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Maniaci et al.

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(54) **APPARATUSES AND METHODS FOR FACILITATING A HEALTH CHECK IN RESPECT OF COMMUNICATION NETWORKS AND SYSTEMS, INCLUSIVE OF AN OUTER LOOP HEALTH CHECK**

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H04L 41/0813 (2022.01)
H04L 41/0866 (2022.01)
H04L 43/16 (2022.01)

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CPC ***H04L 43/50*** (2013.01); ***H04L 41/0813*** (2013.01); ***H04L 41/0866*** (2013.01); ***H04L 43/16*** (2013.01)

(58) **Field of Classification Search**
CPC . H04L 43/50; H04L 41/0813; H04L 41/0866; H04L 43/16
See application file for complete search history.

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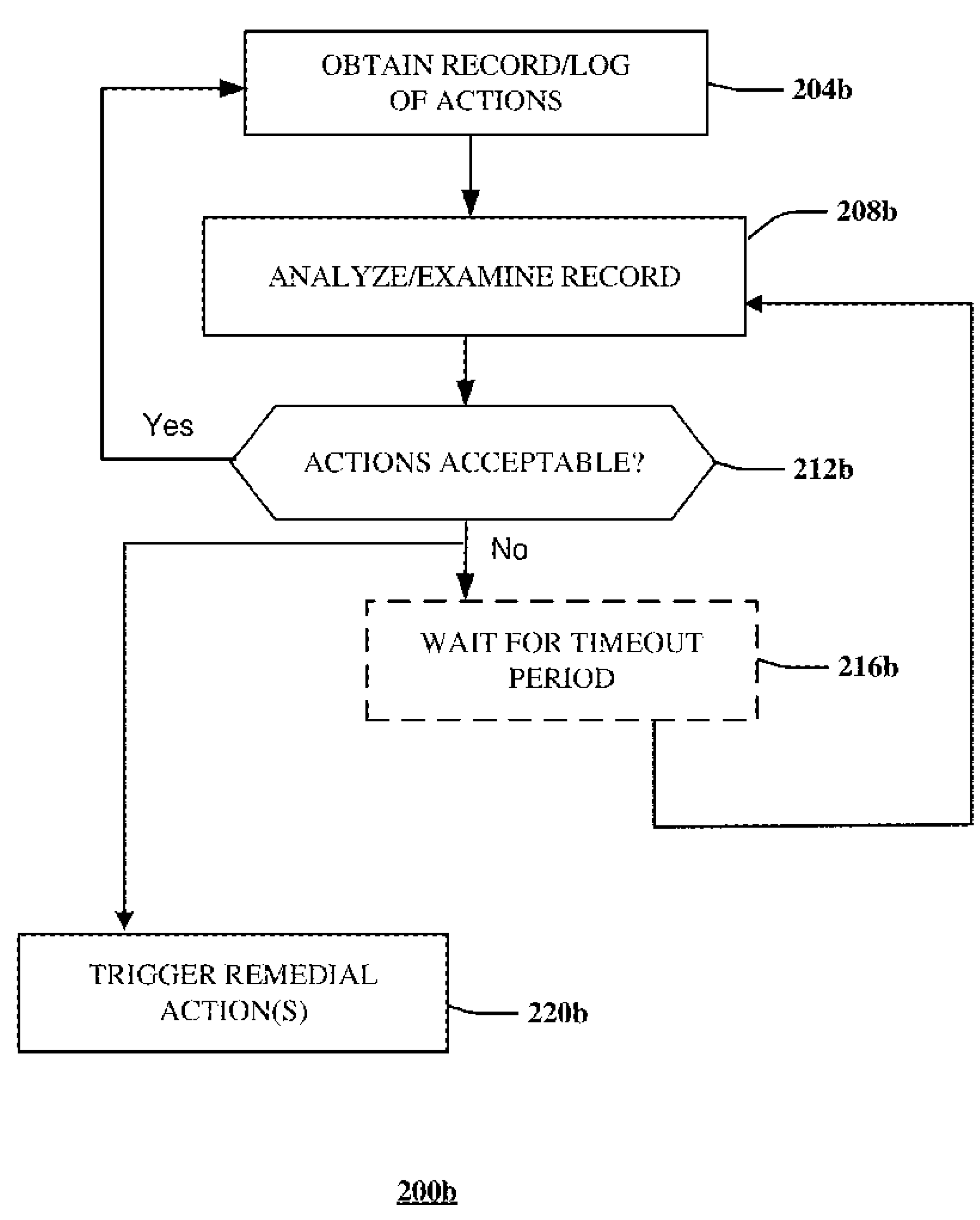
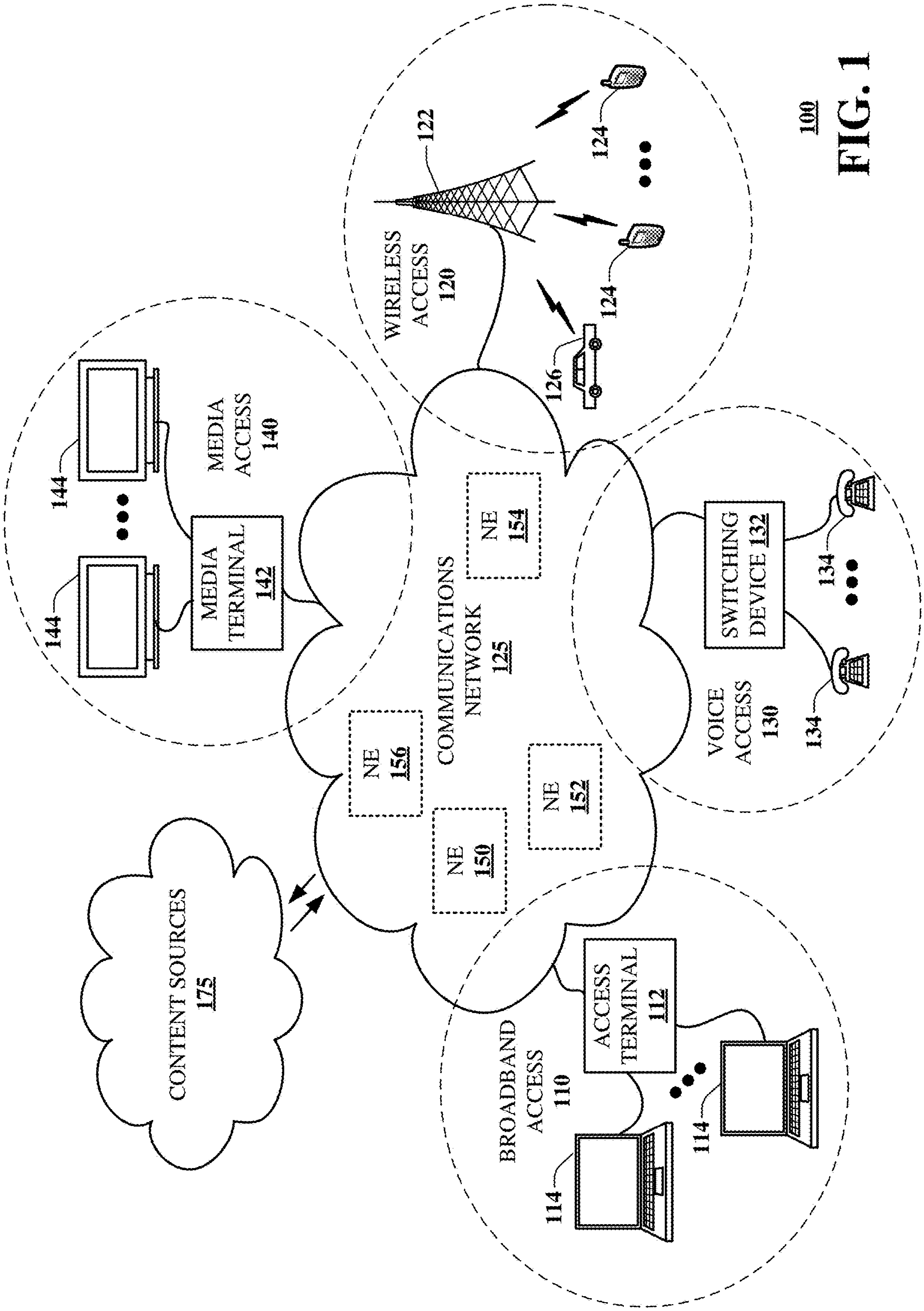
(57) **ABSTRACT**

Aspects of the subject disclosure may include, for example, examining first actions imposed as part of a maintenance activity in respect of a communication network while the communication network is subjected to second actions as part of the maintenance activity, determining, based on the examining, that the first actions, in whole or in part, fail to adhere to a threshold, a requirement, or a specification, and based on the determining, reversing at least one action of the first actions. Other embodiments are disclosed.

