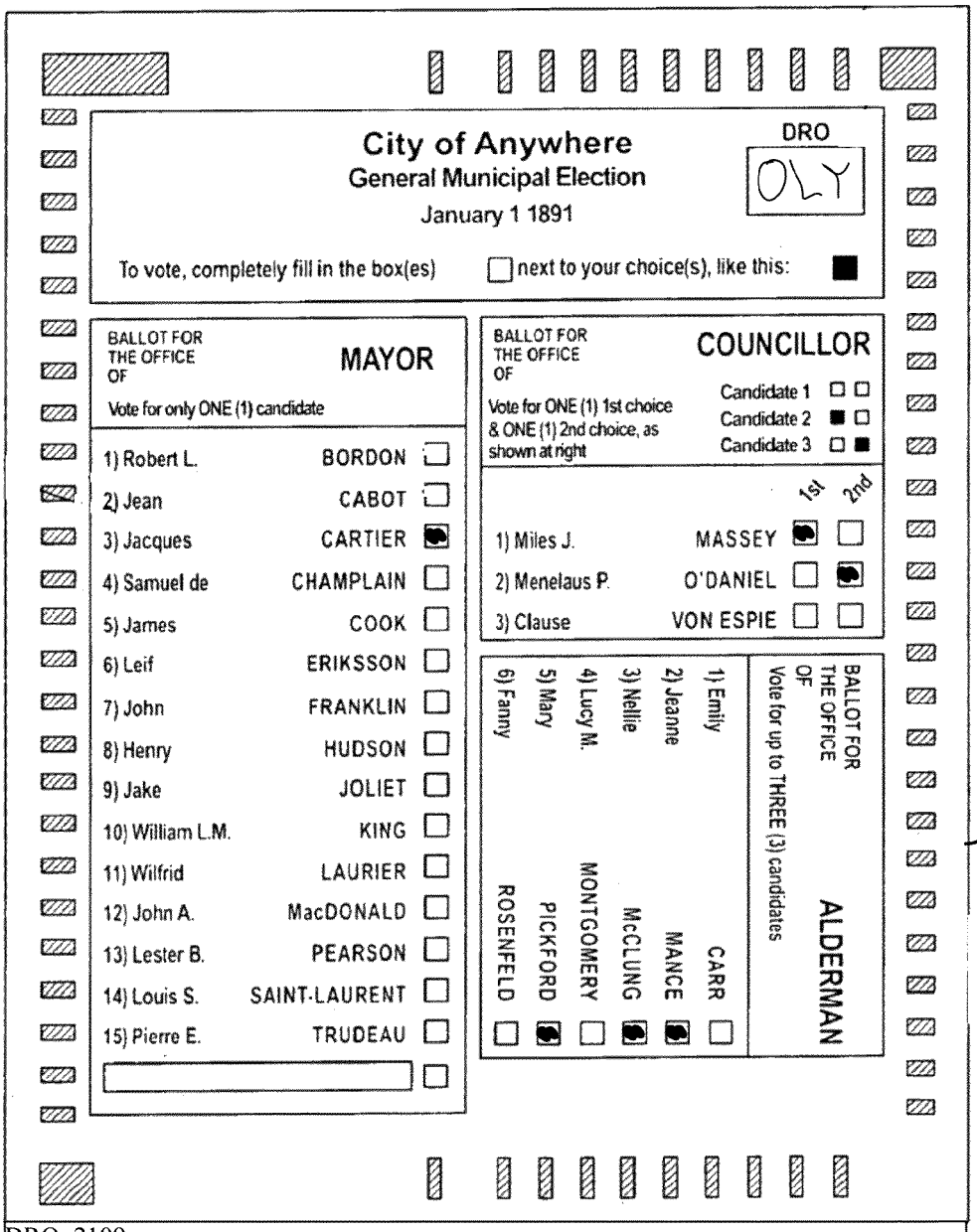

105-a
405
440
420
435
425
Tabulator Paper Ballot Path
Auxiliary Paper Ballot Path
445
430
Auxiliary Ballot Box
Tabulator Ballot Box
415
410
400

FIG. 4



DRO: 2109

Office Of Mayor: 0,0,1,0,0,0,0,0,0,0,0,0,0,0,78D
Vote for: Jacques CARTIER

Office of Councillor (800,0) (1,790), (0,0)
Vote for: Miles J. MASSEY (1st), Menelaus P. O'DANIEL (2nd)

Office of Alderman: 2,812,2,823,788,774
Vote for: Jeanne MANCE, Nellie McCLUNG, Mary PICKFORD

510

500

FIG. 5

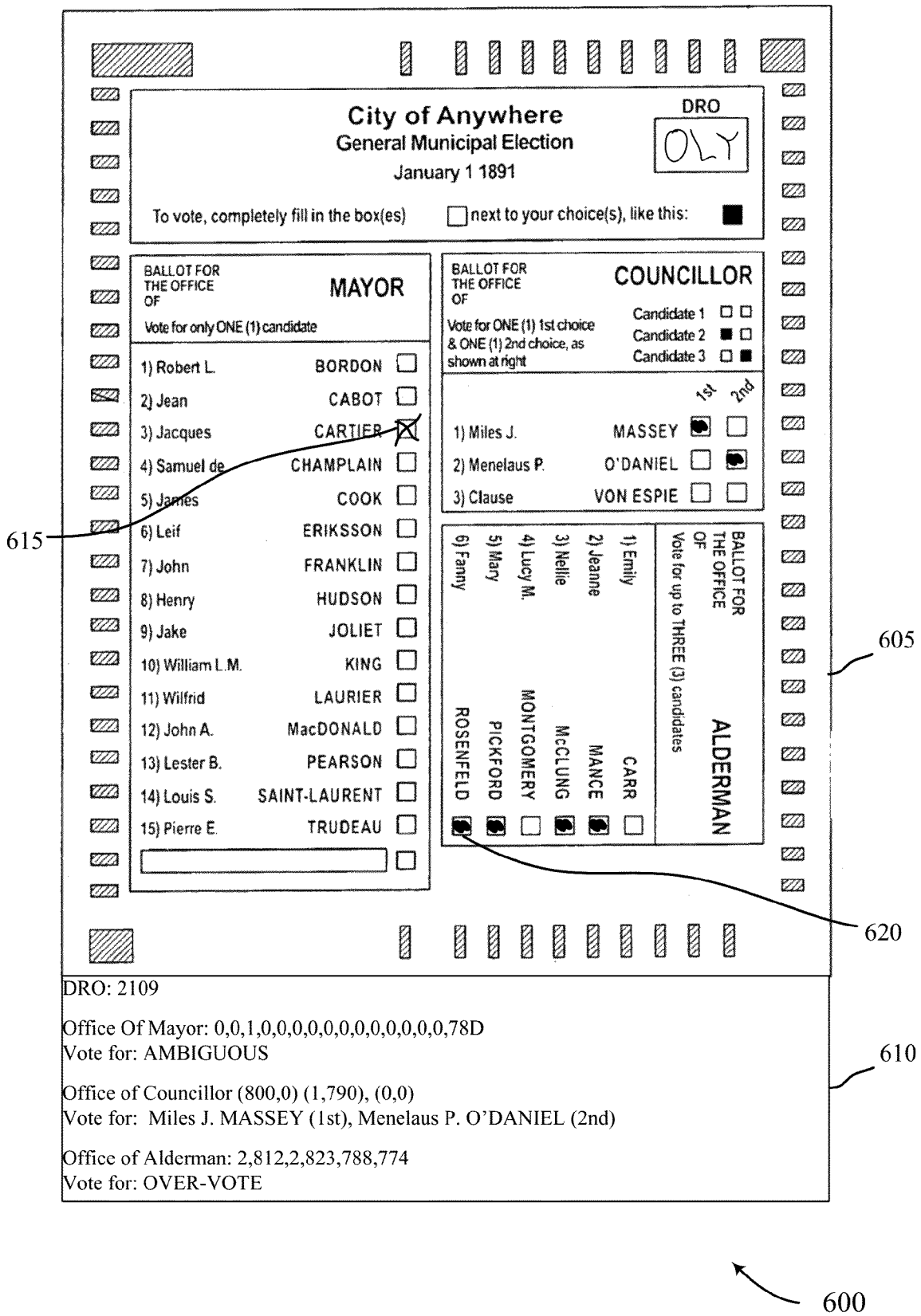

City of Anywhere
General Municipal Election
January 1 1891
DRO
OLY
To vote, completely fill in the box(es) next to your choice(s), like this:
BALLOT FOR THE OFFICE OF
MAYOR
Vote for only ONE (1) candidate
1) Robert L. BORDON
2) Jean CABOT
3) Jacques CARTIER
4) Samuel de CHAMPLAIN
5) James COOK
6) Leif ERIKSSON
7) John FRANKLIN
8) Henry HUDSON
9) Jake JOLIET
10) William L.M. KING
11) Wilfrid LAURIER
12) John A. MacDONALD
13) Lester B. PEARSON
14) Louis S. SAINT-LAURENT
15) Pierre E. TRUDEAU
BALLOT FOR THE OFFICE OF
COUNCILLOR
Vote for ONE (1) 1st choice & ONE (1) 2nd choice, as shown at right
Candidate 1
Candidate 2
Candidate 3
1st
2nd
1) Miles J. MASSEY
2) Menelaus P. O'DANIEL
3) Clause VON ESPIE
BALLOT FOR THE OFFICE OF
ALDERMAN
Vote for up to THREE (3) candidates
1) Emily CARR
2) Jeanne MANCE
3) Nellie McCLUNG
4) Lucy M. MONTGOMERY
5) Mary PICKFORD
6) Fanny ROSENFELD
615
605
620
DRO: 2109
Office Of Mayor: 0,0,1,0,0,0,0,0,0,0,0,0,0,0,78D
Vote for: AMBIGUOUS
Office of Councillor (800,0) (1,790), (0,0)
Vote for: Miles J. MASSEY (1st), Menelaus P. O'DANIEL (2nd)
Office of Alderman: 2,812,2,823,788,774
Vote for: OVER-VOTE
610
600

FIG. 6

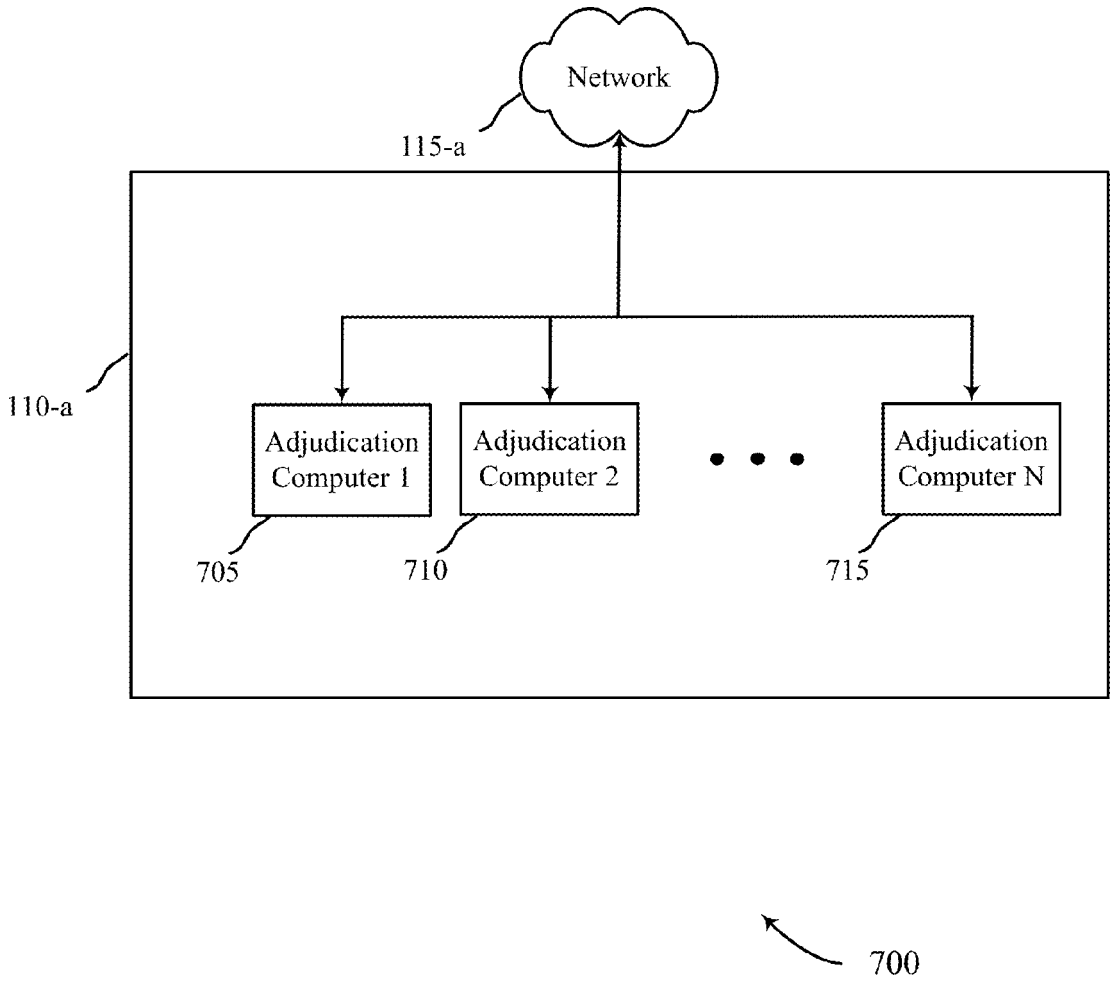

Network
115-a
110-a
Adjudication Computer 1
Adjudication Computer 2
Adjudication Computer N
705
710
715
700