20 Claims, 7 Drawing Sheets



200b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MEDIA TERMINAL 142
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NE 154
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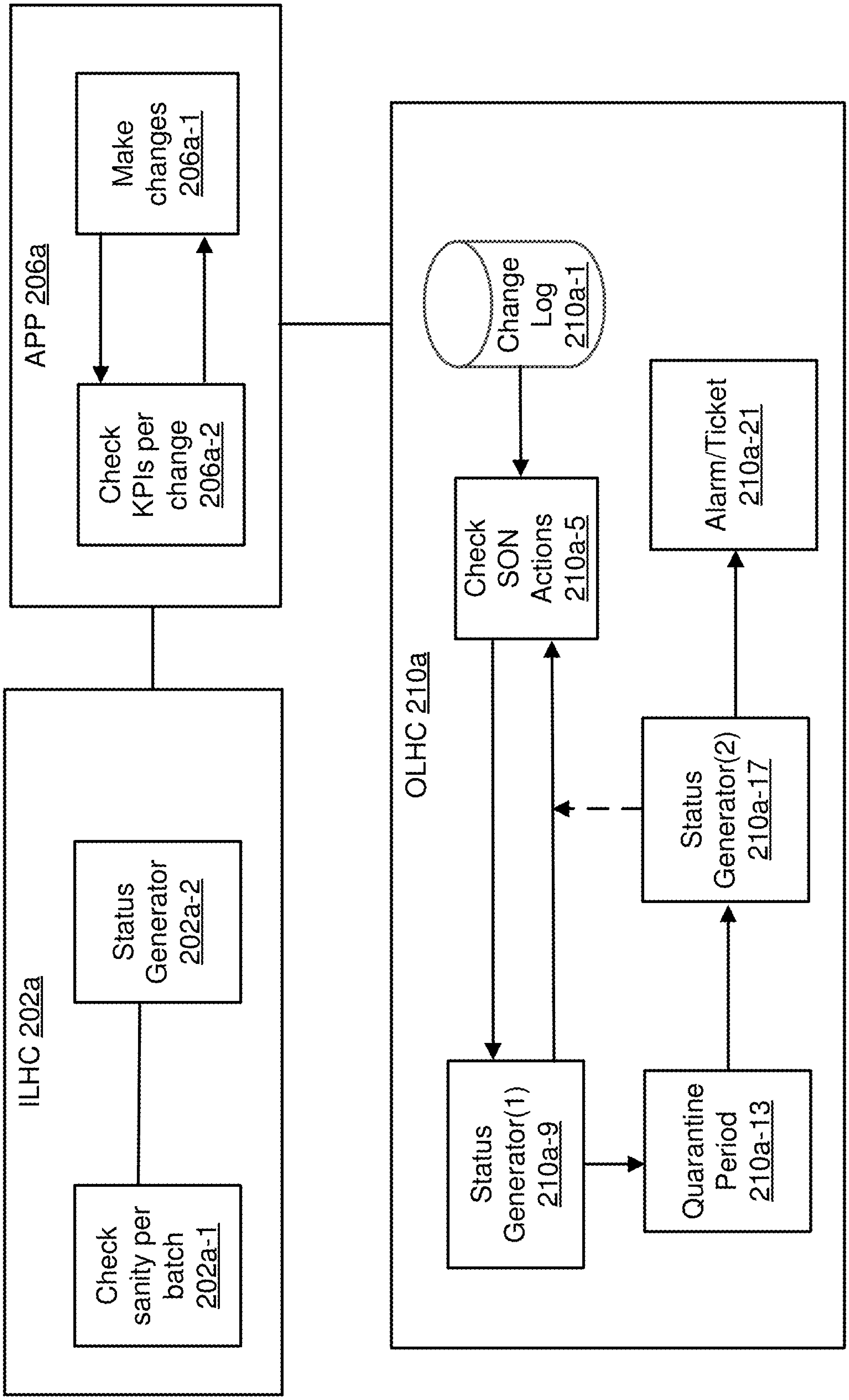
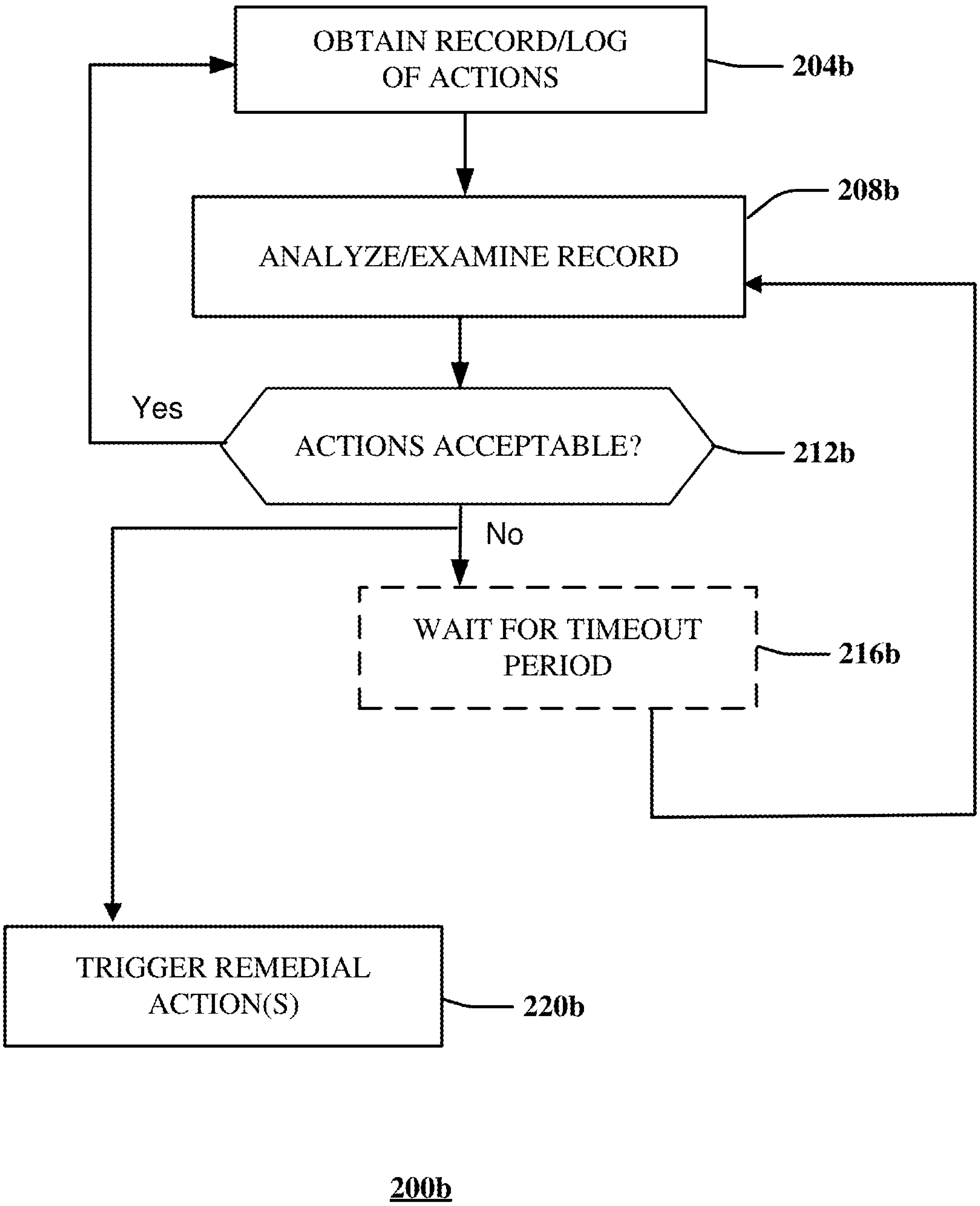
NE 150
NE 152
SWITCHING DEVICE 132
134
134
VOICE ACCESS 130
CONTENT SOURCES 175
BROADBAND ACCESS 110
ACCESS TERMINAL 112
114
114
100

FIG. 1

FIG. 2A

200a


APP 206a
Make changes 206a-1
Check KPIs per change 206a-2
ILHC 202a
Check sanity per batch 202a-1
Status Generator 202a-2
OLHC 210a
Change Log 210a-1
Check SON Actions 210a-5
Alarm/Ticket 210a-21
Status Generator(1) 210a-9
Quarantine Period 210a-13
Status Generator(2) 210a-17


OBTAIN RECORD/LOG OF ACTIONS
204b
208b
ANALYZE/EXAMINE RECORD
Yes
ACTIONS ACCEPTABLE?
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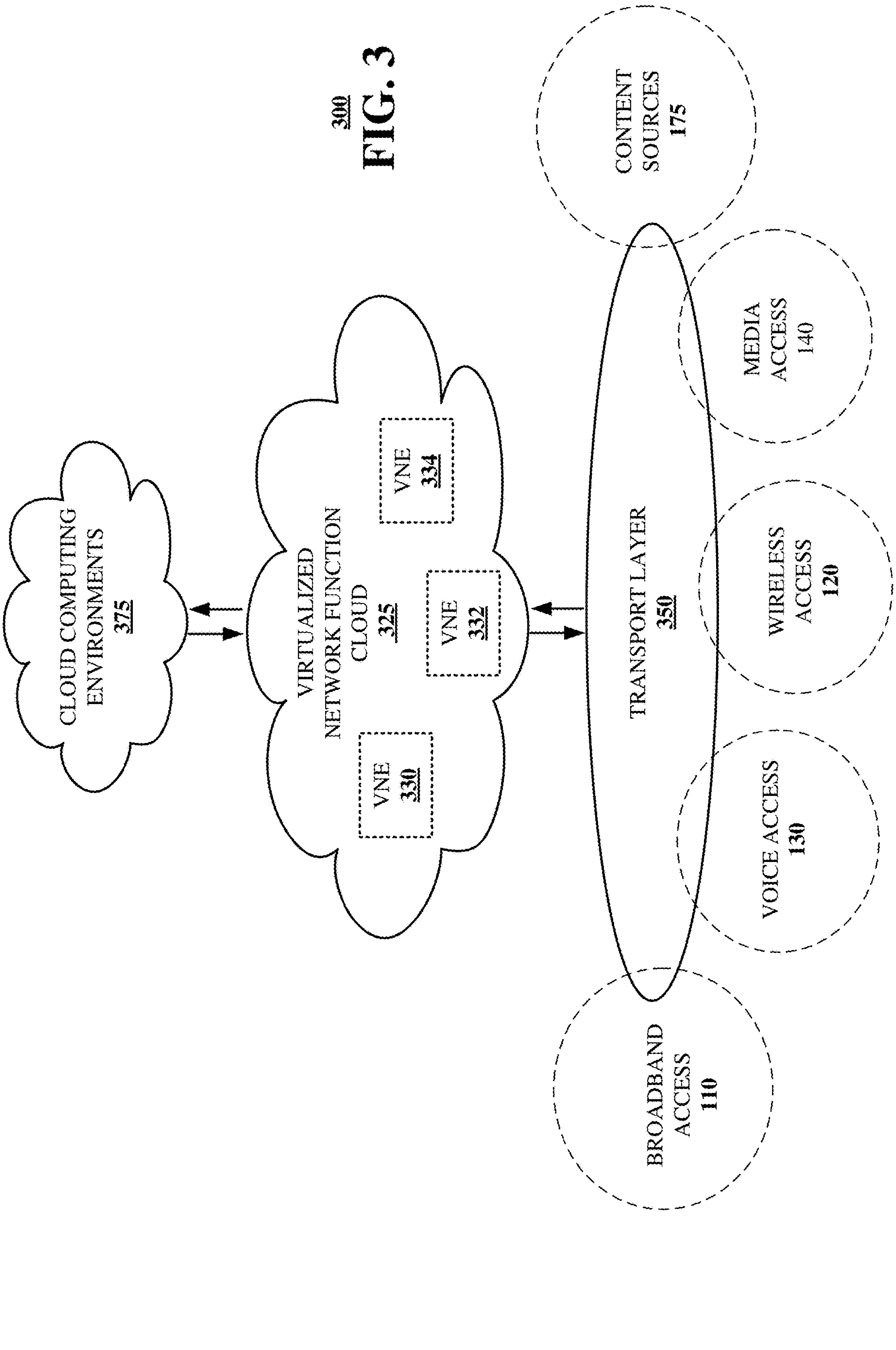
No
WAIT FOR TIMEOUT PERIOD
216b
TRIGGER REMEDIAL ACTION(S)
220b
200b

FIG. 2B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VNE 330
VNE 332
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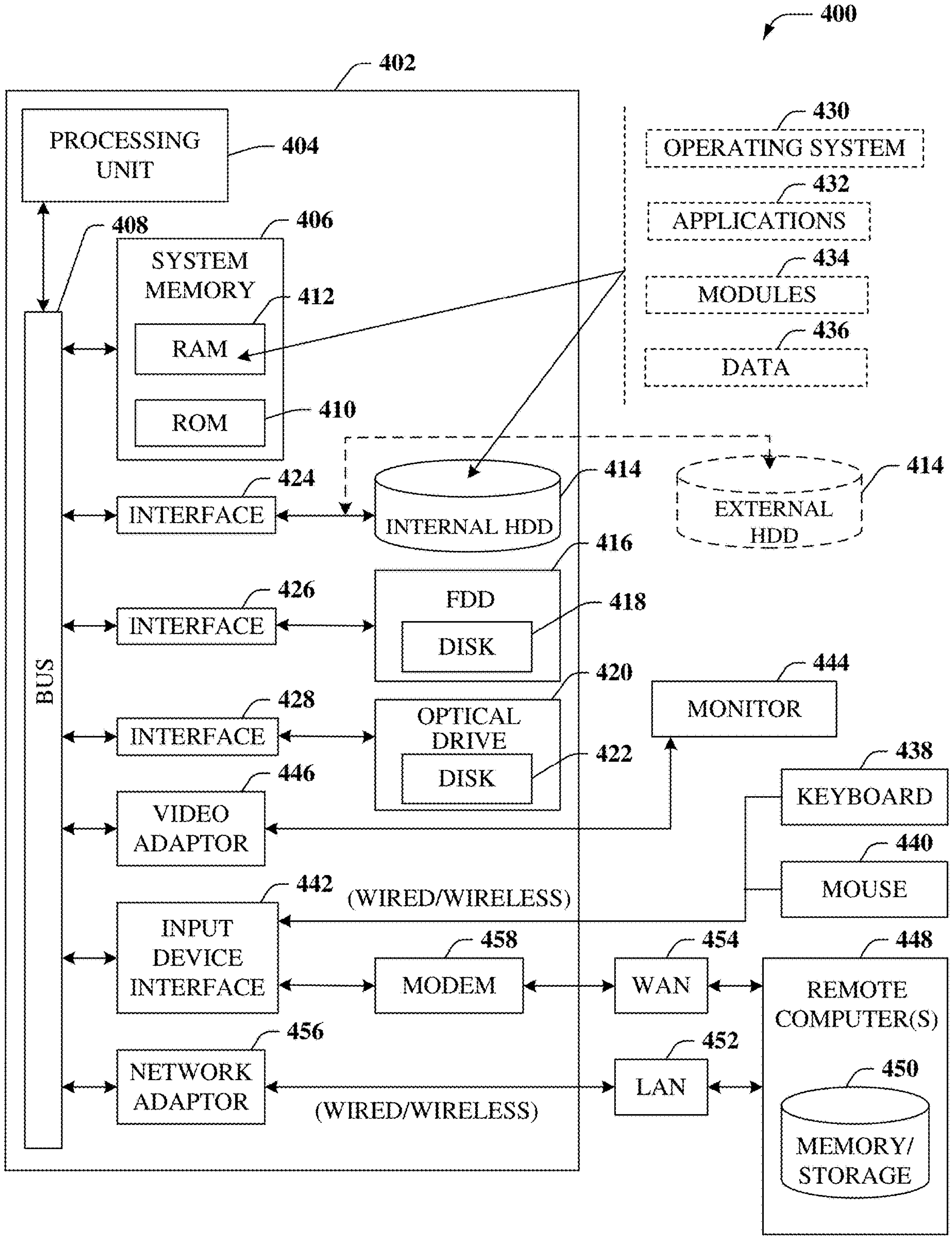
VOICE ACCESS 130
WIRELESS ACCESS 120
MEDIA ACCESS 140
CONTENT SOURCES 175