FIG. 7

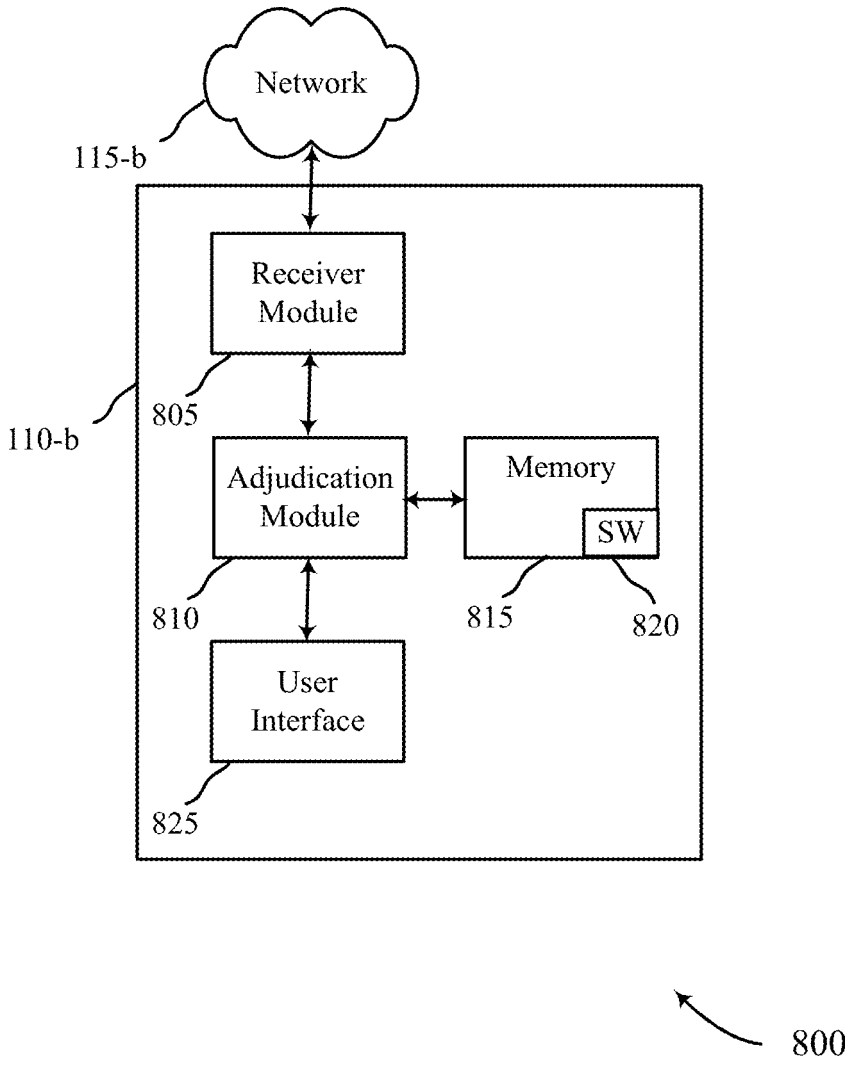
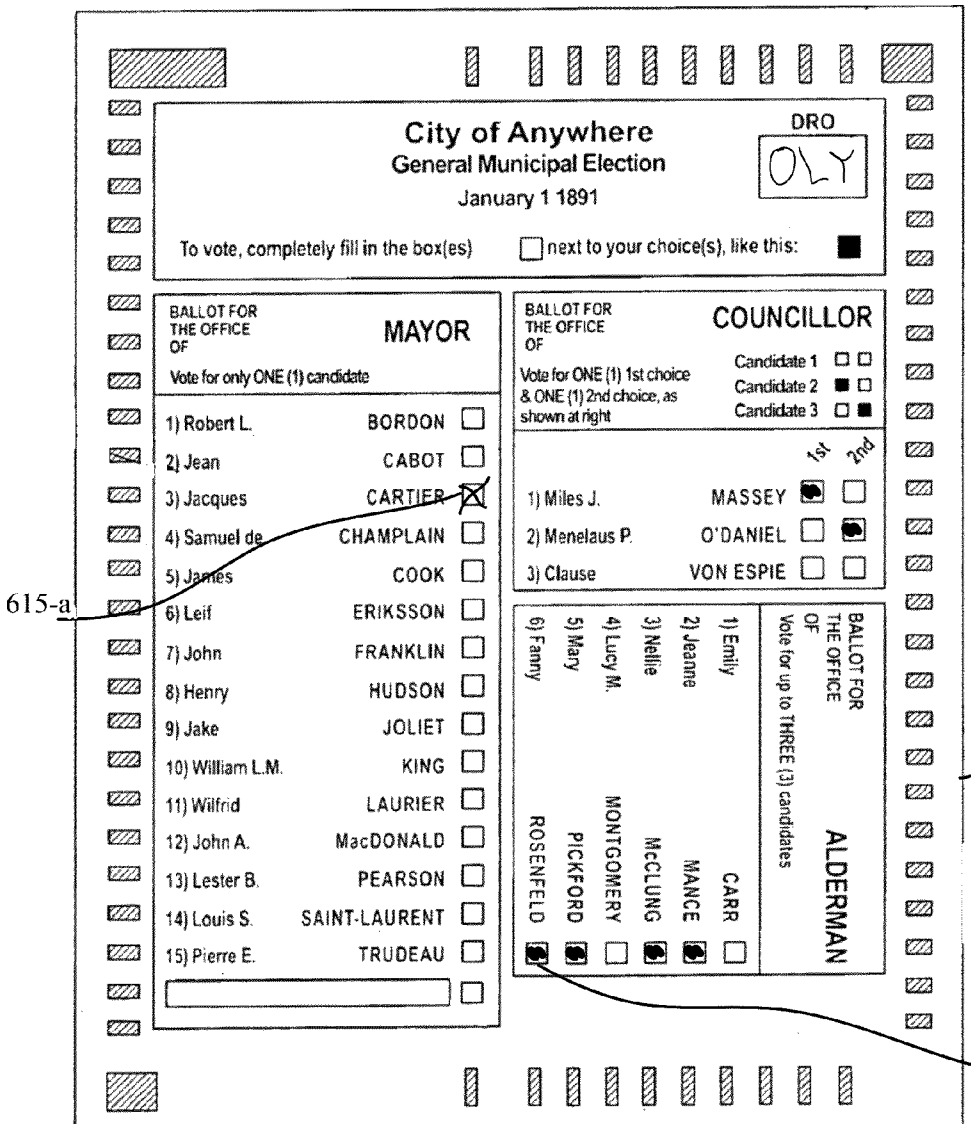

Network
115-b
Receiver Module
805
110-b
Adjudication Module
Memory
SW
810
815
820
User Interface
825
800

FIG. 8



DRO: 2109

Office Of Mayor: 0,0,1,0,0,0,0,0,0,0,0,0,0,0,0,78D
Vote for: AMBIGUOUS

Office of Councillor (800,0) (1,790), (0,0)
Vote for: Miles J. MASSEY (1st), Menelaus P. O'DANIEL (2nd)

Office of Alderman: 2,812,2,823,788,774
Vote for: OVER-VOTE

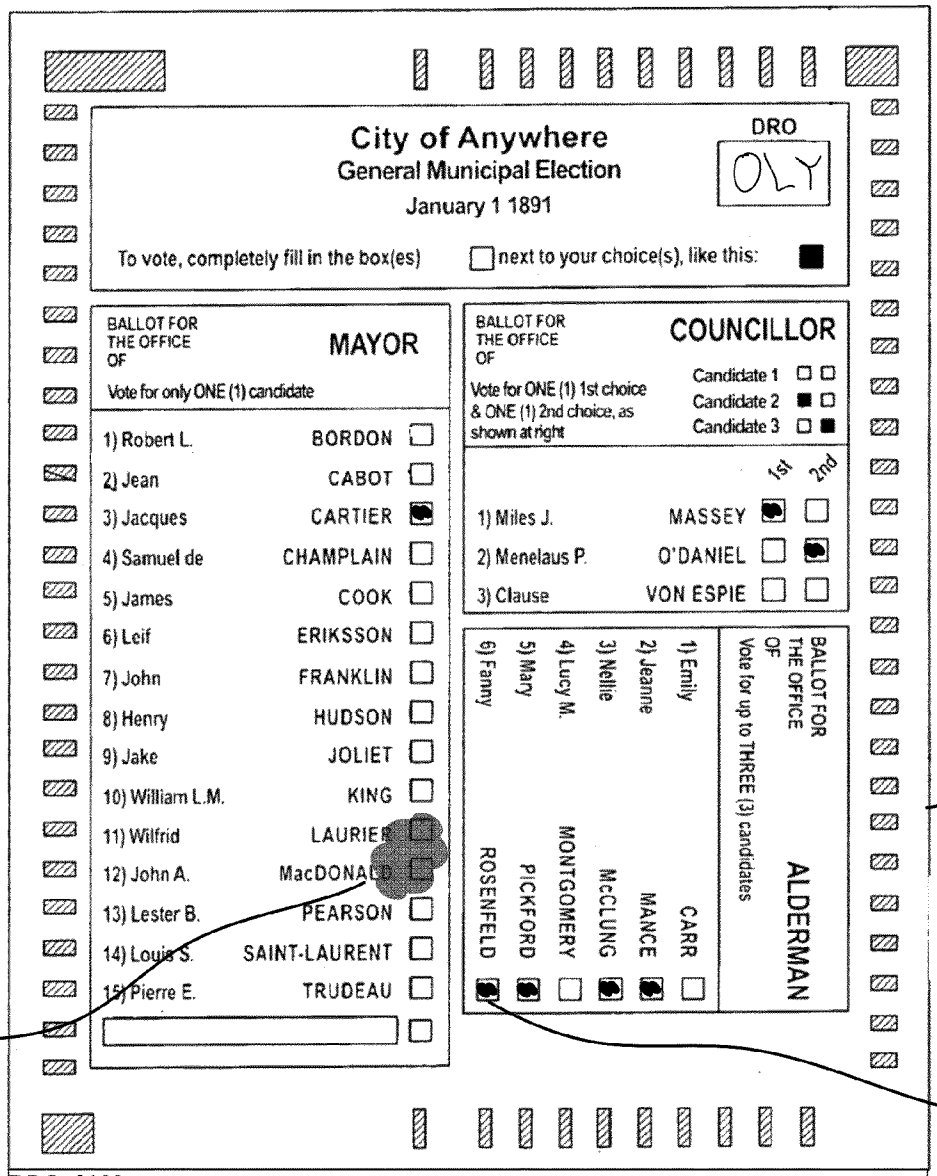
610-a

Adjudication Session on Batch – 1, Ballot – 1, by
User – Admin from Machine ADJUDICATION1
Office of Mayor
01/02/1891 12:59:31 PM Office of Mayor
Choice 3 > Marginal Mark: Mark ADDED
01/02/1891 12:59:36 PM Contest
ADJUDICATED