FIG. 3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INTERFACE
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DISK
422
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MONITOR
BUS
446
VIDEO ADAPTOR
438
KEYBOARD
440
MOUSE
442
(WIRED/WIRELESS)
INPUT DEVICE INTERFACE
458
MODEM
454
WAN
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NETWORK ADAPTOR
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LAN
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MEMORY/ STORAGE
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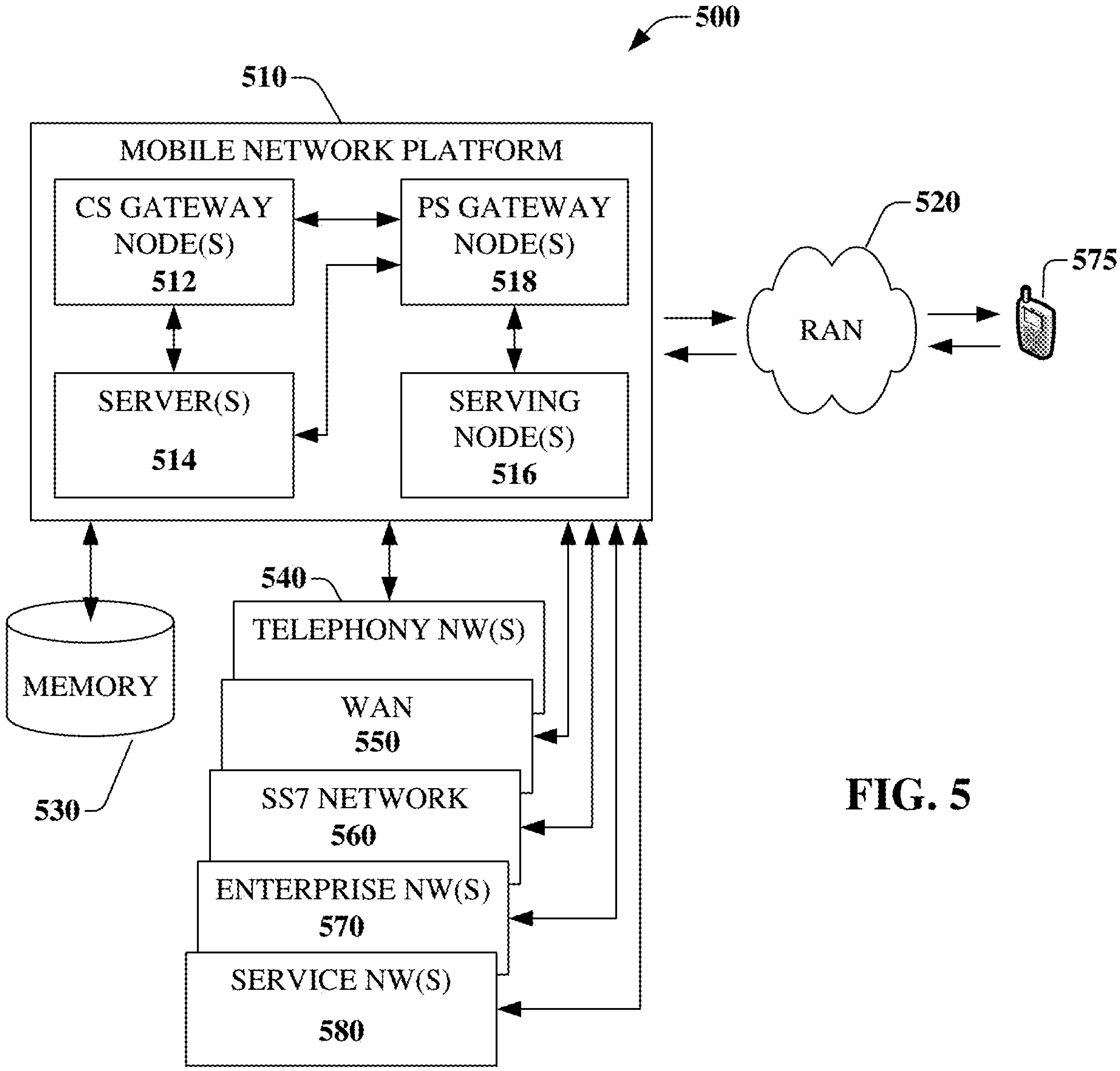
FIG. 4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SERVER(S) 514
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RAN
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MEMORY
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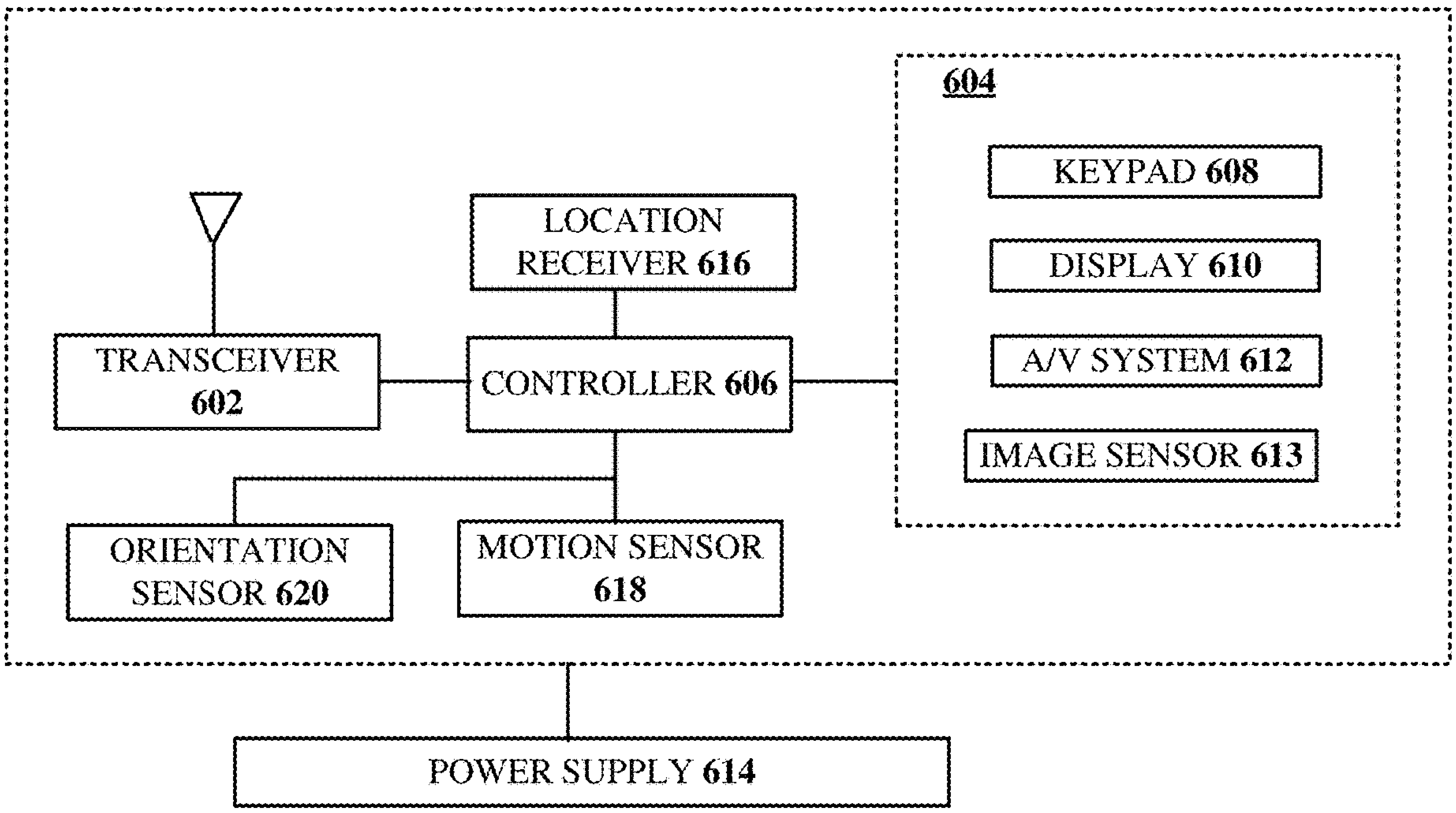
SS7 NETWORK 560
ENTERPRISE NW(S) 570
SERVICE NW(S) 580

FIG. 5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DISPLAY 610
A/V SYSTEM 612
IMAGE SENSOR 613
LOCATION RECEIVER 616
TRANSCEIVER 602
CONTROLLER 606
ORIENTATION SENSOR 620
MOTION SENSOR 618
POWER SUPPLY 614

600

FIG. 6

APPARATUSES AND METHODS FOR FACILITATING A HEALTH CHECK IN RESPECT OF COMMUNICATION NETWORKS AND SYSTEMS, INCLUSIVE OF AN OUTER LOOP HEALTH CHECK

FIELD OF THE DISCLOSURE

The subject disclosure relates to apparatuses and methods for facilitating a health check in respect of communication networks and systems, inclusive of an outer loop health check (OLHC).

BACKGROUND

As the world increasingly becomes connected via vast communication networks and systems and via various communication devices, additional opportunities are created/generated to provision communication services. Self-organizing networks (SONs) are examples of types of communication networks that may be used to provision communication services. SONs are radio access networks (RANs) that automatically plan and configure themselves, and in many instances, when issues arise SONs are capable of initiating remedies.

SON applications make many changes/modifications each day. Some applications may make modifications that may necessitate a locking or unlocking of resources (e.g., cells) of a network or system. In some instances, a modification may be so invasive or pervasive that it may lead to the resource not reentering service. Due to the automated nature of many SON technologies, a mistake or error in logic can quickly and easily turn into a "reportable offence" (as potentially governed by an administrative or jurisdictional entity) with potential punishments or sanctions, a loss of goodwill or reputation amongst stakeholders (e.g., a pool of users or subscribers), etc.

In an effort to mitigate against the odds of mistakes or errors impacting a network or system, checks or tests may be performed in respect of any changes or modifications that may be made. For example, as part of a serial or sequential procedure, a first modification may be made and then a first test may be performed to validate/confirm that the first modification worked for its intended purposes. Assuming that the first modification is validated successfully, a second modification may be enacted and then a second test may be performed to validate/confirm that the second modification worked for its intended purposes. This procedure of modifying and then validating/testing may be repeated. While effective at ensuring that the modifications work for their intended purposes, the serial/sequential nature of the procedure has its own drawbacks in relation to modern networks and systems featuring hundreds or even thousands of nodes, links, parameters, etc. For example, in relation to modifications that are to be enacted as part of a network/system maintenance activity, there may be hundreds or even thousands of modifications that may need to be enacted over a relatively short time frame (e.g., a few hours), which is to say that the maintenance activity may be subject to a time constraint or time limit. The serial/sequential procedure of modify-and-test set forth above is too slow for modern networks or system to ensure that all of the modifications will be enacted prior to the expiration of the time period allocated for such modifications, and may even lead to a

portion of a network/system being inoperable once the time period has expired due to a failure to complete the modifications.

BRIEF DESCRIPTION OF THE DRAWINGS

Reference will now be made to the accompanying drawings, which are not necessarily drawn to scale, and wherein:

FIG. **1** is a block diagram illustrating an exemplary, non-limiting embodiment of a communications network in accordance with various aspects described herein.

FIG. **2**A is a block diagram illustrating an example, non-limiting embodiment of a system in accordance with various aspects described herein.

FIG. **2**B depicts an illustrative embodiment of a method in accordance with various aspects described herein.

FIG. **3** is a block diagram illustrating an example, non-limiting embodiment of a virtualized communication network in accordance with various aspects described herein.

FIG. **4** is a block diagram of an example, non-limiting embodiment of a computing environment in accordance with various aspects described herein.

FIG. **5** is a block diagram of an example, non-limiting embodiment of a mobile network platform in accordance with various aspects described herein.

FIG. **6** is a block diagram of an example, non-limiting embodiment of a communication device in accordance with various aspects described herein.

DETAILED DESCRIPTION

The subject disclosure describes, among other things, illustrative embodiments for facilitating and managing operations pertaining to a configuration, maintenance, testing, and modification of one or more communication networks or systems by enabling a separation between tasks directed to enacting changes and tasks directed to validating/verifying those changes. Other embodiments are described in the subject disclosure.

One or more aspects of the subject disclosure include, in whole or in part, obtaining a record of first modifications in respect of a self-organizing network (SON); analyzing the record a first time, the analyzing of the record the first time occurring while the SON is subject second modifications; and determining, based on the analyzing of the record the first time, whether the first modifications are acceptable relative to a threshold, a requirement, a specification, or any combination thereof, resulting in a first determination.

One or more aspects of the subject disclosure include, in whole or in part, examining first actions imposed as part of a maintenance activity in respect of a communication network while the communication network is subjected to second actions as part of the maintenance activity; determining, based on the examining, that the first actions, in whole or in part, fail to adhere to a threshold, a requirement, or a specification; and based on the determining, reversing at least one action of the first actions.

One or more aspects of the subject disclosure include, in whole or in part, obtaining, by a processing system including a processor, a log of first actions taken by a self-organizing network (SON) while the SON is undertaking second actions; analyzing, by the processing system and based on the obtaining, the log relative to a historical record of data in accordance with a test to determine that at least one action of the first actions departs from the historical record of data in an amount greater than a threshold, resulting in a determination; and causing, by the processing system and based on the determination, a remedial action to be initiated to address the at least one action.

Referring now to FIG. **1**, a block diagram is shown illustrating an example, non-limiting embodiment of a system **100** in accordance with various aspects described herein. For example, the system **100** can facilitate, in whole or in part, obtaining a record of first modifications in respect of a self-organizing network (SON), analyzing the record a first time, the analyzing of the record the first time occurring while the SON is subject second modifications, and determining, based on the analyzing of the record the first time, whether the first modifications are acceptable relative to a threshold, a requirement, a specification, or any combination thereof, resulting in a first determination. The system **100** can facilitate, in whole or in part, examining first actions imposed as part of a maintenance activity in respect of a communication network while the communication network is subjected to second actions as part of the maintenance activity, determining, based on the examining, that the first actions, in whole or in part, fail to adhere to a threshold, a requirement, or a specification, and based on the determining, reversing at least one action of the first actions. The system **100** can facilitate, in whole or in part, obtaining, by a processing system including a processor, a log of first actions taken by a SON while the SON is undertaking second actions, analyzing, by the processing system and based on the obtaining, the log relative to a historical record of data in accordance with a test to determine that at least one action of the first actions departs from the historical record of data in an amount greater than a threshold, resulting in a determination, and causing, by the processing system and based on the determination, a remedial action to be initiated to address the at least one action.

In particular, in FIG. **1** a communications network **125** is presented for providing broadband access **110** to a plurality of data terminals **114** via access terminal **112**, wireless access **120** to a plurality of mobile devices **124** and vehicle **126** via base station or access point **122**, voice access **130** to a plurality of telephony devices **134**, via switching device **132** and/or media access **140** to a plurality of audio/video display devices **144** via media terminal **142**. In addition, communication network **125** is coupled to one or more content sources **175** of audio, video, graphics, text and/or other media. While broadband access **110**, wireless access **120**, voice access **130** and media access **140** are shown separately, one or more of these forms of access can be combined to provide multiple access services to a single client device (e.g., mobile devices **124** can receive media content via media terminal **142**, data terminal **114** can be provided voice access via switching device **132**, and so on).

The communications network **125** includes a plurality of network elements (NE) **150**, **152**, **154**, **156**, etc. for facilitating the broadband access **110**, wireless access **120**, voice access **130**, media access **140** and/or the distribution of content from content sources **175**. The communications network **125** can include a circuit switched or packet switched network, a voice over Internet protocol (VOIP) network, Internet protocol (IP) network, a cable network, a passive or active optical network, a 4G, 5G, or higher generation wireless access network, WIMAX network, UltraWideband network, personal area network or other wireless access network, a broadcast satellite network and/or other communications network.

In various embodiments, the access terminal **112** can include a digital subscriber line access multiplexer (DSLAM), cable modem termination system (CMTS), optical line terminal (OLT) and/or other access terminal. The data terminals **114** can include personal computers, laptop computers, netbook computers, tablets or other computing devices along with digital subscriber line (DSL) modems, data over coax service interface specification (DOCSIS) modems or other cable modems, a wireless modem such as a 4G, 5G, or higher generation modem, an optical modem and/or other access devices.

In various embodiments, the base station or access point **122** can include a 4G, 5G, or higher generation base station, an access point that operates via an 802.11 standard such as 802.11n, 802.11ac or other wireless access terminal. The mobile devices **124** can include mobile phones, e-readers, tablets, phablets, wireless modems, and/or other mobile computing devices.

In various embodiments, the switching device **132** can include a private branch exchange or central office switch, a media services gateway, VOIP gateway or other gateway device and/or other switching device. The telephony devices **134** can include traditional telephones (with or without a terminal adapter), VoIP telephones and/or other telephony devices.

In various embodiments, the media terminal **142** can include a cable head-end or other TV head-end, a satellite receiver, gateway or other media terminal **142**. The display devices **144** can include televisions with or without a set top box, personal computers and/or other display devices.

In various embodiments, the content sources **175** include broadcast television and radio sources, video on demand platforms and streaming video and audio services platforms, one or more content data networks, data servers, web servers and other content servers, and/or other sources of media.

In various embodiments, the communications network **125** can include wired, optical and/or wireless links and the network elements **150**, **152**, **154**, **156**, etc. can include service switching points, signal transfer points, service control points, network gateways, media distribution hubs, servers, firewalls, routers, edge devices, switches and other network nodes for routing and controlling communications traffic over wired, optical and wireless links as part of the Internet and other public networks as well as one or more private networks, for managing subscriber access, for billing and network management and for supporting other network functions.

Referring now to FIG. **2**A, a block diagram illustrating an example, non-limiting embodiment of a system **200***a* in accordance with various aspects described herein is shown. In some embodiments, one or more parts or portions of the system **200***a* may function within, or may be operatively overlaid upon, one or more parts/portions of the system **100** of FIG. **1**.

The system **200***a* may be divided into, or at least conceptualized as including, a plurality of portions, referred to herein as an inner loop health check (ILHC) **202***a*, an application (APP) **206***a*, and an outer loop health check (OLHC) **210***a*. Logic and operations associated with these portions are described in further detail below. While shown separately for ease and convenience in description, in some embodiments logic or functionality associated with a first of the portions (e.g., the APP **206***a*) may be reallocated/reassigned to a second of the portions (e.g., the ILHC **202***a*) without any loss of generality or accuracy in the description. Stated differently, one of skill in the art will appreciate that the logic or functionality may be rearranged (relative to what is shown in FIG. **2**A) without departing from the scope and spirit of this disclosure.

The APP **206***a* may facilitate changes or modifications to be made to a network or system (e.g., a SON) as part of block **206***a***-1**. As part of those modifications, key performance indicators (KPIs) may be monitored/checked in block **206***a***-2**. By way of illustration, and without limitations, KPIs may pertain to, or include: latency, throughput, signal to noise plus interference ratio (SINR), loading, capacity, etc.

The changes made/facilitated by the APP **206***a* (e.g., the block **206***a***-1**) may be aggregated as part of a batch that may be examined/checked by the ILHC **202***a* (e.g., the block **202***a***-1**). The examination/check of the block **202***a***-1** may lead to a generation of status via the block **202***a***-2**. For example, as part of blocks **202***a***-1** and **202***a***-2**, if the examination/check of block **202***a***-1** yields a negative indication (meaning that a change included in the batch results in some error, fault, or other negative condition), the status generator **202***a***-2** may cause the APP **206***a* to undo or reverse a change effectuated by, e.g., the block **206***a***-1**, may issue a trouble ticket that may need to be addressed (by the SON, by personnel, etc.), may suspend or terminate an execution of the APP **206***a*, etc.

Operations associated with the ILHC **202***a* and the APP **206***a* may (largely) proceed in a serial or sequential manner, similar to the serial/sequential procedure outlined above. However, those operations may execute (at least partially) in parallel with operations that may be performed/executed by the OLHC **210***a*. The OLHC **210***a* may facilitate a validation or verification on a higher or broader level than the test/validation provided by the ILHC **202***a* described above.

In some embodiments, the OLHC **210***a* may maintain a log **210***a***-1** of changes/modifications that may be effectuated by the APP **206***a*. The log **210***a***-1** may be arranged as a table, a graph, or the like. In some embodiments, date or time stamps may be maintained in the log **210***a***-1** to track the order or sequence of actions or changes that may have been invoked by the APP **206***a*. In some embodiments, permissions may be utilized to protect the integrity/sanctity of the log **210***a***-1**. For example, in some embodiments only specified portions of a network or system (or, for that matter, personnel) may have access (e.g., read or write access) to the log **210***a***-1**.

The OLHC **210***a* may check/examine actions (e.g., modifications) undertaken by the APP **206***a* (or, analogously, SON) in accordance with the data/information stored in the log **210***a***-1** as represented by block **210***a***-5**. The check performed via the block **210***a***-5** may yield a generation of status as represented by the block **210***a***-9**. For example, if the check/examination of block **210***a***-5** yields a positive status in block **210***a***-9** (meaning that any changes are acceptable or within specified thresholds), flow may proceed back to (or may be maintained at) block **210***a***-5** to continue checking the actions. Conversely, if the check/examination of block **210***a***-5** yields a negative status in block **210***a***-9** (meaning that any changes are unacceptable or outside of specified thresholds), flow may proceed to, e.g., block **210***a***-13**.

The block **210***a***-13** may correspond to a quarantine period. For example, it may be the case that isolating a given change/modification, or providing for a timeout period, may cure whatever deficiency may have been identified as part of blocks **210***a***-5** and **210***a***-9**. As one of skill in the art will appreciate, and in the context of a SON, the SON may (potentially by way of machine learning or artificial intelligence) be able to self-remedy any issues that may be identified. In this respect, it is recognized that the block **210***a***-13** may enable the SON to cure itself, potentially without any special/particular actions having to be initiated or undertaken by the OLHC **210***a*.

Following an expiration of the timeout associated with the quarantine period **210***a***-13**, another status generation **210***a***-17** may be undertaken. Assuming that the quarantine/timeout period associated with block **210***a***-13** is effective (as represented by a positive status generated via the status generator (**2**) **210***a***-17**), flow may proceed from block **210***a***-17** to block **210***a***-5** to continue monitoring/checking changes. Conversely, if the quarantine/timeout period associated with block **210***a***-13** is ineffective (as represented by a negative status generated via the status generator (**2**) **210***a***-17**), flow may proceed from block **210***a***-17** to block **210***a***-21**. Block **210***a***-21** may result in a generation of an alarm, a ticket, etc., that may need to be addressed by, e.g., the APP **206***a* (or, analogously, SON), personnel, etc.

As one skilled in the art will appreciate, the arrangement and use of the system **200***a*, inclusive of the OLHC **210***a*, may enable a check, examination, or test to be performed on changes or modifications made or effectuated by the APP **206***a* (e.g., via the block **206***a***-1**) without having to wait for an output or result of that check/examination/test to be available for the next change/modification to be initiated or effectuated. In this manner, the APP **206***a* may be able to arrange for, or process, a large amount of tasks/workloads associated with changes or modifications within relatively small/tight time windows/periods (e.g., pursuant to a time limit or time constraint), while still enabling/ensuring that the changes/modifications work for intended purposes (potentially relative to one or more thresholds, specifications, requirements, or the like). In this respect, the operations facilitated by the system **200***a* represent substantial improvements in terms of the speed and efficiency by which tasks associated with practical applications of configuring and maintaining communication networks and systems (e.g., SONs) are conducted/effectuated.

Referring to FIG. **2**B, a flowchart of an illustrative embodiment of a method **200***b* in accordance with various aspects described herein is shown. The method **200***b* may be implemented (e.g., executed), in whole or in part, in conjunction with one or more systems, networks, devices, or components, such as for example the systems, networks, devices, and components described herein. For example, aspects of the method **200***b* may be implemented via the OLHC **210***a* of FIG. **2**A. The method **200***b* may be implemented to realize functionality associated with one or more algorithms or techniques for configuring, maintaining, or modifying a communication network or system. The method **200***b* is described below in relation to the blocks shown in FIG. **2**B. The blocks may be associated with operations that may be implemented via one or more instructions (e.g., executable instructions). The instructions may be executed by a processing system that may include one or more processors.