905

900

FIG. 9



DRO: 2109

Office Of Mayor: 0,0,1,0,0,0,0,0,0,0,0,0,0,0,78D
Vote for: OVER-VOTE

1010

Office of Councillor (800,0) (1,790), (0,0)
Vote for: Miles J. MASSEY (1st), Menelaus P. O'DANIEL (2nd)

Office of Alderman: 2,812,2,823,788,774
Vote for: OVER-VOTE

Adjudication Session on Batch – 1, Ballot – 1, by
User – Admin from Machine ADJUDICATION1
Office of Mayor
01/02/1891 12:59:31 PM Office of Mayor
Choice 3 > Stray Mark: Mark removed
01/02/1891 12:59:36 PM Contest
ADJUDICATED

1015

FIG. 10

1000

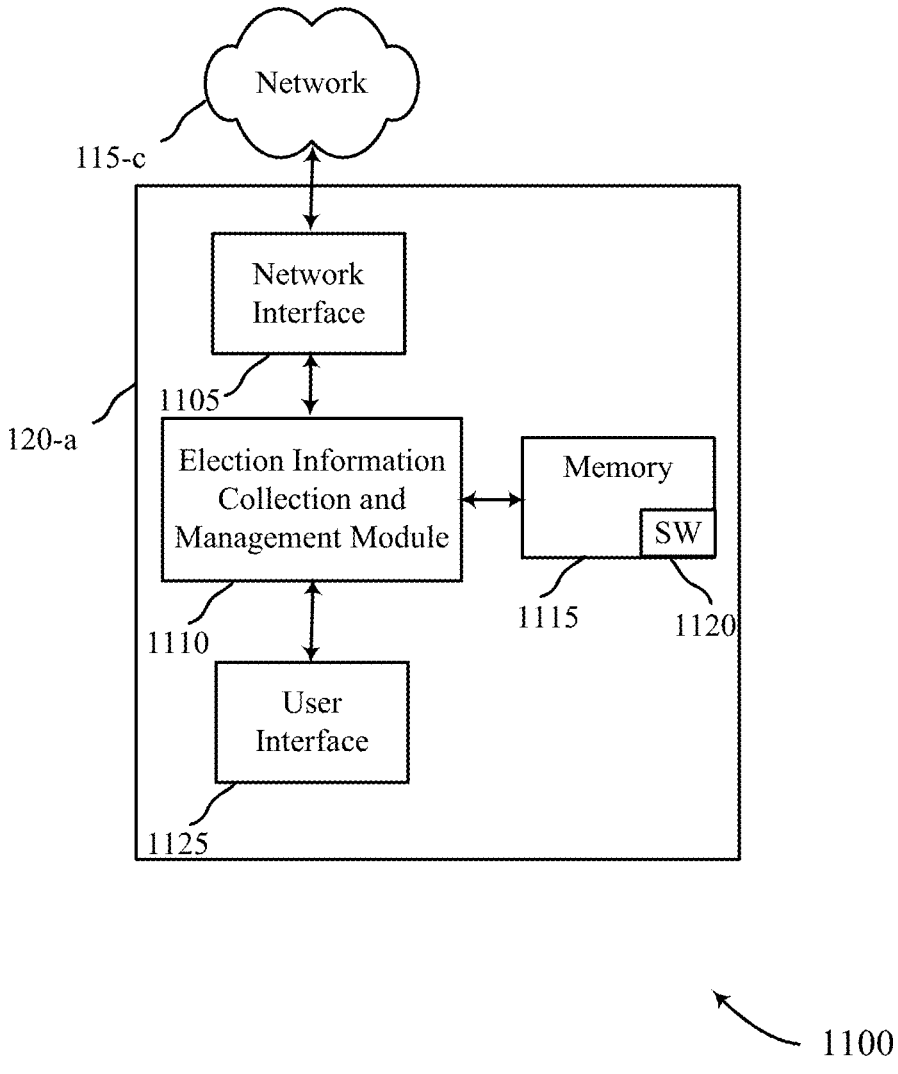

Network
115-c
Network Interface
1105
120-a
Election Information Collection and Management Module
Memory
SW
1115
1120
1110
User Interface
1125
1100

FIG. 11

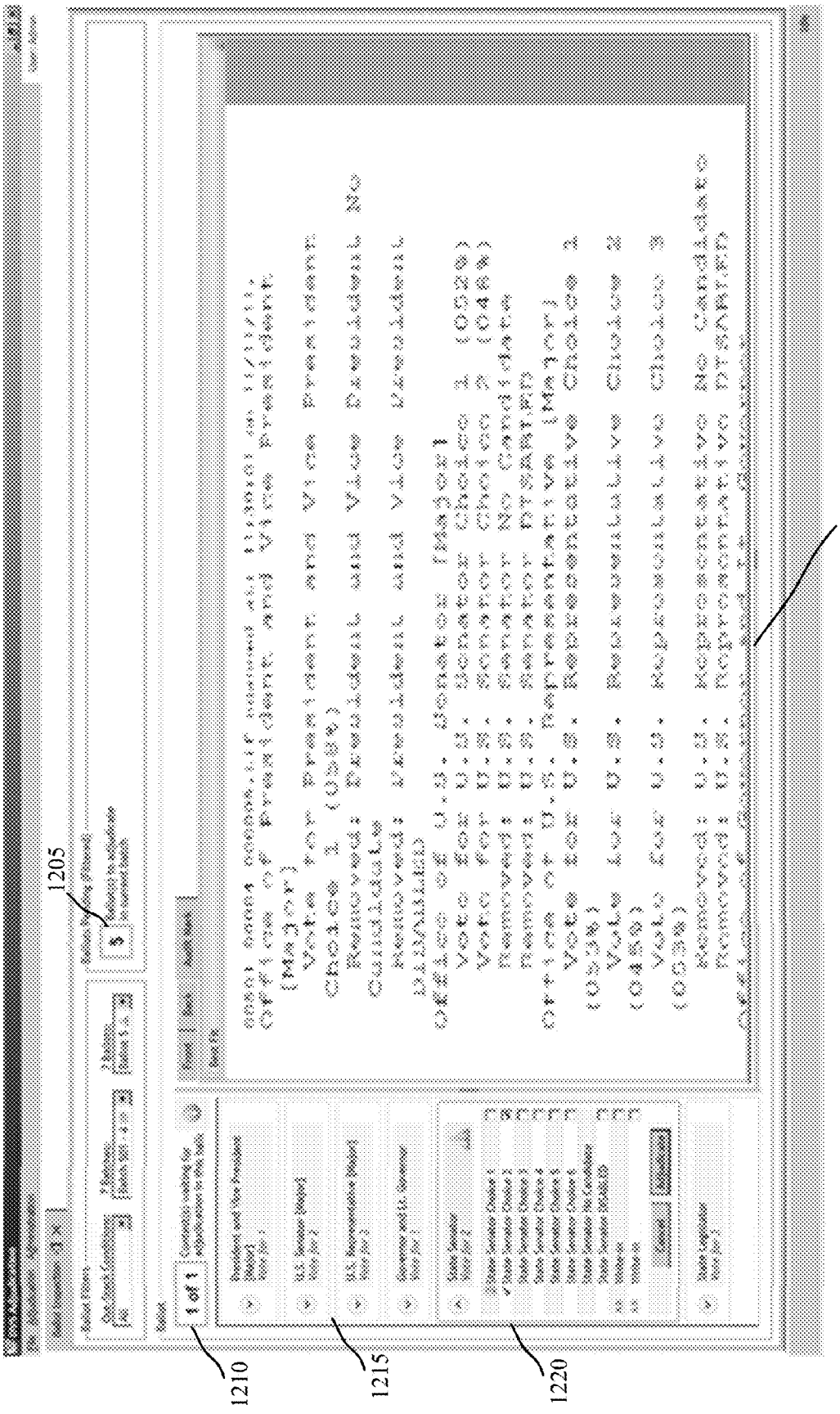


FIG. 12

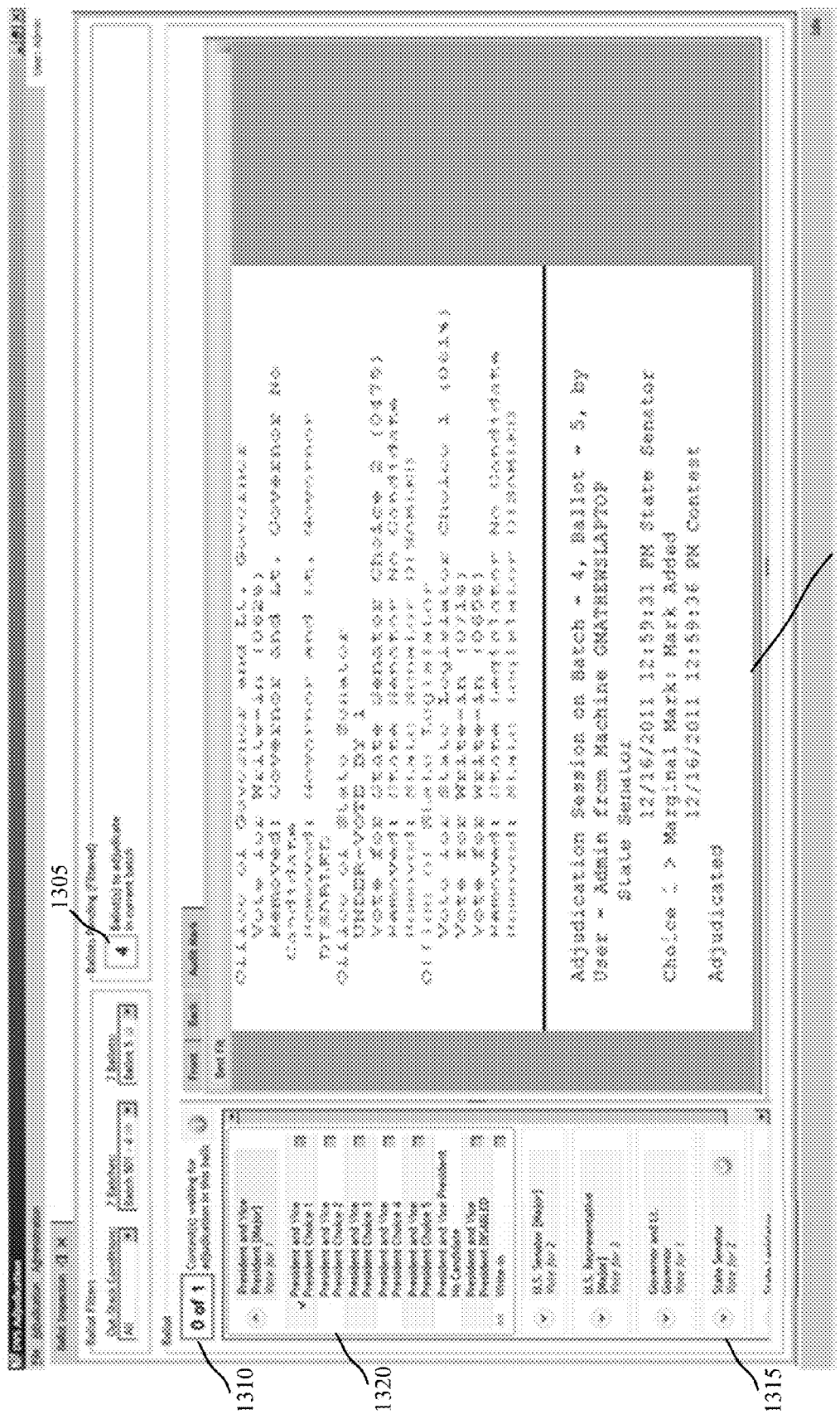

1305
1310
1320
1315
1325
1300
Adjudication Session on Batch - 4, Ballot - 5, by
User - Admin from Machine CHATSWORTHPOP
State Senator
12/16/2011 12:59:31 PM State Senator
Choice 1 > Marginal Mark: Mark Added
12/16/2011 12:59:36 PM Contest
Adjudicated