In block **204***b*, a record or log of actions (e.g., modifications) initiated or effectuated by, e.g., a SON may be obtained. Block **204***b* may include a generation of the record/log in the first instance, may include obtaining data/information associated with the record/log from another entity or party, etc.

In block **208***b*, the record (e.g., as represented within block **204***b*) may be analyzed or examined. For example, block **208***b* may include a comparison of the actions relative to one or more thresholds, requirements, specifications, etc. In some embodiments, block **208***b* may include a performance of one or more tests, potentially in accordance with one or more procedures or algorithms. In some embodiments, machine learning and/or artificial intelligence techniques/technologies may aid or assist the analysis/examination of the record. For example, historical data may be analyzed to generate predictions or assessments regarding future behaviors, activities, modifications, or the like.

In block **212**, a determination may be made whether the actions (as represented within block **204***b*) are acceptable. The determination of block **212***b* may be based on the (results of the) analysis/examination of block **208***b*. If the determination of block **212***b* is answered in the affirmative, flow may proceed from block **212***b* to block **204***b* to continue monitoring the action(s). Conversely, if the determination of block **212***b* is answered in the negative, flow may proceed from block **212***b* to, e.g., block **216***b* or block **220***b* as described in further detail below.

In block **216***b*, a timeout or quarantine period may be initiated. For example, and as described above, it may be the case that a SON communication network or system may be able to self-remedy or self-heal, and the timeout/quarantine period may be utilized to enable the network/system to undergo such self-remedying/self-healing. In this respect, and once the timeout/quarantine period has expired, flow may proceed from block **216***b* to block **208***b* to (re-)analyze/examine whether the action(s) are acceptable following the passage of time.

In block **220***b*, one or more remedial actions may be initiated or triggered. For example, block **220***b* may include: generating a command or directive to undo one or more of the actions referenced in block **204***b* (as potentially directed to a network or system, or an entity thereof), suspending or terminating functionality associated with an application, an asset (e.g., network or system infrastructure, a user equipment, etc.), or the like, issuing a message, alert, report, or the like (potentially directed to personnel), etc.

In terms of the flow from block **212***b* to block **216***b* or block **220***b*, in some embodiments a retry counter (or the like) may be used to determine whether, and to what extent, block **216***b* is to be used. For example, it may be the case that in a particular environment that no timeout or quarantine period is to be used, such that flow may always proceed from block **212***b* to block **220***b* when the determination of block **212***b* is answered in the negative. Conversely, in other environments it may be the case that more time or flexibility is available/afforded, such that multiple instances of the timeout/quarantine of block **216***b* (or, analogously, a lengthy timeout/quarantine period) may be enabled in an effort to allow any issues to be cured over time without direct intervention. In this respect, it is appreciated that the use of the timeout/quarantine of block **216***b* is optional (as fairly represented by the dashed lines of block **216***b* in FIG. **2**B), and the nature or extent of the timeout/quarantine may be customized or adapted to meet/satisfy the particulars of the environment at hand.

While for purposes of simplicity of explanation, the respective processes are shown and described as a series of blocks in FIG. **2**B, it is to be understood and appreciated that the claimed subject matter is not limited by the order of the blocks, as some blocks may occur in different orders and/or concurrently with other blocks from what is depicted and described herein. Moreover, not all illustrated blocks may be required to implement the methods described herein.

In some embodiments, rates or paces of modifications or actions imposed in a communication network or system may be based on rates or paces by which those modifications may be analyzed or examined. For example, by controlling or regulating the rate/pace at which modifications/actions are allowed to occur, it may be possible to (efficiently) reverse-course in the event that an error, an inconsistency, or the like is discovered based on the analysis/examination.

Various embodiments of this disclosure may include services and/or microservices that may be used to monitor actions (e.g., SON actions) taken in respect of networks, systems, communication services, etc. In some embodiments, the monitoring of the actions may pertain to alarms, resources, parameters, attributes, etc. An OLHC may assist in facilitating the monitoring. When a degradation or degraded state is detected (as potentially determined based on a comparison with one or more thresholds, specifications, requirements, or the like), further actions or investigations may be initiated, undertaken, executed, or performed.

Various aspects of this disclosure may enhance a stability and reliability of operations in communication networks and systems. For example, aspects of this disclosure may reduce an amount or extent of outages, degradations, or the like, that might otherwise impact a communication network or system. Aspects of this disclosure may reduce an effect/impact of design flaws (aka "bugs") or unintended/undesirable modifications made to a communication network/system configuration, and may serve to potentially identify the same before a negative result manifests itself in a way that may impact quality of service or quality of experience. In this respect, aspects of this disclosure represent substantial improvements to technologies associated with designing, testing, troubleshooting, and maintaining communication networks and systems. In brief, and as one of skill in the art will appreciate based on a review of this disclosure, the various aspects of this disclosure are not directed to abstract ideas. To the contrary, the various aspects of this disclosure are directed to, and encompass, significantly more than any abstract idea standing alone, as fairly represented by the various improvements made to technology, in relation to the various practical applications associated therewith.

Referring now to FIG. **3**, a block diagram **300** is shown illustrating an example, non-limiting embodiment of a virtualized communication network in accordance with various aspects described herein. In particular a virtualized communication network is presented that can be used to implement some or all of the subsystems and functions of system **100**, the subsystems and functions of system **200***a*, and method **200***b* presented in FIGS. **1**, **2**A, and **2**B. For example, the virtualized communication network **300** can facilitate, in whole or in part, obtaining a record of first modifications in respect of a self-organizing network (SON), analyzing the record a first time, the analyzing of the record the first time occurring while the SON is subject second modifications, and determining, based on the analyzing of the record the first time, whether the first modifications are acceptable relative to a threshold, a requirement, a specification, or any combination thereof, resulting in a first determination. The virtualized communication network **300** can facilitate, in whole or in part, examining first actions imposed as part of a maintenance activity in respect of a communication network while the communication network is subjected to second actions as part of the maintenance activity, determining, based on the examining, that the first actions, in whole or in part, fail to adhere to a threshold, a requirement, or a specification, and based on the determining, reversing at least one action of the first actions. The virtualized communication network **300** can facilitate, in whole or in part, obtaining, by a processing system including a processor, a log of first actions taken by a SON while the SON is undertaking second actions, analyzing, by the processing system and based on the obtaining, the log relative to a historical record of data in accordance with a test to determine that at least one action of the first actions departs from the historical record of data in an amount greater than a threshold, resulting in a determination, and causing, by the processing system and based on the determination, a remedial action to be initiated to address the at least one action.

In particular, a cloud networking architecture is shown that leverages cloud technologies and supports rapid innovation and scalability via a transport layer **350**, a virtualized network function cloud **325** and/or one or more cloud computing environments **375**. In various embodiments, this cloud networking architecture is an open architecture that leverages application programming interfaces (APIs); reduces complexity from services and operations; supports more nimble business models; and rapidly and seamlessly scales to meet evolving customer requirements including traffic growth, diversity of traffic types, and diversity of performance and reliability expectations.

In contrast to traditional network elements-which are typically integrated to perform a single function, the virtualized communication network employs virtual network elements (VNEs) **330**, **332**, **334**, etc. that perform some or all of the functions of network elements **150**, **152**, **154**, **156**, etc. For example, the network architecture can provide a substrate of networking capability, often called Network Function Virtualization Infrastructure (NFVI) or simply infrastructure that is capable of being directed with software and Software Defined Networking (SDN) protocols to perform a broad variety of network functions and services. This infrastructure can include several types of substrates. The most typical type of substrate being servers that support Network Function Virtualization (NFV), followed by packet forwarding capabilities based on generic computing resources, with specialized network technologies brought to bear when general-purpose processors or general-purpose integrated circuit devices offered by merchants (referred to herein as merchant silicon) are not appropriate. In this case, communication services can be implemented as cloud-centric workloads.

As an example, a traditional network element **150** (shown in FIG. **1**), such as an edge router can be implemented via a VNE **330** composed of NFV software modules, merchant silicon, and associated controllers. The software can be written so that increasing workload consumes incremental resources from a common resource pool, and moreover so that it is elastic: so, the resources are only consumed when needed. In a similar fashion, other network elements such as other routers, switches, edge caches, and middle boxes are instantiated from the common resource pool. Such sharing of infrastructure across a broad set of uses makes planning and growing infrastructure easier to manage.

In an embodiment, the transport layer **350** includes fiber, cable, wired and/or wireless transport elements, network elements and interfaces to provide broadband access **110**, wireless access **120**, voice access **130**, media access **140** and/or access to content sources **175** for distribution of content to any or all of the access technologies. In particular, in some cases a network element needs to be positioned at a specific place, and this allows for less sharing of common infrastructure. Other times, the network elements have specific physical layer adapters that cannot be abstracted or virtualized and might require special DSP code and analog front ends (AFEs) that do not lend themselves to implementation as VNEs **330**, **332** or **334**. These network elements can be included in transport layer **350**.

The virtualized network function cloud **325** interfaces with the transport layer **350** to provide the VNEs **330**, **332**, **334**, etc. to provide specific NFVs. In particular, the virtualized network function cloud **325** leverages cloud operations, applications, and architectures to support networking workloads. The virtualized network elements **330**, **332** and **334** can employ network function software that provides either a one-for-one mapping of traditional network element function or alternately some combination of network functions designed for cloud computing. For example, VNEs **330**, **332** and **334** can include route reflectors, domain name system (DNS) servers, and dynamic host configuration protocol (DHCP) servers, system architecture evolution (SAE) and/or mobility management entity (MME) gateways, broadband network gateways, IP edge routers for IP-VPN, Ethernet and other services, load balancers, distributers and other network elements. Because these elements do not typically need to forward large amounts of traffic, their workload can be distributed across a number of servers—each of which adds a portion of the capability, and which creates an elastic function with higher availability overall than its former monolithic version. These virtual network elements **330**, **332**, **334**, etc. can be instantiated and managed using an orchestration approach similar to those used in cloud compute services.

The cloud computing environments **375** can interface with the virtualized network function cloud **325** via APIs that expose functional capabilities of the VNEs **330**, **332**, **334**, etc. to provide the flexible and expanded capabilities to the virtualized network function cloud **325**. In particular, network workloads may have applications distributed across the virtualized network function cloud **325** and cloud computing environment **375** and in the commercial cloud or might simply orchestrate workloads supported entirely in NFV infrastructure from these third-party locations.

Turning now to FIG. **4**, there is illustrated a block diagram of a computing environment in accordance with various aspects described herein. In order to provide additional context for various embodiments of the embodiments described herein, FIG. **4** and the following discussion are intended to provide a brief, general description of a suitable computing environment **400** in which the various embodiments of the subject disclosure can be implemented. In particular, computing environment **400** can be used in the implementation of network elements **150**, **152**, **154**, **156**, access terminal **112**, base station or access point **122**, switching device **132**, media terminal **142**, and/or VNEs **330**, **332**, **334**, etc. Each of these devices can be implemented via computer-executable instructions that can run on one or more computers, and/or in combination with other program modules and/or as a combination of hardware and software. For example, the computing environment **400** can facilitate, in whole or in part, obtaining a record of first modifications in respect of a self-organizing network (SON), analyzing the record a first time, the analyzing of the record the first time occurring while the SON is subject second modifications, and determining, based on the analyzing of the record the first time, whether the first modifications are acceptable relative to a threshold, a requirement, a specification, or any combination thereof, resulting in a first determination. The computing environment **400** can facilitate, in whole or in part, examining first actions imposed as part of a maintenance activity in respect of a communication network while the communication network is subjected to second actions as part of the maintenance activity, determining, based on the examining, that the first actions, in whole or in part, fail to adhere to a threshold, a requirement, or a specification, and based on the determining, reversing at least one action of the first actions. The computing environment **400** can facilitate, in whole or in part, obtaining, by a processing system including a processor, a log of first actions taken by a SON while the SON is undertaking second actions, analyzing, by the processing system and based on the obtaining, the log relative to a historical record of data in accordance with a test to determine that at least one action of the first actions departs from the historical record of data in an amount greater than a threshold, resulting in a determination, and causing, by the processing system and based on the determination, a remedial action to be initiated to address the at least one action.

Generally, program modules comprise routines, programs, components, data structures, etc., that perform particular tasks or implement particular abstract data types. Moreover, those skilled in the art will appreciate that the methods can be practiced with other computer system configurations, comprising single-processor or multiprocessor computer systems, minicomputers, mainframe computers, as well as personal computers, hand-held computing devices, microprocessor-based or programmable consumer electronics, and the like, each of which can be operatively coupled to one or more associated devices.

As used herein, a processing circuit includes one or more processors as well as other application specific circuits such as an application specific integrated circuit, digital logic circuit, state machine, programmable gate array or other circuit that processes input signals or data and that produces output signals or data in response thereto. It should be noted that while any functions and features described herein in association with the operation of a processor could likewise be performed by a processing circuit.

The illustrated embodiments of the embodiments herein can be also practiced in distributed computing environments where certain tasks are performed by remote processing devices that are linked through a communications network. In a distributed computing environment, program modules can be located in both local and remote memory storage devices.

Computing devices typically comprise a variety of media, which can comprise computer-readable storage media and/or communications media, which two terms are used herein differently from one another as follows. Computer-readable storage media can be any available storage media that can be accessed by the computer and comprises both volatile and nonvolatile media, removable and non-removable media. By way of example, and not limitation, computer-readable storage media can be implemented in connection with any method or technology for storage of information such as computer-readable instructions, program modules, structured data or unstructured data.

Computer-readable storage media can comprise, but are not limited to, random access memory (RAM), read only memory (ROM), electrically erasable programmable read only memory (EEPROM), flash memory or other memory technology, compact disk read only memory (CD-ROM), digital versatile disk (DVD) or other optical disk storage, magnetic cassettes, magnetic tape, magnetic disk storage or other magnetic storage devices or other tangible and/or non-transitory media which can be used to store desired information. In this regard, the terms "tangible" or "non-transitory" herein as applied to storage, memory or computer-readable media, are to be understood to exclude only propagating transitory signals per se as modifiers and do not relinquish rights to all standard storage, memory or computer-readable media that are not only propagating transitory signals per se.

Computer-readable storage media can be accessed by one or more local or remote computing devices, e.g., via access requests, queries or other data retrieval protocols, for a variety of operations with respect to the information stored by the medium.

Communications media typically embody computer-readable instructions, data structures, program modules or other structured or unstructured data in a data signal such as a modulated data signal, e.g., a carrier wave or other transport mechanism, and comprises any information delivery or transport media. The term "modulated data signal" or signals refers to a signal that has one or more of its characteristics set or changed in such a manner as to encode information in one or more signals. By way of example, and not limitation, communication media comprise wired media, such as a wired network or direct-wired connection, and wireless media such as acoustic, RF, infrared and other wireless media.

With reference again to FIG. **4**, the example environment can comprise a computer **402**, the computer **402** comprising a processing unit **404**, a system memory **406** and a system bus **408**. The system bus **408** couples system components including, but not limited to, the system memory **406** to the processing unit **404**. The processing unit **404** can be any of various commercially available processors. Dual microprocessors and other multiprocessor architectures can also be employed as the processing unit **404**.

The system bus **408** can be any of several types of bus structure that can further interconnect to a memory bus (with or without a memory controller), a peripheral bus, and a local bus using any of a variety of commercially available bus architectures. The system memory **406** comprises ROM **410** and RAM **412**. A basic input/output system (BIOS) can be stored in a non-volatile memory such as ROM, erasable programmable read only memory (EPROM), EEPROM, which BIOS contains the basic routines that help to transfer information between elements within the computer **402**, such as during startup. The RAM **412** can also comprise a high-speed RAM such as static RAM for caching data.

The computer **402** further comprises an internal hard disk drive (HDD) **414** (e.g., EIDE, SATA), which internal HDD **414** can also be configured for external use in a suitable chassis (not shown), a magnetic floppy disk drive (FDD) **416**, (e.g., to read from or write to a removable diskette **418**) and an optical disk drive **420**, (e.g., reading a CD-ROM disk **422** or, to read from or write to other high-capacity optical media such as the DVD). The HDD **414**, magnetic FDD **416** and optical disk drive **420** can be connected to the system bus **408** by a hard disk drive interface **424**, a magnetic disk drive interface **426** and an optical drive interface **428**, respectively. The hard disk drive interface **424** for external drive implementations comprises at least one or both of Universal Serial Bus (USB) and Institute of Electrical and Electronics Engineers (IEEE) 1394 interface technologies. Other external drive connection technologies are within contemplation of the embodiments described herein.

The drives and their associated computer-readable storage media provide nonvolatile storage of data, data structures, computer-executable instructions, and so forth. For the computer **402**, the drives and storage media accommodate the storage of any data in a suitable digital format. Although the description of computer-readable storage media above refers to a hard disk drive (HDD), a removable magnetic diskette, and a removable optical media such as a CD or DVD, it should be appreciated by those skilled in the art that other types of storage media which are readable by a computer, such as zip drives, magnetic cassettes, flash memory cards, cartridges, and the like, can also be used in the example operating environment, and further, that any such storage media can contain computer-executable instructions for performing the methods described herein.

A number of program modules can be stored in the drives and RAM **412**, comprising an operating system **430**, one or more application programs **432**, other program modules **434** and program data **436**. All or portions of the operating system, applications, modules, and/or data can also be cached in the RAM **412**. The systems and methods described herein can be implemented utilizing various commercially available operating systems or combinations of operating systems.

A user can enter commands and information into the computer **402** through one or more wired/wireless input devices, e.g., a keyboard **438** and a pointing device, such as a mouse **440**. Other input devices (not shown) can comprise a microphone, an infrared (IR) remote control, a joystick, a game pad, a stylus pen, touch screen or the like. These and other input devices are often connected to the processing unit **404** through an input device interface **442** that can be coupled to the system bus **408**, but can be connected by other interfaces, such as a parallel port, an IEEE 1394 serial port, a game port, a universal serial bus (USB) port, an IR interface, etc.

A monitor **444** or other type of display device can be also connected to the system bus **408** via an interface, such as a video adapter **446**. It will also be appreciated that in alternative embodiments, a monitor **444** can also be any display device (e.g., another computer having a display, a smart phone, a tablet computer, etc.) for receiving display information associated with computer **402** via any communication means, including via the Internet and cloud-based networks. In addition to the monitor **444**, a computer typically comprises other peripheral output devices (not shown), such as speakers, printers, etc.

The computer **402** can operate in a networked environment using logical connections via wired and/or wireless communications to one or more remote computers, such as a remote computer(s) **448**. The remote computer(s) **448** can be a workstation, a server computer, a router, a personal computer, portable computer, microprocessor-based entertainment appliance, a peer device or other common network node, and typically comprises many or all of the elements described relative to the computer **402**, although, for purposes of brevity, only a remote memory/storage device **450** is illustrated. The logical connections depicted comprise wired/wireless connectivity to a local area network (LAN) **452** and/or larger networks, e.g., a wide area network (WAN) **454**. Such LAN and WAN networking environments are commonplace in offices and companies, and facilitate enterprise-wide computer networks, such as intranets, all of which can connect to a global communications network, e.g., the Internet.

When used in a LAN networking environment, the computer **402** can be connected to the LAN **452** through a wired and/or wireless communication network interface or adapter **456**. The adapter **456** can facilitate wired or wireless communication to the LAN **452**, which can also comprise a wireless AP disposed thereon for communicating with the adapter **456**.

When used in a WAN networking environment, the computer **402** can comprise a modem **458** or can be connected to a communications server on the WAN **454** or has other means for establishing communications over the WAN **454**, such as by way of the Internet. The modem **458**, which can be internal or external and a wired or wireless device, can be connected to the system bus **408** via the input device interface **442**. In a networked environment, program modules depicted relative to the computer **402** or portions thereof, can be stored in the remote memory/storage device **450**. It will be appreciated that the network connections shown are example and other means of establishing a communications link between the computers can be used.

The computer **402** can be operable to communicate with any wireless devices or entities operatively disposed in wireless communication, e.g., a printer, scanner, desktop and/or portable computer, portable data assistant, communications satellite, any piece of equipment or location associated with a wirelessly detectable tag (e.g., a kiosk, news stand, restroom), and telephone. This can comprise Wireless Fidelity (Wi-Fi) and BLUETOOTH® wireless technologies. Thus, the communication can be a predefined structure as with a conventional network or simply an ad hoc communication between at least two devices.

Wi-Fi can allow connection to the Internet from a couch at home, a bed in a hotel room or a conference room at work, without wires. Wi-Fi is a wireless technology similar to that used in a cell phone that enables such devices, e.g., computers, to send and receive data indoors and out; anywhere within the range of a base station. Wi-Fi networks use radio technologies called IEEE 802.11 (a, b, g, n, ac, ag, etc.) to provide secure, reliable, fast wireless connectivity. A Wi-Fi network can be used to connect computers to each other, to the Internet, and to wired networks (which can use IEEE 802.3 or Ethernet). Wi-Fi networks operate in the unlicensed 2.4 and 5 GHz radio bands for example or with products that contain both bands (dual band), so the networks can provide real-world performance similar to the basic 10BaseT wired Ethernet networks used in many offices.

Turning now to FIG. **5**, an embodiment **500** of a mobile network platform **510** is shown that is an example of network elements **150**, **152**, **154**, **156**, and/or VNEs **330**, **332**, **334**, etc. For example, the platform **510** can facilitate, in whole or in part, obtaining a record of first modifications in respect of a self-organizing network (SON), analyzing the record a first time, the analyzing of the record the first time occurring while the SON is subject second modifications, and determining, based on the analyzing of the record the first time, whether the first modifications are acceptable relative to a threshold, a requirement, a specification, or any combination thereof, resulting in a first determination. The platform **510** can facilitate, in whole or in part, examining first actions imposed as part of a maintenance activity in respect of a communication network while the communication network is subjected to second actions as part of the maintenance activity, determining, based on the examining, that the first actions, in whole or in part, fail to adhere to a threshold, a requirement, or a specification, and based on the determining, reversing at least one action of the first actions. The platform **510** can facilitate, in whole or in part, obtaining, by a processing system including a processor, a log of first actions taken by a SON while the SON is undertaking second actions, analyzing, by the processing system and based on the obtaining, the log relative to a historical record of data in accordance with a test to determine that at least one action of the first actions departs from the historical record of data in an amount greater than a threshold, resulting in a determination, and causing, by the processing system and based on the determination, a remedial action to be initiated to address the at least one action.

In one or more embodiments, the mobile network platform **510** can generate and receive signals transmitted and received by base stations or access points such as base station or access point **122**. Generally, mobile network platform **510** can comprise components, e.g., nodes, gateways, interfaces, servers, or disparate platforms, that facilitate both packet-switched (PS) (e.g., internet protocol (IP), frame relay, asynchronous transfer mode (ATM)) and circuit-switched (CS) traffic (e.g., voice and data), as well as control generation for networked wireless telecommunication. As a non-limiting example, mobile network platform **510** can be included in telecommunications carrier networks and can be considered carrier-side components as discussed elsewhere herein. Mobile network platform **510** comprises CS gateway node(s) **512** which can interface CS traffic received from legacy networks like telephony network(s) **540** (e.g., public switched telephone network (PSTN), or public land mobile network (PLMN)) or a signaling system #7 (SS7) network **560**. CS gateway node(s) **512** can authorize and authenticate traffic (e.g., voice) arising from such networks. Additionally, CS gateway node(s) **512** can access mobility, or roaming, data generated through SS7 network **560**; for instance, mobility data stored in a visited location register (VLR), which can reside in memory **530**. Moreover, CS gateway node(s) **512** interfaces CS-based traffic and signaling and PS gateway node(s) **518**. As an example, in a 3GPP UMTS network, CS gateway node(s) **512** can be realized at least in part in gateway GPRS support node(s) (GGSN). It should be appreciated that functionality and specific operation of CS gateway node(s) **512**, PS gateway node(s) **518**, and serving node(s) **516**, is provided and dictated by radio technology(ies) utilized by mobile network platform **510** for telecommunication over a radio access network **520** with other devices, such as a radiotelephone **575**.