FIG. 13

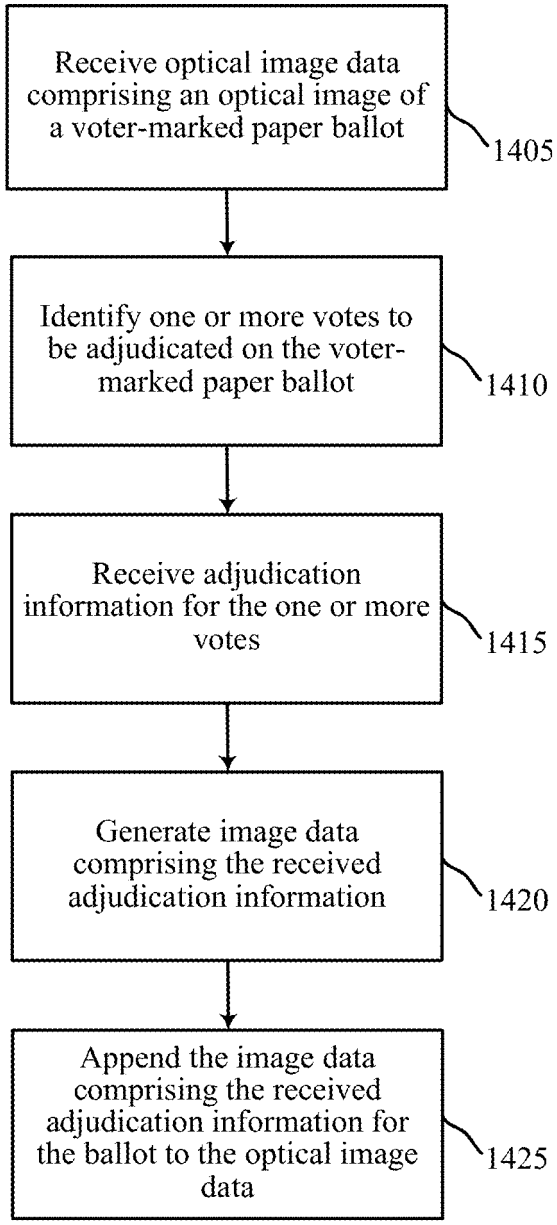

Receive optical image data comprising an optical image of a voter-marked paper ballot
1405
Identify one or more votes to be adjudicated on the voter-marked paper ballot
1410
Receive adjudication information for the one or more votes
1415
Generate image data comprising the received adjudication information
1420
Append the image data comprising the received adjudication information for the ballot to the optical image data
1425
1400

FIG. 14

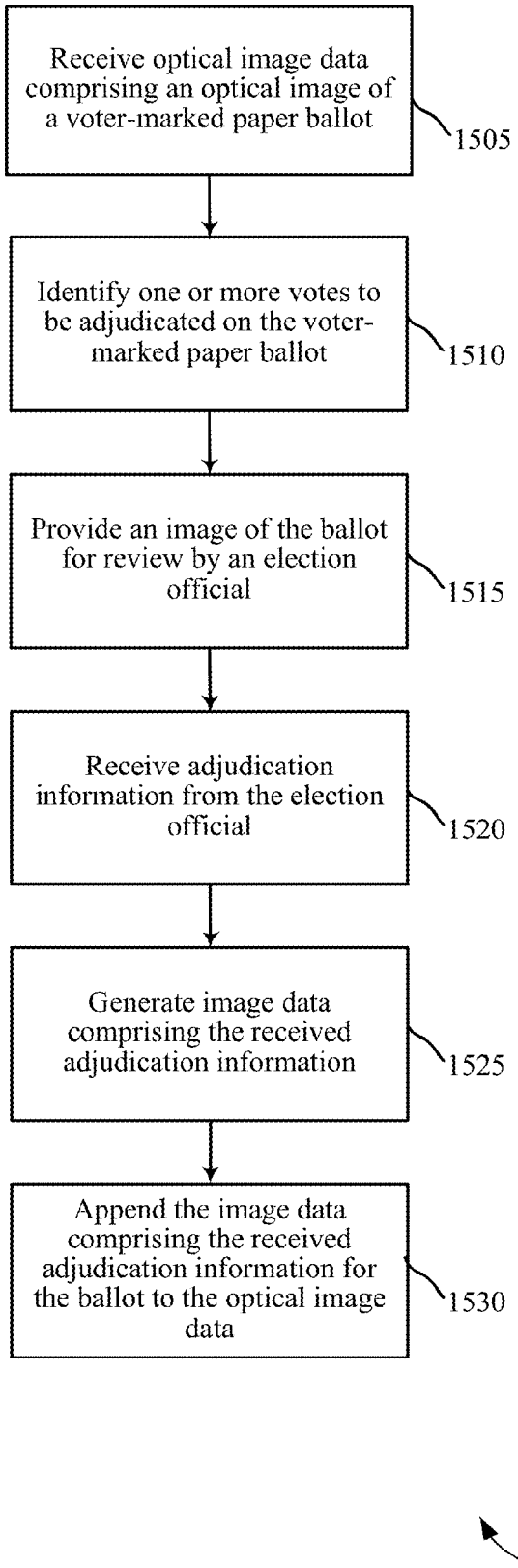

Receive optical image data comprising an optical image of a voter-marked paper ballot
1505
Identify one or more votes to be adjudicated on the voter-marked paper ballot
1510
Provide an image of the ballot for review by an election official
1515
Receive adjudication information from the election official
1520
Generate image data comprising the received adjudication information
1525
Append the image data comprising the received adjudication information for the ballot to the optical image data
1530
1500

FIG. 15

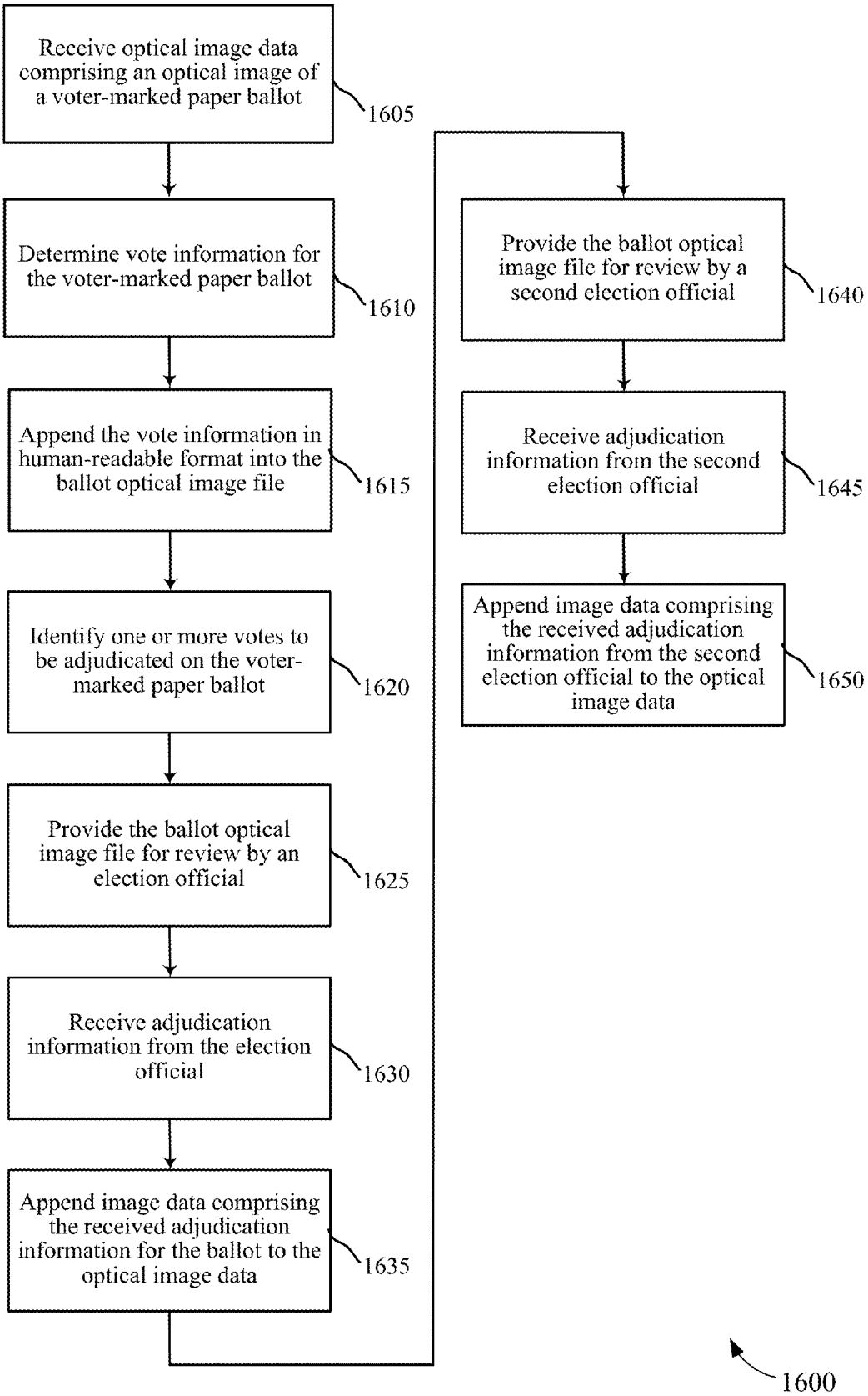

Receive optical image data comprising an optical image of a voter-marked paper ballot
1605
Determine vote information for the voter-marked paper ballot
1610
Append the vote information in human-readable format into the ballot optical image file
1615
Identify one or more votes to be adjudicated on the voter-marked paper ballot
1620
Provide the ballot optical image file for review by an election official
1625
Receive adjudication information from the election official
1630
Append image data comprising the received adjudication information for the ballot to the optical image data
1635
Provide the ballot optical image file for review by a second election official
1640
Receive adjudication information from the second election official
1645
Append image data comprising the received adjudication information from the second election official to the optical image data
1650
1600

FIG. 16

BALLOT ADJUDICATION IN VOTING SYSTEMS UTILIZING BALLOT IMAGES

CROSS REFERENCES

This application is a continuation of U.S. patent application Ser. No. 13/470,091, filed May 11, 2012, entitled, "BALLOT ADJUDICATION IN VOTING SYSTEMS UTILIZING BALLOT IMAGES," which is incorporated by reference in its entirety for all purposes.

BACKGROUND

The present invention relates to voting systems in general and, in particular, to methods and systems for adjudicating ballots utilizing ballot images.

Electronic tabulation of voter-marked paper ballots has been used in elections for some time. Such systems may provide efficient vote tabulation if ballots are received without any errors, modifications, or write-in candidates included on the ballot. Electronic tabulation systems for voter-marked ballots may include optical scanners that scan the voter-marked ballots. Such ballots may have a target area that is evaluated by a computer that receives an image of the scanned ballot to determine if a vote is cast for a particular election, such as a bubble or square next to a candidate's name on a ballot. Electronic tabulation systems may also receive ballots generated from direct-recording electronic (DRE) voting machines, in which a voter may electronically enter votes without a voter-marked paper ballot.

In some instances optical scan systems may not be able to determine with high confidence that a particular vote has been cast. For example, a voter may partially fill in a target area next to a candidate name, may place a mark next to the target area rather than filling in the target area, and/or soil the ballot in some fashion (e.g., coffee stain).