In addition to receiving and processing CS-switched traffic and signaling, PS gateway node(s) **518** can authorize and authenticate PS-based data sessions with served mobile devices. Data sessions can comprise traffic, or content(s), exchanged with networks external to the mobile network platform **510**, like wide area network(s) (WANs) **550**, enterprise network(s) **570**, and service network(s) **580**, which can be embodied in local area network(s) (LANs), can also be interfaced with mobile network platform **510** through PS gateway node(s) **518**. It is to be noted that WANs **550** and enterprise network(s) **570** can embody, at least in part, a service network(s) like IP multimedia subsystem (IMS). Based on radio technology layer(s) available in technology resource(s) or radio access network **520**, PS gateway node(s) **518** can generate packet data protocol contexts when a data session is established; other data structures that facilitate routing of packetized data also can be generated. To that end, in an aspect, PS gateway node(s) **518** can comprise a tunnel interface (e.g., tunnel termination gateway (TTG) in 3GPP UMTS network(s) (not shown)) which can facilitate packetized communication with disparate wireless network(s), such as Wi-Fi networks.

In embodiment **500**, mobile network platform **510** also comprises serving node(s) **516** that, based upon available radio technology layer(s) within technology resource(s) in the radio access network **520**, convey the various packetized flows of data streams received through PS gateway node(s) **518**. It is to be noted that for technology resource(s) that rely primarily on CS communication, server node(s) can deliver traffic without reliance on PS gateway node(s) **518**; for example, server node(s) can embody at least in part a mobile switching center. As an example, in a 3GPP UMTS network, serving node(s) **516** can be embodied in serving GPRS support node(s) (SGSN).

For radio technologies that exploit packetized communication, server(s) **514** in mobile network platform **510** can execute numerous applications that can generate multiple disparate packetized data streams or flows, and manage (e.g., schedule, queue, format . . .) such flows. Such application(s) can comprise add-on features to standard services (for example, provisioning, billing, customer support . . .) provided by mobile network platform **510**. Data streams (e.g., content(s) that are part of a voice call or data session) can be conveyed to PS gateway node(s) **518** for authorization/authentication and initiation of a data session, and to serving node(s) **516** for communication thereafter. In addition to application server, server(s) **514** can comprise utility server(s), a utility server can comprise a provisioning server, an operations and maintenance server, a security server that can implement at least in part a certificate authority and firewalls as well as other security mechanisms, and the like. In an aspect, security server(s) secure communication served through mobile network platform **510** to ensure network's operation and data integrity in addition to authorization and authentication procedures that CS gateway node(s) **512** and PS gateway node(s) **518** can enact. Moreover, provisioning server(s) can provision services from external network(s) like networks operated by a disparate service provider; for instance, WAN **550** or Global Positioning System (GPS) network(s) (not shown). Provisioning server(s) can also provision coverage through networks associated to mobile network platform **510** (e.g., deployed and operated by the same service provider), such as the distributed antennas networks shown in FIG. **1**(*s*) that enhance wireless service coverage by providing more network coverage.

It is to be noted that server(s) **514** can comprise one or more processors configured to confer at least in part the functionality of mobile network platform **510**. To that end, the one or more processors can execute code instructions stored in memory **530**, for example. It should be appreciated that server(s) **514** can comprise a content manager, which operates in substantially the same manner as described hereinbefore.

In example embodiment **500**, memory **530** can store information related to operation of mobile network platform **510**. Other operational information can comprise provisioning information of mobile devices served through mobile network platform **510**, subscriber databases; application intelligence, pricing schemes, e.g., promotional rates, flat-rate programs, couponing campaigns; technical specification(s) consistent with telecommunication protocols for operation of disparate radio, or wireless, technology layers; and so forth. Memory **530** can also store information from at least one of telephony network(s) **540**, WAN **550**, SS7 network **560**, or enterprise network(s) **570**. In an aspect, memory **530** can be, for example, accessed as part of a data store component or as a remotely connected memory store.

In order to provide a context for the various aspects of the disclosed subject matter, FIG. **5**, and the following discussion, are intended to provide a brief, general description of a suitable environment in which the various aspects of the disclosed subject matter can be implemented. While the subject matter has been described above in the general context of computer-executable instructions of a computer program that runs on a computer and/or computers, those skilled in the art will recognize that the disclosed subject matter also can be implemented in combination with other program modules. Generally, program modules comprise routines, programs, components, data structures, etc. that perform particular tasks and/or implement particular abstract data types.

Turning now to FIG. **6**, an illustrative embodiment of a communication device **600** is shown. The communication device **600** can serve as an illustrative embodiment of devices such as data terminals **114**, mobile devices **124**, vehicle **126**, display devices **144** or other client devices for communication via either communications network **125**. For example, the computing device **600** can facilitate, in whole or in part, obtaining a record of first modifications in respect of a self-organizing network (SON), analyzing the record a first time, the analyzing of the record the first time occurring while the SON is subject second modifications, and determining, based on the analyzing of the record the first time, whether the first modifications are acceptable relative to a threshold, a requirement, a specification, or any combination thereof, resulting in a first determination. The computing device **600** can facilitate, in whole or in part, examining first actions imposed as part of a maintenance activity in respect of a communication network while the communication network is subjected to second actions as part of the maintenance activity, determining, based on the examining, that the first actions, in whole or in part, fail to adhere to a threshold, a requirement, or a specification, and based on the determining, reversing at least one action of the first actions. The computing device **600** can facilitate, in whole or in part, obtaining, by a processing system including a processor, a log of first actions taken by a SON while the SON is undertaking second actions, analyzing, by the processing system and based on the obtaining, the log relative to a historical record of data in accordance with a test to determine that at least one action of the first actions departs from the historical record of data in an amount greater than a threshold, resulting in a determination, and causing, by the processing system and based on the determination, a remedial action to be initiated to address the at least one action.

The communication device **600** can comprise a wireline and/or wireless transceiver **602** (herein transceiver **602**), a user interface (UI) **604**, a power supply **614**, a location receiver **616**, a motion sensor **618**, an orientation sensor **620**, and a controller **606** for managing operations thereof. The transceiver **602** can support short-range or long-range wireless access technologies such as Bluetooth®, ZigBee®, Wi-Fi, DECT, or cellular communication technologies, just to mention a few (Bluetooth® and ZigBee® are trademarks registered by the Bluetooth® Special Interest Group and the ZigBee® Alliance, respectively). Cellular technologies can include, for example, CDMA-1X, UMTS/HSDPA, GSM/GPRS, TDMA/EDGE, EV/DO, WiMAX, SDR, LTE, as well as other next generation wireless communication technologies as they arise. The transceiver **602** can also be adapted to support circuit-switched wireline access technologies (such as PSTN), packet-switched wireline access technologies (such as TCP/IP, VOIP, etc.), and combinations thereof.

The UI **604** can include a depressible or touch-sensitive keypad **608** with a navigation mechanism such as a roller ball, a joystick, a mouse, or a navigation disk for manipulating operations of the communication device **600**. The keypad **608** can be an integral part of a housing assembly of the communication device **600** or an independent device operably coupled thereto by a tethered wireline interface (such as a USB cable) or a wireless interface supporting for example Bluetooth®. The keypad **608** can represent a numeric keypad commonly used by phones, and/or a QWERTY keypad with alphanumeric keys. The UI **604** can further include a display **610** such as monochrome or color LCD (Liquid Crystal Display), OLED (Organic Light Emitting Diode) or other suitable display technology for conveying images to an end user of the communication device **600**. In an embodiment where the display **610** is touch-sensitive, a portion or all of the keypad **608** can be presented by way of the display **610** with navigation features.

The display **610** can use touch screen technology to also serve as a user interface for detecting user input. As a touch screen display, the communication device **600** can be adapted to present a user interface having graphical user interface (GUI) elements that can be selected by a user with a touch of a finger. The display **610** can be equipped with capacitive, resistive or other forms of sensing technology to detect how much surface area of a user's finger has been placed on a portion of the touch screen display. This sensing information can be used to control the manipulation of the GUI elements or other functions of the user interface. The display **610** can be an integral part of the housing assembly of the communication device **600** or an independent device communicatively coupled thereto by a tethered wireline interface (such as a cable) or a wireless interface.

The UI **604** can also include an audio system **612** that utilizes audio technology for conveying low volume audio (such as audio heard in proximity of a human ear) and high-volume audio (such as speakerphone for hands free operation). The audio system **612** can further include a microphone for receiving audible signals of an end user. The audio system **612** can also be used for voice recognition applications. The UI **604** can further include an image sensor **613** such as a charged coupled device (CCD) camera for capturing still or moving images.

The power supply **614** can utilize common power management technologies such as replaceable and rechargeable batteries, supply regulation technologies, and/or charging system technologies for supplying energy to the components of the communication device **600** to facilitate long-range or short-range portable communications. Alternatively, or in combination, the charging system can utilize external power sources such as DC power supplied over a physical interface such as a USB port or other suitable tethering technologies.

The location receiver **616** can utilize location technology such as a global positioning system (GPS) receiver capable of assisted GPS for identifying a location of the communication device **600** based on signals generated by a constellation of GPS satellites, which can be used for facilitating location services such as navigation. The motion sensor **618** can utilize motion sensing technology such as an accelerometer, a gyroscope, or other suitable motion sensing technology to detect motion of the communication device **600** in three-dimensional space. The orientation sensor **620** can utilize orientation sensing technology such as a magnetometer to detect the orientation of the communication device **600** (north, south, west, and east, as well as combined orientations in degrees, minutes, or other suitable orientation metrics).

The communication device **600** can use the transceiver **602** to also determine a proximity to a cellular, Wi-Fi, Bluetooth®, or other wireless access points by sensing techniques such as utilizing a received signal strength indicator (RSSI) and/or signal time of arrival (TOA) or time of flight (TOF) measurements. The controller **606** can utilize computing technologies such as a microprocessor, a digital signal processor (DSP), programmable gate arrays, application specific integrated circuits, and/or a video processor with associated storage memory such as Flash, ROM, RAM, SRAM, DRAM or other storage technologies for executing computer instructions, controlling, and processing data supplied by the aforementioned components of the communication device **600**.

Other components not shown in FIG. **6** can be used in one or more embodiments of the subject disclosure. For instance, the communication device **600** can include a slot for adding or removing an identity module such as a Subscriber Identity Module (SIM) card or Universal Integrated Circuit Card (UICC). SIM or UICC cards can be used for identifying subscriber services, executing programs, storing subscriber data, and so on.

The terms "first," "second," "third," and so forth, as used in the claims, unless otherwise clear by context, is for clarity only and does not otherwise indicate or imply any order in time. For instance, "a first determination," "a second determination," and "a third determination," does not indicate or imply that the first determination is to be made before the second determination, or vice versa, etc.

In the subject specification, terms such as "store," "storage," "data store," data storage," "database," and substantially any other information storage component relevant to operation and functionality of a component, refer to "memory components," or entities embodied in a "memory" or components comprising the memory. It will be appreciated that the memory components described herein can be either volatile memory or nonvolatile memory, or can comprise both volatile and nonvolatile memory, by way of illustration, and not limitation, volatile memory, non-volatile memory, disk storage, and memory storage. Further, nonvolatile memory can be included in read only memory (ROM), programmable ROM (PROM), electrically programmable ROM (EPROM), electrically erasable ROM (EEPROM), or flash memory. Volatile memory can comprise random access memory (RAM), which acts as external cache memory. By way of illustration and not limitation, RAM is available in many forms such as synchronous RAM (SRAM), dynamic RAM (DRAM), synchronous DRAM (SDRAM), double data rate SDRAM (DDR SDRAM), enhanced SDRAM (ESDRAM), Synchlink DRAM (SLDRAM), and direct Rambus RAM (DRRAM). Additionally, the disclosed memory components of systems or methods herein are intended to comprise, without being limited to comprising, these and any other suitable types of memory.

Moreover, it will be noted that the disclosed subject matter can be practiced with other computer system configurations, comprising single-processor or multiprocessor computer systems, mini-computing devices, mainframe computers, as well as personal computers, hand-held computing devices (e.g., PDA, phone, smartphone, watch, tablet computers, netbook computers, etc.), microprocessor-based or programmable consumer or industrial electronics, and the like. The illustrated aspects can also be practiced in distributed computing environments where tasks are performed by remote processing devices that are linked through a communications network; however, some if not all aspects of the subject disclosure can be practiced on stand-alone computers. In a distributed computing environment, program modules can be located in both local and remote memory storage devices.