Furthermore, in many jurisdictions voter intent is used as a basis for evaluating and adjudicating ballots for purposes of tabulating votes. Thus, if a voter improperly completed a ballot with a mark outside of a target area, a review of the ballot may indicate that the voter intended to cast a certain vote, and thus the ballot should be properly tabulated to include the intended vote. Similarly, a voter may mark an area for a particular candidate, and afterward realize that they made an error or change their mind. The voter may cross out the vote and mark a different area for a different candidate, and make a note such as, for example, writing "not this one" next to the crossed-out mark. An electronic scanning and tabulation system may not tabulate such a vote properly, while a human review of the ballot may readily reveal that the voter did intend to vote for the different candidate. Such instances may consume a significant amount of resources at the polling place or later, when the votes recorded on the ballots are being tabulated.

Furthermore, many jurisdictions have a number of voters that vote through a mail-in ballot, and in some elections the voting may be done exclusively through mail-in ballots. Such mail-in ballots may have an increased likelihood of votes requiring adjudication, as the voter is not able to simply ask for a new ballot if they improperly mark or otherwise soil their original ballot. Furthermore, voters may complete mail-in ballots at their home, which may increase the likelihood that a ballot will be soiled with food or drink stains, which may lead to incorrect vote tabulation by an optical scan tabulation system.

SUMMARY

Methods, systems, and devices are described for adjudicating votes made on voter-marked paper ballots. Voter-marked paper ballots may be optically scanned to obtain optical image data of the voter-marked paper ballots. The optical image data may be analyzed to determine the votes contained in the ballot for tabulation purposes. One or more votes on the ballot, or the ballot as a whole, may be identified as requiring adjudication by an election official. Adjudication information, according to various embodiments, is appended to the optical images of the voter-marked paper ballots such that the image of the ballot and the image of the adjudication information may be viewed in an optical image. The optical image may be stored in a file format that allows the ballot image and the appended adjudication information to be viewed using readily available image viewers.

In one set of embodiments, methods for ballot adjudication of a voter-marked paper ballot are provided that include receiving optical image data comprising an optical image of a voter-marked paper ballot, identifying one or more votes recorded on the voter-marked paper ballot to be adjudicated, receiving adjudication information for the ballot, generating image data comprising the received adjudication information for the ballot, and appending the image data comprising the received adjudication information for the ballot to the optical image data.

In other embodiments, a system for adjudication of voter-marked paper ballots is provided. The systems, according to various embodiments, may comprise a receiver module configured to receive ballot optical image data comprising an optical image of a voter-marked paper ballot, and an adjudication module configured to receive adjudication information for the ballot, generate image data comprising the received adjudication information for the ballot and append the image data for the ballot to the optical image data. The adjudication module may be configured to receive an indication that the ballot requires adjudication when a mark within a target area of the ballot is determined to be ambiguous. In some embodiments, the adjudication module is further configured to provide an image of the ballot for review by an election official and receive the adjudication information from the election official. In some embodiments, multiple election officials may adjudicate a ballot, with each adjudication having corresponding image data comprising the received adjudication information for the ballot that is appended to the image data for the ballot.

BRIEF DESCRIPTION OF THE DRAWINGS

A further understanding of the nature and advantages of the present disclosure may be realized by reference to the following drawings. In the appended figures, similar components or features may have the same reference label. Further, various components of the same type may be distinguished by following the reference label by a dash and a second label that distinguishes among the similar components. If only the first reference label is used in the specification, the description is applicable to any one of the similar components having the same first reference label irrespective of the second reference label.

FIG. **1** is a block diagram of a ballot scanning, tabulation, and adjudication system including components configured according to various embodiments.

FIG. **2** is an image of a paper ballot according to various embodiments.

FIG. **3** is an image of a voter-marked paper ballot according to various embodiments.

FIG. **4** is an illustration of an optical scan ballot system according to various embodiments.

FIG. **5** is an image of a voter-marked paper ballot with an audit mark according to various embodiments.

FIG. **6** is an image of a voter-marked paper ballot containing an ambiguous mark according to various embodiments.

FIG. **7** is a block diagram of an adjudication system according to various embodiments.

FIG. **8** is a block diagram of an adjudication computer according to various embodiments.

FIG. **9** is an image of a voter-marked paper ballot containing an ambiguous mark, an audit mark, and an adjudication mark, according to various embodiments.

FIG. **10** is an image of a soiled voter-marked paper ballot containing an audit mark and an adjudication mark according to various embodiments.

FIG. **11** is a block diagram of a central server computer system according to various embodiments.

FIG. **12** is a screen shot provided by a central server computer system according to various embodiments.

FIG. **13** is another screen shot provided by a central server computer system according to various embodiments.

FIG. **14** is a flow chart illustrating operational steps of ballot adjudication according to various embodiments.

FIG. **15** is another flow chart illustrating operational steps of ballot adjudication according to various embodiments.

FIG. **16** is another flow chart illustrating operational steps of ballot adjudication according to various embodiments.

DETAILED DESCRIPTION

Methods, systems, and devices are described for adjudicating votes made on voter-marked paper ballots. Voter-marked paper ballots may be scanned to obtain optical image data of the voter-marked paper ballots. The optical image may be analyzed to determine the votes contained in the ballot for tabulation purposes. One or more votes on the ballot, or the ballot as a whole, may be identified as requiring adjudication by an election official. Adjudication information, according to various embodiments, is appended to the optical images of the voter-marked paper ballots such that the image of the ballot and the image of the adjudication information may be viewed in an optical image. The optical image may be stored in a file format that allows the ballot image and the appended adjudication information to be viewed using readily available image viewers.

This description provides examples, and is not intended to limit the scope, applicability or configuration of the invention. Rather, the ensuing description will provide those skilled in the art with an enabling description for implementing embodiments of the invention. Various changes may be made in the function and arrangement of elements.

Thus, various embodiments may omit, substitute, or add various procedures or components as appropriate. For instance, it should be appreciated that the methods may be performed in an order different than that described, and that various steps may be added, omitted or combined. Also, aspects and elements described with respect to certain embodiments may be combined in various other embodiments. It should also be appreciated that the following systems, methods, devices, and software may individually or collectively be components of a larger system, wherein other procedures may take precedence over or otherwise modify their application.

It may be beneficial to provide the ability to audit the election results. In some instances, one or more votes on a voter-marked paper ballot may need to be adjudicated by an election official. Such adjudication may be used in order to establish the intent of the voter that marked the paper ballot. For example, an optical scan tabulation system may not record a vote for a particular candidate because a box or bubble next to the candidate's name was not completely filled in. An election official reviewing such a ballot may readily conclude that the voter intended to cast a vote for the particular candidate, and that the optical scan tabulation system simply did not tabulate the vote because the mark for the candidate did not register as a vote for the candidate.

When auditing election results, officials may desire to view the original ballot, along with any adjudications of votes on the ballot. In many instances, the assessment of what constitutes a vote in favor of a particular candidate or a particular answer to a question is determined by subjective assessment. Thus, in order to maintain integrity of the election process, a record of ballot adjudications may be desired, such that a record of the originally tabulated vote and any adjudicated votes are clear.

With reference now to FIG. **1**, a block diagram of a ballot scanning, tabulation, and adjudication system **100** according to some embodiments is described. In the system **100** of FIG. **1**, an optical scan ballot system **105** is configured to receive voter-marked paper ballots, scan the ballots, and provide an optical image of the voter marked paper ballots. The optical scan ballot system **105** may include any of several types of scanning equipment, and in an embodiment includes a feeding mechanism that receives ballots and feeds the ballots through a scanner and then into a ballot box. In some embodiments, the optical scan ballot system marks each scanned ballot with one or more marks that may be used to identify the paper ballot. In other embodiments, the optical scan ballot system **105** evaluates marks on the ballots and determines votes made by the voter. These determined votes may be stored for tabulation to determine election outcome. In some embodiments, determined votes may be printed on the ballots by the optical scan ballot system **105** using an internal printer. According to a set of embodiments, an optical image of the ballot is obtained by the optical scan ballot system **105**, and in some embodiments the vote outcomes determined by the optical scan ballot system **105** are included as an audit mark in the optical image. Such an optical image may then be viewed by other systems to display the optical image of the voter-marked paper ballot along with the audit mark provided by the optical scan ballot system **105**. Examples of optical scan ballot systems **105** will be described in more detail below.

The ballot scanning, tabulation, and adjudication system **100** of FIG. **1** may also include adjudication system **110**. The adjudication system **110** is connected through a network **115** to the optical scan ballot system **105** and to a central server computer system **120**. Adjudication system **110** may receive data containing the optical images of paper ballots and audit marks and the votes recognized by the optical scan ballot system, if provided, from the optical scan ballot system **105**. In some cases, the adjudication system **110** may receive data containing the optical images of paper ballots and audit marks from an election tabulation manager located at the central server computer system **120**. An election official using the adjudication system **110** may review optical images of the paper ballots, and, based on the review, make a determination as to whether the marks were properly counted as votes or whether changes should be made to properly record the votes on the paper ballot. In some embodiments, an audit mark is viewable along with the image of the paper ballot allowing the election official to review the votes recognized by the optical scan ballot system and compare the votes to the marks on the paper ballot. The election official may make any necessary changes and enter the changes through the adjudication sys-

tem **110**, which then may append an image to the optical image of the ballot that includes the adjudication information. Such an appended image may be referred to as an adjudication mark. Adjudication system **110** and central server computer system **120** will be described in additional detail below.

With reference now to FIG. **2**, an example of a paper ballot **200** is described. The ballot **200** includes a number of voter selection areas **205**, **210**, **215** that represent voter selections for different offices or ballot questions. In the example ballot **200**, there is also an election official area **220**, which may be used by an election official to validate the particular ballot. Such validation may take the form of a signature or initials in the election official area **220** by an election official, however, other types of authentication may also be used. The election official area **220**, according to a set of embodiments, serves to mark the paper ballot **200** as having been officially issued. It will be readily understood that paper ballots such as ballot **200** may include pre-printed ballots and/or ballots printed locally on-demand by a local printer. The voter will generally take the validated blank paper ballot **200** to a private area (such as a desk with privacy barriers), and make a mark or marks (this can be done in numerous ways such as filling in a box or oval, etc) beside the chosen candidate(s) with a marking instrument. While this disclosure may generally refer to selection of a candidate or candidates, it will be readily understood that some votes relate to other questions such as referendum questions, ballot initiatives, and the like. The concepts described herein extend to votes obtained all matters whether candidates, weighted candidate votes, referendum questions and the like.

FIG. **3** illustrates an example of a ballot **300** that has been properly completed by a voter. After the voter has marked the ballot **300**, the voter may provide the ballot to be tabulated. In some situations, the voter may drop the completed ballot (e.g., ballot **300**) into a ballot box that election officials then take for processing and tabulation. In some embodiments, the election officials may direct the voter to place the ballot into an optical scan ballot system, such as optical scan ballot system **105** illustrated of FIG. **1**, that scans the ballot and performs processing to determine the votes on the ballot.

FIG. **4** is an illustration of a ballot receiving system **400** according to some embodiments. In one set of embodiments, the ballot receiving system **400** includes an optical scan ballot system **105**-*a* that includes a hybrid paper/electronic vote tabulator **405**. The hybrid paper/electronic vote tabulator **405**, also referred to as a tabulation unit, is coupled with tabulator ballot box **410**. An optional auxiliary ballot box **415** is also illustrated in FIG. **4**, and may receive ballots that are not provided to the optical scan ballot system **105**. As voters come into the polling location, they may be processed by an election official who determines voter eligibility (based on local election rules), and also determines the proper ballot for the voter. The voter may then mark the ballot and take the marked paper ballot to the tabulation unit **405**. In some embodiments, the tabulation unit **405** includes a display **420** that instructs the voter to feed the ballot into the tabulation unit **405** through path **425**. The ballot may then be fed through the tabulator unit **405** and an image of the ballot created using a digital scanning device **430**. According to various embodiments, the scanning device **430** takes a high resolution optical scan of the ballot and moves the ballot into the tabulator ballot box **410** through opening **435**. In one particular aspect of the invention, the tabulation unit **405** takes the resulting high resolution scanned image of the entire ballot, and saves a copy of this image to a non-volatile memory linked to the optical scan ballot system **105**-*a*. System **400** may also include, as illustrated in FIG. **4**, earphones **440**, and a pendant manual trigger **445**, for use by voters that require such devices.

The tabulation unit **405** of a set of embodiments includes a processing module that executes software code to analyze the optical image of the ballot to determine the votes recorded on the ballot. The tabulation unit **405**, in some embodiments, also randomly assigns a filename to each scanned image to ensure that the order in which the ballots were scanned remains private. The tabulation unit **405** may also send a copy of the images to the central server computer system **120** and/or the adjudication system **110** of FIG. **1** for image recognition. In embodiments where tabulation unit **405** performs image processing, a ballot processing application runs an image recognition routine that is applied to the digital image and enables the tabulation unit **405** to selectively recognize specific areas of each image and may analyze such specific areas as described in more detail below to define a series of processing results associated with the particular ballot.

For example, the tabulation unit **405** may analyze the various security markings on the ballot to ensure it is a valid ballot, perform a pixel count check to verify that the election official area **20** was initialed by the election official, and perform a pixel count of each voter selection area on the ballot. In addition, as further examples of such processing results, depending on the pixel count of each marking box, the mark may be classified as a 'vote', a 'non-vote.' or an 'ambiguous mark.' These classifications may be based, for example, on the total pixel counts of the marking areas (e.g., areas **205**, **210**, and **215** in the example of FIG. **2**) of the ballot, and/or a pattern of pixels in the marking areas. The determination of a vote, non-vote, or ambiguous mark is made according to pixel levels defined by election officials at a given time prior to the election. According to some embodiments, election officials may define, in pixels, the minimum pixel count that is to be classified as a 'vote,' the maximum pixel count (if any) that is to be defined as a definite 'non-vote,' and a range of pixels in between those values that will constitute an 'ambiguous mark.' These pixel values are loaded on each tabulation unit **405**. After calculating these pixel values for each marking area, the tabulation unit **405** may return the ballot to the voter with an appropriate error message if any errors are detected in the ballot, or feed the ballot to the tabulator ballot box, An error may be detected, for example, if one or more voting areas contain an ambiguous mark, if too many marking areas in one category were classified as votes resulting in an "over-vote," if no marking areas in one or more category were classified as votes (resulting in a blank ballot for one or more elections) and/or no pixel count was recorded in the election official area. In some embodiments, the tabulation unit **405** may be programmed to allow a voter to verify the ballot in the case of over-voted or blank ballots, thus preserving the voter's right to cast an over-voted or blank ballot. In other embodiments, the optical scan ballot system **105**-*a* may return a ballot to the voter when an ambiguous mark or over-vote is detected, allowing the voter to correct the ballot or obtain a replacement ballot.

In some embodiments, once the determination of the total votes for a ballot has been made, the tabulation unit **405** appends a footer to the saved ballot image that contains processing results for that specific ballot. FIG. **5** illustrates an image **500** that includes an optical image of a voter-marked paper ballot **505** as shown in FIG. **3**, along with an audit mark **510** that is appended to the ballot optical image. The audit mark **510**, according to some embodiments, is included as an image in the same file that contains the optical image of the voter-marked paper ballot. In such a manner, if a user displays the optical image of the voter-marked paper ballot, the audit

mark will also be displayed allowing the user to view the ballot and voter markings as well as information on how the tabulation unit registered the votes for the ballot. Such a system allows for auditing of election results in an efficient manner. It will be understood that appending an optical audit mark image to the ballot optical image is just one manner in which the votes recorded for a ballot may be associated with the ballot. In other embodiments, the information from the tabulation unit may be stored in a separate database and associated with a particular ballot, or may be stored in the ballot optical image file as extra data or metadata that may or may not be displayed along with an image of the ballot. The embodiment of FIG. **5** illustrates the audit mark **510** at a footer of the optical ballot image **505**, although it will be readily understood that an audit mark image **510** may be located at different locations relative to the ballot image **505**. The audit mark **510** may also be referred to as a "fingerprint" or a "vote stamp" that is attached or otherwise associated with each image.

In embodiments where the audit mark **510** is appended as an image to the voter-marked paper ballot optical image **505**, the image may be saved in a format that is widely viewable by a variety of different image viewers. For example, the optical image may be stores as a .jpg file, a .tiff file, or a .pdf file, to name just a few examples. Various different types of viewers may be used to display such files, allowing the review of election results that does not require specialized software. Furthermore, the inclusion of an audit mark with the ballot optical image allows for review of how an optical scanning system read the particular ballot through simply viewing the optical image file.

With reference again to FIG. **4**, the ballot receiving system **400** may also include components to enable voting by an individual with a challenge such as visual impairment, illiteracy, inability to read the language in which the ballot is written, physical impairment with only limited motor abilities, etc. In such cases, an election official may initialize, for example, an "audio ballot" which may be administered directly by the tabulation unit **405**. When the election official initializes, or activates, the audio ballot the voter may put on earphones **440** and take hold of the handheld pendant that includes the manual trigger selector **445**. According to various embodiments, an audio ballot may simply be an audio version of the ballot, which may be stored to a local memory of the tabulation unit **405**. The voter negotiates through the ballot through the audio interface and makes candidate selections via the manual trigger **440**. In one embodiment, each time the voter makes a selection, and upon completion of voting for each individual race, the tabulation unit **405** asks the voter to confirm the choices after it is audibly reviewed. Upon completion of the audio ballot, a final review may be read back to the voter, and the voter is asked one more time to confirm the selected choices. In one embodiment, the tabulation unit **405** includes a printer that allows printing of the voter's selections on the ballot, and an optical image thereof may also be generated. In other embodiments, an audio clip of the final voter review, along with a subsequent audible voter confirmation of the review, may be recorded and stored in the tabulation unit **405**. In other embodiments, this set of voter selections stored electronically that do not have a paper record can be used to create an optical image file that presents the vote selections in the same or similar format as a marked ballot, which can be printed and scanned in a similar fashion as other scanned paper ballots. In addition, once the voter is finished with this final review, the election official may provide the voter one last chance to cancel the ballot and start over. Once the final review is completed, the tabulation unit **405** may be used to cast the audio ballot. By doing so, the votes from that audio ballot are appended to the ongoing tally of the tabulation unit **405**, an audio recording to the process may be saved to the memory, and optionally a printer associated with the tabulation unit may prints the vote on a paper ballot or print a summary of the audio vote onto a paper chit. The ballot or chit then falls into the tabulator ballot box **410** in order to maintain secrecy, or may be printed in encrypted form for audio playback on either the tabulation unit **405** or external device.

At the end of voting, in real time, or periodically throughout the voting process, the tabulation unit **405**, according to various embodiments, maintains an ongoing tally for all the ballots that passed through that particular machine, and those results may be transmitted by various known methods and technologies to a central location such as central server computer system **120** of FIG. **1**. The central server computer system **120** may include, for example, a central election database that stores results from a number of optical scan ballot systems **105**-*a* located throughout the election jurisdiction. The various election results from the various optical scan ballot systems **105**-*a* may be summed together, provided to election officials, and stored to a memory, according to various embodiments.

As described above, while voting occurs or once the vote has been completed, the optical image data for each of the scanned ballots along with the appended audit mark if present, may be transferred to the central server computer system **120**. Election officials may perform various management, auditing, and adjudication tasks. In some embodiments, to ensure that the tabulation units **405** have functioned correctly, and also to verify the integrity of the vote overall, auditing of the optical image data may be performed. This may be in the form of a random spot check, a structured check to gain a certain confidence rate in the tabulator integrity, or a complete check of every ballot cast. Additionally, adjudication may be needed to determine proper votes cast on particular ballots. In some embodiments, an election information collection and management module located at the central server computer system, as will be described in additional detail below, identifies ballots that require adjudication. Such ballots may be ballots that were identified by the optical scan ballot system **105** as having errors, provisional or challenge ballots, and/or ballots that are damaged and unable to be read, for example.

Ballots identified as requiring adjudication may be provided to an election official who may confirm, correct, or appropriately change one or more votes recorded for the particular ballot based on their review of the ballot optical image. For example, FIG. **6** illustrates a ballot optical image **600** including an image of the voter-marked paper ballot **605** and an appended audit mark **605**. In this particular example, the ballot includes two errors. The first error is an improperly filled in selection **615**, where the voter simply marked a box with an X rather than filling in the box. The optical analysis of this ballot by the optical scan ballot system **105** (or other system that performs optical analysis of ballots to determine votes), as indicated in the audit mark **610**, identified mark **615** as AMBIGUOUS. This may result from the number of pixels for the particular ballot area being below the defined threshold for counting the mark as a vote and above the defined threshold for identifying the mark as ambiguous, as described above. The second error on the ballot **605** is an overvote **620** for the office of Alderman. An election official may review this optical image and readily discern that mark **615** indicates that the voter intended to vote for Jacques Cartier for the office of Mayor, and that mark **620** is, in fact, an overvote. The

election official may update the vote recorded for the ballot **605** to include a vote for Jacques Cartier and include no vote for the office of Alderman because the intention of the voter is not able to be discerned.

Depending on the adjudication strategy used, an adjudication committee, for example, may have any number of terminals accessing the ballot optical images. With reference now to FIG. **7**, an adjudication architecture **700** is described for a set of embodiments. An adjudication system **110**-*a* may be coupled with network **115**-*a*, and may receive optical image data for ballots identified as requiring adjudication. The optical image data may be provided by a central system, such as central server computer system **120** of FIG. **1**, or may be provided directly from a ballot scanner such as optical scan ballot system **105** of FIG. **1** or **4**. The adjudication system **110**-*a* in this example includes a number of adjudication computers **705** through **715**, that may be used to review ballot optical images, review audit marks associated with the ballots, and make determinations on whether particular marks on ballots should be recorded as votes.

With reference now to FIG. **8**, an adjudication architecture **800** according to another set of embodiments is described. In FIG. **8**, an adjudication system **110**-*b* is coupled with network **115**-*b*, and may receive optical image data for ballots identified as requiring adjudication. The optical image data may be provided by a central system, such as central server computer system **120** of FIG. **1**, or may be provided directly from a ballot scanner such as optical scan ballot system **105** of FIG. **1** or **4**. The adjudication system **110**-*b* in this example may be an example of one of the adjudication computers **705** through **715** of FIG. **7**, may be a stand alone computer, or may be a computer that is connected directly to an optical scan ballot system. Adjudication system **110**-*b* may be used to review ballot optical images, review audit marks associated with the ballots, and make determinations on whether particular marks on ballots should be recorded as votes. In some embodiments, adjudication system **110**-*b* includes a receiver module **805**, an adjudication module **810**, a memory **815** that includes software **820**, and a user interface **825**. The receiver module **805** may include, for example, network interface hardware to allow connection with and communication over network **115**-*b*. Such network interface hardware may include wired or wireless network interface cards and components, as are well understood in the art.

The adjudication module **810** may receive ballots to be adjudicated through the receiver module and may provide optical images of the ballots, and any included audit mark or other audit information, to the user interface **825**. The user interface may include a monitor to display images to the election official, as well as a keyboard, mouse, or other data input device, as are well known. An election official accessing the user interface **825** may review the provided optical image and make a determination on votes for the ballot. The election official may provide input to the user interface **825**, that the adjudication module **810** receives and uses to generate an adjudication mark. The adjudication module **810** may generate an optical image of the adjudication mark and append the adjudication mark to the ballot optical image, along with other relevant adjudication information. The optical image data including the adjudication mark may then be provided to the receiver module **805** and transmitted, for example, back to the central server computer system. Adjudication information may include adjudication of votes for a ballot, as well as information related to the date and time of adjudication, and identification of the election official that performed adjudication, for example.

Memory **815** may include random access memory (RAM) and read-only memory (ROM), and store computer-readable, computer-executable software code **820** containing instructions that are configured to, when executed (or when compiled and executed), cause the adjudication module **810** to perform various functions described herein (e.g., provide ballot optical images for review, receive adjudication information, append an optical image of the adjudication information to the ballot optical image, etc.). The components of the adjudication system **110**-*b* may, individually or collectively, be implemented with one or more Application Specific Integrated Circuits (ASICs) adapted to perform some or all of the applicable functions in hardware. Each of the noted modules may be a means for performing one or more functions related to operation of the adjudication system **110**-*b*.

With reference now to FIG. **9**, an example of a ballot optical image **900** following adjudication is described. In this example, the ballot optical image **900** includes an image of voter marked paper ballot **605**-*a* and audit mark **610**-*a* as illustrated in FIG. **6**. As described above, the voter marked paper ballot **605**-*a* includes two errors related to marks **615**-*a* and **620**-*a*. An election official may review the marks, and make an adjudication that mark **615**-*a* is, in fact, a vote for Jacques Cartier, which is choice 3 on the ballot. The election official inputs this adjudication into the user interface of the adjudication system **110**, and the adjudication system **110** generates image data **905** that includes the adjudication information. In the example of FIG. **9**, the image data **905** of the adjudication information is appended to the ballot optical image data below the audit mark **610**-*a*. In embodiments that do not include an audit mark image **610**-*a*, image data **905** for the adjudication information may simply be appended to the ballot optical image data below the ballot optical image **605**-*a*, or at another suitable location adjacent the optical image of the ballot **605**-*a* and/or audit mark **610**-*a*. The adjudication information in image data **905**, in this example, includes an identification of the user, namely the election official that performed the adjudication, an identification of the particular ballot question or office that was adjudicated, the change in the vote that was adjudicated, and a reason. In the example image data **905**, it is noted that choice 3 was adjudicated (corresponding to Jacques Cartier) and that a marginal mark, corresponding to the ambiguous mark for that candidate, was added as a vote for the candidate. In such a manner, another user, election official, candidate representative, or observer may view the optical image and readily discern the image of the ballot as it was cast by the voter, the result of the initial optical scan of the ballot, and how the ballot was adjudicated. This can provide enhanced transparency and confidence in election results.

With reference now to FIG. **10**, an optical image **1000** of another ballot with audit and adjudication marks is described. In this example, a ballot optical image **1005**, audit mark **1010**, and adjudication mark **1015** are provided in optical image data. In this example, the optical scan ballot system that generated the audit mark **1010** identified two races as having over-votes. One resulting from mark **1020**, and another resulting from a soiled area **1025** on the ballot **1005**. Such soiled areas **1025** may be, for example, a coffee stain, food stain, or other type of soil on the ballot. Soiled ballots may be encountered with increased frequency, for example, in mail-in ballots. In this example, an election official readily discerns that mark **1020** is in fact an error on the ballot **1005**, and that mark **1025**, which resulted in the over-vote indication is a stray mark and not a vote. In this case, the election official adjudicated ballot **1005** to remove the stray mark and record the vote for that particular election area of the ballot **1005** to

be for choice 3, corresponding to Jaques Cartier. It will be readily understood that the examples of FIGS. **9** and **10** are but two examples of common situations requiring adjudication. Other examples include votes for write-in candidates, overvotes where the voter also includes a note that a particular vote is not to be counted, marks that are next to a candidates name instead of in the marking area for the votes, etc. Additionally, multiple adjudications may be performed for any particular ballot, with each adjudication appended to the ballot optical image separately from other adjudications. In such a manner, an entire chain of adjudications may be viewed in the single optical image file, allowing a user to view the initial read of the ballot and each adjudication for the ballot.

With reference now to FIG. **11**, a system **1100** is described that includes central server computer system **120**-*a* connected with network **115**-*c*, according to a set of embodiments. The central server computer system **120**-*a* may include a network interface **1105**, an election information collection and management module **1110**, memory **1115** that includes software **1120** stored therein, and a user interface **1125**. The central server computer system **120**-*a* may communicate with optical scan ballot system(s) and adjudication system(s), such as systems **105** and **110** of FIGS. **1**, **4**, and **7**-**8**, through the network **115**-*c* in order to receive and send information to such systems. The network interface **1105** may include, for example, commonly used network interface hardware to allow connection with and communication over network **115**-*c*. Such network interface hardware may include wired or wireless network interface cards and components, as are well understood in the art.

The election information collection and management module **1110** may receive optical image data from optical scan ballot systems and store the data in memory **1115**. Memory **1115** may include a database that is located locally and/or remotely from the central server computer system **120**-*a*. Furthermore, central server computer system **120**-*a* itself may include a single computer, or may include multiple computers which may be located remotely from one another. In any event, the election information collection and management module **1110** may receive optical image data and use this data to determine cumulative vote counts for one or more elections, and to perform election management tasks such as assigning ballots identified as having errors for adjudication, and assigning ballots to be audited according auditing procedures for the jurisdiction to verify the optical scan ballot systems appear to be properly tabulating votes. In one embodiment, the election information collection and management module **1110** receives optical image data for each scanned ballot, along with audit mark information for each ballot, and maintains appropriate vote counts based on the data. If the audit mark information for a ballot indicates one or more errors for the ballot, the election information collection and management module **1110** may assign the ballot to one or more election officials for adjudication. The election officials may adjudicate the ballots using an adjudication system **110** such as described with respect to FIGS. **1**, and **7**-**8**. The election information collection and management module **1110** may receive the adjudicated ballot information back from adjudication systems and update the vote counts for the various elections based on the adjudication information. The election information collection and management module **1110** may then store the optical image data, including the ballot optical image and the adjudication information, in memory **1115** for future retrieval as needed.

The user interface **1125** may include a monitor to display images to the election management officials, as well as a keyboard, mouse, or other data input device as are well known. An election official accessing the user interface **1125** may review optical images including one or more of audit mark information and adjudication information, as necessary. The election official may also use the user interface **1125** to monitor the status of ballots that have been assigned for adjudication and that have been received back at the election information collection and management module **1110** following adjudication. The user interface **1125** may also provide statistical information for use by election officials, as well as a number of other types of information for efficient election management.

Memory **1115** may include random access memory (RAM) and read-only memory (ROM), and store computer-readable, computer-executable software code **1120** containing instructions that are configured to, when executed (or when compiled and executed), cause the election information collection and management module **1110** to perform various functions described herein (e.g., receive ballot optical images, identify images that require adjudication, receive adjudication information, maintain cumulative vote counts, etc.). The components of the central server computer system **120**-*a* may, individually or collectively, be implemented with one or more Application Specific Integrated Circuits (ASICs) adapted to perform some or all of the applicable functions in hardware. Each of the noted modules may be a means for performing one or more functions related to operation of the central server computer system **120**-*a*.

In one embodiment, the election information collection and management module **1110** executes software that allows for management of the election process, including assigning ballots that require adjudication to one or more election officials. FIG. **12** illustrates a screen shot **1200** that may be provided to an election official operating an adjudication system, such as adjudication system **110** of FIGS. **1**, and **7**-**8**. Various areas of the screen provide information to the election official, such as an indication of ballots pending **1205**, that indicates how many ballots are pending for adjudication by the election official. The election official may select a ballot to adjudicate, and is provided with an indication **1210** of contents of the ballot that are awaiting adjudication. Different races for the particular election are listed at **1215**, with an area **1220** provided to indicate the particular race or question that requires adjudication. The election official may view an image of the ballot, an image of an audit mark for the ballot, and/or an image of a prior adjudication mark in area **1225**. The election official may adjudicate the ballot by selecting a candidate that is determined to have been selected by the voter and marking a check box for the candidate, illustrated in this embodiment at **1220**.

Following the completion of adjudication the software may update the information provided to the election official, illustrated for one example in the screen shot **1300** of FIG. **13**. In this example, following the adjudication of the ballot of the example of FIG. **12**, the indication of ballots pending **1305**, is updated to indicate how many ballots remain pending for adjudication by the election official. The indication **1310** of contents of the ballot awaiting adjudication is also updated, to indicate, in this example, that no other areas of the ballot require adjudication. Different races for the particular election are listed at **1315**, which may be expanded to view the recorded vote on the ballot at area **1320**. The election official may view an image of the adjudication mark that they just generated, an image of the ballot, an image of an audit mark for the ballot, and/or an image of a prior adjudication mark in area **1325**. In such a manner, ballots may be reviewed and

adjudicated in a transparent and efficient manner, and that allows for efficient and effective management through central server computer system **120**.

With reference now to FIG. **14**, a method **1400** for adjudicating ballots is described. The method **1400** may, for example, be performed by an adjudication system, a central server computer system, or optical scan ballot system of FIGS. **1**, **4**, **7-8**, and **11**, or using any combination of the devices described for these figures. Initially, at block **1405**, optical image data comprising an optical image of a voter-marked paper ballot is received. As discussed above, optical image data may be received from an optical scan ballot system that scans a voter-marked paper ballot, for example. One or more votes to be adjudicated on the voter-marked paper ballot are identified, according to block **1410**. Such votes may be identified, for example, as votes that have ambiguous marks on the voter-marked paper ballot, elections or races in which no vote is entered (an 'undervote'), elections or races where too many candidates have been voted for (an 'overvote'), and/or the presence of a write-in candidate. Such votes also may be identified as a result of a damaged or misread ballot where no vote selections can be determined. In some embodiments, votes may be identified as a result of a ballot as a whole that is to be adjudicated. A ballot as a whole may be identified for adjudication in a number of situations, such as misread or damaged ballots as mentioned above, provisional ballots, absentee or mailed-in ballots that may have different formats, etc. Votes requiring adjudication may be identified, in some examples, by a central server computer system, with the optical image data and identified votes for adjudication provided to an adjudication system over a network. In some embodiments, votes requiring adjudication may be identified by an optical scan ballot system, with adjudication of the votes also performed with an adjudication system that is located with or near such an optical scan ballot system. In still other embodiments, areas of multiple ballots may be identified to be adjudicated, such as when a significant number of ballots are identified as not having a vote for a particular race, for example, which may indicate that a system may not be properly reading the ballots.

With continuing reference to FIG. **14**, adjudication information for the one or more votes is received, as indicated at block **1415**. Such adjudication information may include, for example, an identification of the election official that is adjudicating the ballot, a date and time of adjudication, information on how the one or more votes have been adjudicated, and/or reasons for the adjudication (e.g., ambiguous mark, stray mark, etc.). Adjudication information may also include, in some embodiments, identification of a computer being used for adjudication and a location of the computer. At block **1420**, image data is generated that comprises the received adjudication information. Such image data may include all, or a subset of the adjudication information, and in some examples, non-image data may be included with the image data that includes all or a subset of the adjudication information. Finally, at block **1425**, the image data comprising the received adjudication information for the ballot is appended to the optical image data. The optical image data then includes data that comprises an optical image of the voter-marked paper ballot and an optical image of the adjudication information that may be displayed together when the optical image data is displayed.

In some embodiments, the optical image data is in a format that is widely known and used, such as, for example, .jpg, .tiff, .bmp, or .pdf format. Having optical image data in such a format allows the ballot optical image and the adjudication information optical image to be viewed on many different platforms and using any of a number of widely available viewers, rather than requiring a proprietary viewer to view both the ballot and adjudication information. Storing the optical image data and adjudication information in the same optical data file also allows viewing of all of the pertinent election information related to the ballot without the need to access a separate database or data store that may have some of the information related to a ballot, such as adjudication information.

With reference now to FIG. **15**, another method **1500** for adjudicating ballots is described. The method **1500** may, for example, be performed by an adjudication system, a central server computer system, or optical scan ballot system of FIGS. **1**, **4**, **7-8**, and **11**, or using any combination of the devices described for these figures. Initially, at block **1505**, optical image data comprising an optical image of a voter-marked paper ballot is received. As discussed above, optical image data may be received from an optical scan ballot system that scans a voter-marked paper ballot, for example. One or more votes to be adjudicated on the voter-marked paper ballot are identified, according to block **1510**. Such votes may be identified as described above, for example, as votes that have ambiguous marks, undervote situations, overvote situations, and/or the presence of a write-in candidate. Such votes also may be identified as a result of a damaged or misread ballot where no vote selections can be determined. In some embodiments, votes may be identified as a result of a ballot as a whole that is to be adjudicated, similarly as described above. Votes requiring adjudication may be identified, in some examples, by a central server computer system, or by an optical scan ballot system, with adjudication of the votes performed with an adjudication system that is located either locally or remotely. In other embodiments, areas of multiple ballots may be identified to be adjudicated, similarly as described above.

With continuing reference to FIG. **15**, an image of the ballot for review is provided to an election official, as indicated at block **1515**. In some embodiments, adjudication is performed on an adjudication system that runs specialized software the communicates with corresponding software on a central server computer system. The software at the central server computer system, in such embodiments, communicates ballots that require adjudication to the adjudication system, along with an identification of the votes on the ballot that require adjudication. At block **1520**, adjudication information is received from the election official. The software at the adjudication system, in an example, provides the ballot and information related to votes requiring adjudication an election official who then adjudicates the ballot based on a visual review of the ballot. Adjudication information may include, for example, an identification of the election official that is adjudicating the ballot, a date and time of adjudication, information on how the one or more votes have been adjudicated, and/or reasons for the adjudication (e.g., ambiguous mark, stray mark, etc.). Adjudication information may also include, in some embodiments, identification of a computer being used for adjudication and a location of the computer. At block **1525**, image data is generated that comprises the received adjudication information. Such image data may include all, or a subset of the adjudication information, and in some examples, non-image data may be included with the image data that includes all or a subset of the adjudication information. Finally, at block **1530**, the image data comprising the received adjudication information for the ballot is appended to the optical image data. The optical image data then includes data that comprises an optical image of the voter-marked paper ballot and an optical image of the adju-

dication information that may be displayed together when the optical image data is displayed.

In some embodiments, as described above, the optical image data is in a format that is widely known and used, allowing the ballot optical image and the adjudication information optical image to be viewed on many different platforms and using any of a number of widely available viewers. Storing the optical image data and adjudication information in the same optical data file also allows viewing of all of the pertinent election information related to the ballot without the need to access a separate database or data store that may have some of the information related to a ballot, such as adjudication information.

In some embodiments, one or more ballots may be adjudicated multiple times. For example, all ballots having write-in candidates may be adjudicated, with ballots having ambiguous marks, overvotes, undervotes, or other errors may be separately adjudicated. Thus, ballots having both a write-in candidate and one or more other errors may be adjudicated multiple times. In other examples, separate officials may adjudicate ballots independently, and in the event that the adjudications do not agree, a judge may make a final ruling on how a vote is to be adjudicated. For example, representatives of each candidate on a ballot may provide separate opinions on how a vote is to be adjudicated, with non-matching opinions ruled on by an elections judge. With reference now to FIG. **16**, a method **1600** for adjudicating ballots multiple times is described. The method **1600** may, for example, be performed by an adjudication system, a central server computer system, or optical scan ballot system of FIGS. **1**, **4**, **7-8**, and **11**, or using any combination of the devices described for these figures. Initially, at block **1605**, optical image data comprising an optical image of a voter-marked paper ballot is received. As discussed above, optical image data may be received from an optical scan ballot system that scans a voter-marked paper ballot, for example. At block **1610**, vote information for the ballot is determined Such vote information may be determined as described above, for example, by performing a pixel-based analysis of voting and non-voting areas on the ballot to identify votes cast by the ballot, as well as any errors on the ballot, such as stray marks, overvotes, undervotes, and ambiguous marks. The vote information is appended to the optical image of the ballot in a human-readable format, according to block **1615**.

At block **1620**, one or more votes to be adjudicated on the voter-marked paper ballot are identified. Such votes may be identified as described above, as one or more votes that have an identified error, for example. An image of the ballot for review is then provided to an election official, as indicated at block **1625**. In some embodiments, adjudication is performed on an adjudication system such as described above that runs specialized software as part of an election management software suite that runs across a central server computer system and one or more adjudication systems. At block **1630**, adjudication information is received from the election official. Adjudication information may include, for example, an identification of the election official that is adjudicating the ballot, a date and time of adjudication, information on how the one or more votes have been adjudicated, and/or reasons for the adjudication (e.g., ambiguous mark, stray mark, etc.). Adjudication information may also include, in some embodiments, identification of a computer being used for adjudication and a location of the computer. At block **1635**, image data is appended to the optical image data that comprises the received adjudication information. Such image data may include all, or a subset of the adjudication information.

Next, at block **1640**, an image of the ballot for review is provided to a second election official. As mentioned above, the second election official may be a representative of a candidate, a representative of a political party, or a second election official focused on a particular type of adjudication such as adjudication of write-in votes. Adjudication may be performed on an adjudication system such as described above. At block **1645**, adjudication information is received from the second election official. Adjudication information may include, for example, an identification of the second election official, along with one or more other items of adjudication information such as described above. At block **1650**, image data is appended to the optical image data that comprises the received adjudication information from the second election official. Such image data may include all, or a subset of the adjudication information. In some embodiments more that two election officials may adjudicate a ballot, in which case the operations of blocks **1640** through **1650** are repeated for each additional election official. Thus, the optical image data includes an optical image of the ballot, and adjudication information from each election official that adjudicated the ballot.

In some embodiments, as described above, the optical image data is in a format that is widely known and used, allowing the ballot optical image and the adjudication information from each election official to adjudicate the ballot to be viewed on many different platforms and using any of a number of widely available viewers. Storing the optical image data and adjudication information in the same optical data file also allows viewing of all of the pertinent election information related to the ballot without the need to access a separate database or data store that may have some of the information related to a ballot, such as adjudication information.

It should be noted that the methods, systems and devices discussed above are intended merely to be examples. It must be stressed that various embodiments may omit, substitute, or add various procedures or components as appropriate. For instance, it should be appreciated that, in alternative embodiments, the methods may be performed in an order different from that described, and that various steps may be added, omitted or combined. Also, features described with respect to certain embodiments may be combined in various other embodiments. Different aspects and elements of the embodiments may be combined in a similar manner. Also, it should be emphasized that technology evolves and, thus, many of the elements are exemplary in nature and should not be interpreted to limit the scope of the invention.

Specific details are given in the description to provide a thorough understanding of the embodiments. However, it will be understood by one of ordinary skill in the art that the embodiments may be practiced without these specific details. For example, well-known circuits, processes, algorithms, structures, and techniques have been shown without unnecessary detail in order to avoid obscuring the embodiments.

Also, it is noted that the embodiments may be described as a process which is depicted as a flow diagram or block diagram. Although each may describe the operations as a sequential process, many of the operations can be performed in parallel or concurrently. In addition, the order of the operations may be rearranged. A process may have additional steps not included in the figure.

Moreover, as disclosed herein, the term "memory" or "memory unit" may represent one or more devices for storing data, including read-only memory (ROM), random access memory (RAM), magnetic RAM, core memory, magnetic disk storage mediums, optical storage mediums, flash

memory devices or other computer-readable mediums for storing information. The term "computer-readable medium" includes, but is not limited to, portable or fixed storage devices, optical storage devices, wireless channels, a sim card, other smart cards, and various other mediums capable of storing, containing or carrying instructions or data.

Furthermore, embodiments may be implemented by hardware, software, firmware, middleware, microcode, hardware description languages, or any combination thereof. When implemented in software, firmware, middleware or microcode, the program code or code segments to perform the necessary tasks may be stored in a computer-readable medium such as a storage medium. Processors may perform the necessary tasks.

Having described several embodiments, it will be recognized by those of skill in the art that various modifications, alternative constructions, and equivalents may be used without departing from the spirit of the invention. For example, the above elements may merely be a component of a larger system, wherein other rules may take precedence over or otherwise modify the application of the invention. Also, a number of steps may be undertaken before, during, or after the above elements are considered. Accordingly, the above description should not be taken as limiting the scope of the invention.

The invention claimed is:

1. A method comprising:

identifying one or more votes to be adjudicated on a voter-marked ballot;

providing an image of the voter-marked ballot for review by one or more election officials;

receiving adjudication information from the one or more election officials, wherein the adjudication information includes a determination whether a particular mark on the ballot should be recorded as a vote;

generating image data comprising the received adjudication information; and

appending the image data comprising the received adjudication information for the ballot to the optical image data.

2. The method of claim **1**, wherein the adjudication information comprises:

an identification of an election official performing the adjudication; and

a record that one or more votes on the ballot have been adjudicated.

3. The method of claim **1**, wherein the adjudication information further comprises a date and time of adjudication.

4. The method of claim **1**, wherein appending the image data comprising the received adjudication information for the ballot to the optical image data comprises:

inserting text in a margin of the optical image of the ballot, the text including the adjudication information.

5. The method of claim **1**, further comprising:

displaying the optical image data including an image of the ballot and adjudication information appended to the image of the ballot.

6. The method of claim **1**, wherein identifying one or more votes recorded on the voter-marked paper ballot to be adjudicated comprises:

evaluating a target area on the ballot; and

determining that a mark within the target area is ambiguous.

7. The method of claim **1**, wherein identifying one or more votes recorded on the voter-marked paper ballot to be adjudicated comprises:

determining that the ballot as a whole is to be adjudicated.

8. The method of claim **1**, wherein identifying one or more votes recorded on the voter-marked paper ballot to be adjudicated comprises:

determining that one or more portions of the ballot include a different number of votes than expected.

9. The method of claim **1**, wherein identifying one or more votes recorded on the voter-marked paper ballot to be adjudicated comprises:

determining that one or more portions of multiple ballots include one or more votes to be adjudicated.

10. The method of claim **1**, wherein identifying one or more votes recorded on the voter-marked paper ballot to be adjudicated comprises:

inspecting the ballot image to determine if a write-in vote has been selected; and

assigning the write-in selection to a candidate.

11. The method of claim **1**, wherein identifying one or more votes recorded on the voter-marked paper ballot to be adjudicated comprises:

receiving an indication that one or more votes recorded on the voter-marked paper ballot require adjudication.

12. A system for adjudication of voter-marked paper ballots, comprising:

a receiver module configured to receive ballot optical image data comprising an optical image of a voter-marked paper ballot; and

an adjudication module configured to receive adjudication information from one or more election officials, wherein the adjudication information includes a determination whether a particular mark on the ballot should be recorded as a vote, generate image data comprising the received adjudication information for the ballot and append the image data for the ballot to the optical image data.

13. The system of claim **12**, wherein the adjudication module is configured to receive an indication that the ballot requires adjudication when a mark within a target area of the ballot is determined to be ambiguous.

14. The system of claim **12**, wherein the adjudication module is configured to receive an indication that the ballot as a whole requires adjudication.

15. The system of claim **12**, wherein the adjudication information comprises one or more of:

an identification of an election official performing the adjudication;

a record that one or more votes on the ballot have been adjudicated; or

a date and time of adjudication.

16. The system of claim **12**, wherein the image data comprising the received adjudication information for the ballot is inserted as text in a margin of the optical image of the ballot.

17. A system for adjudication of voter-marked paper ballots, comprising:

means for identifying one or more votes recorded on a voter-marked paper ballot to be adjudicated;

means for receiving adjudication information from the one or more election officials, wherein the adjudication information includes a determination whether a particular mark on the ballot should be recorded as a vote;

means for generating image data comprising the received adjudication information; and

means for appending the image data comprising the received adjudication information for the ballot to the optical image data.

18. The system of claim 17, further comprising:

means for providing an image of the ballot for review by an election official; and

means for receiving adjudication information from the election official.

19. The system of claim 17, wherein the means for incorporating the adjudication information into the ballot optical image file comprises:

means for inserting text in a margin of the optical image of the ballot, the text including the adjudication information.

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