In one or more embodiments, information regarding use of services can be generated including services being accessed, media consumption history, user preferences, and so forth. This information can be obtained by various methods including user input, detecting types of communications (e.g., video content vs. audio content), analysis of content streams, sampling, and so forth. The generating, obtaining and/or monitoring of this information can be responsive to an authorization provided by the user. In one or more embodiments, an analysis of data can be subject to authorization from user(s) associated with the data, such as an opt-in, an opt-out, acknowledgement requirements, notifications, selective authorization based on types of data, and so forth.

Some of the embodiments described herein can also employ artificial intelligence (AI) to facilitate automating one or more features described herein. The embodiments (e.g., in connection with automatically identifying acquired cell sites that provide a maximum value/benefit after addition to an existing communication network) can employ various AI-based schemes for carrying out various embodiments thereof. Moreover, the classifier can be employed to determine a ranking or priority of each cell site of the acquired network. A classifier is a function that maps an input attribute vector, $x=(x_1, x_2, x_3, x_4 \ldots x_n)$, to a confidence that the input belongs to a class, that is, f(x) =confidence (class). Such classification can employ a probabilistic and/or statistical-based analysis (e.g., factoring into the analysis utilities and costs) to determine or infer an action that a user desires to be automatically performed. A support vector machine (SVM) is an example of a classifier that can be employed. The SVM operates by finding a hypersurface in the space of possible inputs, which the hypersurface attempts to split the triggering criteria from the non-triggering events. Intuitively, this makes the classification correct for testing data that is near, but not identical to training data. Other directed and undirected model classification approaches comprise, e.g., naïve Bayes, Bayesian networks, decision trees, neural networks, fuzzy logic models, and probabilistic classification models providing different patterns of independence can be employed. Classification as used herein also is inclusive of statistical regression that is utilized to develop models of priority.

As will be readily appreciated, one or more of the embodiments can employ classifiers that are explicitly trained (e.g., via a generic training data) as well as implicitly trained (e.g., via observing UE behavior, operator preferences, historical information, receiving extrinsic information). For example, SVMs can be configured via a learning or training phase within a classifier constructor and feature selection module. Thus, the classifier(s) can be used to automatically learn and perform a number of functions, including but not limited to determining according to predetermined criteria which of the acquired cell sites will benefit a maximum number of subscribers and/or which of the acquired cell sites will add minimum value to the existing communication network coverage, etc.

As used in some contexts in this application, in some embodiments, the terms "component," "system" and the like are intended to refer to, or comprise, a computer-related entity or an entity related to an operational apparatus with one or more specific functionalities, wherein the entity can be either hardware, a combination of hardware and software, software, or software in execution. As an example, a component may be, but is not limited to being, a process running on a processor, a processor, an object, an executable, a thread of execution, computer-executable instructions, a program, and/or a computer. By way of illustration and not limitation, both an application running on a server and the server can be a component. One or more components may reside within a process and/or thread of execution and a component may be localized on one computer and/or distributed between two or more computers. In addition, these components can execute from various computer readable media having various data structures stored thereon. The components may communicate via local and/or remote processes such as in accordance with a signal having one or more data packets (e.g., data from one component interacting with another component in a local system, distributed system, and/or across a network such as the Internet with other systems via the signal). As another example, a component can be an apparatus with specific functionality provided by mechanical parts operated by electric or electronic circuitry, which is operated by a software or firmware application executed by a processor, wherein the processor can be internal or external to the apparatus and executes at least a part of the software or firmware application. As yet another example, a component can be an apparatus that provides specific functionality through electronic components without mechanical parts, the electronic components can comprise a processor therein to execute software or firmware that confers at least in part the functionality of the electronic components. While various components have been illustrated as separate components, it will be appreciated that multiple components can be implemented as a single component, or a single component can be implemented as multiple components, without departing from example embodiments.

Further, the various embodiments can be implemented as a method, apparatus or article of manufacture using standard programming and/or engineering techniques to produce software, firmware, hardware or any combination thereof to control a computer to implement the disclosed subject matter. The term "article of manufacture" as used herein is intended to encompass a computer program accessible from any computer-readable device or computer-readable storage/communications media. For example, computer readable storage media can include, but are not limited to, magnetic storage devices (e.g., hard disk, floppy disk, magnetic strips), optical disks (e.g., compact disk (CD), digital versatile disk (DVD)), smart cards, and flash memory devices (e.g., card, stick, key drive). Of course, those skilled in the art will recognize many modifications can be made to this configuration without departing from the scope or spirit of the various embodiments.

In addition, the words "example" and "exemplary" are used herein to mean serving as an instance or illustration. Any embodiment or design described herein as "example" or "exemplary" is not necessarily to be construed as preferred or advantageous over other embodiments or designs. Rather, use of the word example or exemplary is intended to present concepts in a concrete fashion. As used in this application, the term "or" is intended to mean an inclusive "or" rather than an exclusive "or". That is, unless specified otherwise or clear from context, "X employs A or B" is intended to mean any of the natural inclusive permutations. That is, if X employs A; X employs B; or X employs both A and B, then "X employs A or B" is satisfied under any of the foregoing instances. In addition, the articles "a" and "an" as used in this application and the appended claims should generally be construed to mean "one or more" unless specified otherwise or clear from context to be directed to a singular form.

Moreover, terms such as "user equipment," "mobile station," "mobile," subscriber station," "access terminal," "terminal," "handset," "mobile device" (and/or terms representing similar terminology) can refer to a wireless device utilized by a subscriber or user of a wireless communication service to receive or convey data, control, voice, video, sound, gaming or substantially any data-stream or signaling-stream. The foregoing terms are utilized interchangeably herein and with reference to the related drawings.

Furthermore, the terms "user," "subscriber," "customer," "consumer" and the like are employed interchangeably throughout, unless context warrants particular distinctions among the terms. It should be appreciated that such terms can refer to human entities or automated components supported through artificial intelligence (e.g., a capacity to make inference based, at least, on complex mathematical formalisms), which can provide simulated vision, sound recognition and so forth.

As employed herein, the term "processor" can refer to substantially any computing processing unit or device comprising, but not limited to comprising, single-core processors; single-processors with software multithread execution capability; multi-core processors; multi-core processors with software multithread execution capability; multi-core processors with hardware multithread technology; parallel platforms; and parallel platforms with distributed shared memory. Additionally, a processor can refer to an integrated circuit, an application specific integrated circuit (ASIC), a digital signal processor (DSP), a field programmable gate array (FPGA), a programmable logic controller (PLC), a complex programmable logic device (CPLD), a discrete gate or transistor logic, discrete hardware components or any combination thereof designed to perform the functions described herein. Processors can exploit nano-scale architectures such as, but not limited to, molecular and quantum-dot based transistors, switches and gates, in order to optimize space usage or enhance performance of user equipment. A processor can also be implemented as a combination of computing processing units.

As used herein, terms such as "data storage," data storage," "database," and substantially any other information storage component relevant to operation and functionality of a component, refer to "memory components," or entities embodied in a "memory" or components comprising the memory. It will be appreciated that the memory components or computer-readable storage media, described herein can be either volatile memory or nonvolatile memory or can include both volatile and nonvolatile memory.

What has been described above includes mere examples of various embodiments. It is, of course, not possible to describe every conceivable combination of components or methodologies for purposes of describing these examples, but one of ordinary skill in the art can recognize that many further combinations and permutations of the present embodiments are possible. Accordingly, the embodiments disclosed and/or claimed herein are intended to embrace all such alterations, modifications and variations that fall within the spirit and scope of the appended claims. Furthermore, to the extent that the term "includes" is used in either the detailed description or the claims, such term is intended to be inclusive in a manner similar to the term "comprising" as "comprising" is interpreted when employed as a transitional word in a claim.

In addition, a flow diagram may include a "start" and/or "continue" indication. The "start" and "continue" indications reflect that the steps presented can optionally be incorporated in or otherwise used in conjunction with other routines. In this context, "start" indicates the beginning of the first step presented and may be preceded by other activities not specifically shown. Further, the "continue" indication reflects that the steps presented may be performed multiple times and/or may be succeeded by other activities not specifically shown. Further, while a flow diagram indicates a particular ordering of steps, other orderings are likewise possible provided that the principles of causality are maintained.

As may also be used herein, the term(s) "operably coupled to", "coupled to", and/or "coupling" includes direct coupling between items and/or indirect coupling between items via one or more intervening items. Such items and intervening items include, but are not limited to, junctions, communication paths, components, circuit elements, circuits, functional blocks, and/or devices. As an example of indirect coupling, a signal conveyed from a first item to a second item may be modified by one or more intervening items by modifying the form, nature or format of information in a signal, while one or more elements of the information in the signal are nevertheless conveyed in a manner than can be recognized by the second item. In a further example of indirect coupling, an action in a first item can cause a reaction on the second item, as a result of actions and/or reactions in one or more intervening items.

Although specific embodiments have been illustrated and described herein, it should be appreciated that any arrangement which achieves the same or similar purpose may be substituted for the embodiments described or shown by the subject disclosure. The subject disclosure is intended to cover any and all adaptations or variations of various embodiments. Combinations of the above embodiments, and other embodiments not specifically described herein, can be used in the subject disclosure. For instance, one or more features from one or more embodiments can be combined with one or more features of one or more other embodiments. In one or more embodiments, features that are positively recited can also be negatively recited and excluded from the embodiment with or without replacement by another structural and/or functional feature. The steps or functions described with respect to the embodiments of the subject disclosure can be performed in any order. The steps or functions described with respect to the embodiments of the subject disclosure can be performed alone or in combination with other steps or functions of the subject disclosure, as well as from other embodiments or from other steps that have not been described in the subject disclosure. Further, more than or less than all of the features described with respect to an embodiment can also be utilized.

What is claimed is:

1. A method, comprising:

obtaining, by a processing system including a processor, a log of first actions taken by a self-organizing network (SON) while the SON is undertaking second actions;

analyzing, by the processing system and based on the obtaining, the log relative to a historical record of data in accordance with a test to determine that at least one action of the first actions departs from the historical record of data in an amount greater than a threshold, resulting in a determination; and

causing, by the processing system and based on the determination, a remedial action to be initiated to address the at least one action,

wherein the first actions and the second actions are included as part of a plurality of tasks that are executed in respect of the SON, wherein the execution of the plurality of tasks is subject to a time limit, wherein a time that it would take to serially execute and test each of the tasks included in the plurality of tasks would exceed the time limit, and wherein the execution of the plurality of tasks occurs in an amount of time that is less than the time limit.

2. A non-transitory machine-readable medium, comprising executable instructions that, when executed by a processing system including a processor, facilitate performance of operations, the operations comprising:

examining first actions imposed as part of a maintenance activity in respect of a communication network while the communication network is subjected to second actions as part of the maintenance activity;

determining, based on the examining, that the first actions, in whole or in part, fail to adhere to a threshold, a requirement, or a specification; and

based on the determining, reversing at least one action of the first actions,

wherein the first actions and the second actions are included as part of a plurality of tasks that are executed in respect of a self-organizing network (SON), wherein the execution of the plurality of tasks is subject to a time limit, wherein a time that it would take to serially execute and test each of the tasks included in the plurality of tasks would exceed the time limit, and wherein the execution of the plurality of tasks occurs in an amount of time that is less than the time limit.

3. The non-transitory machine-readable medium of claim **2**, wherein the reversing of the at least one action of the first actions results in a reversal of at least one action of the second actions.

4. The non-transitory machine-readable medium of claim **2**, wherein the reversing of the at least one action is initiated after an expiration of a quarantine period.

5. The non-transitory machine-readable medium of claim **2**, wherein the reversing of the at least one action applies to an application, infrastructure of the communication network, a user equipment, or any combination thereof.

6. The non-transitory machine-readable medium of claim **2**, wherein the examining of the first actions occurs with respect to a log or record of historical data.

7. The non-transitory machine-readable medium of claim **2**, wherein the examining is based on a use of machine learning, artificial intelligence, or a combination thereof.

8. A device, comprising:

a processing system including a processor; and

a memory that stores executable instructions that, when executed by the processing system, facilitate performance of operations, the operations comprising:

obtaining a record of first modifications in respect of a self-organizing network (SON);

analyzing the record a first time, the analyzing of the record the first time occurring while the SON is subject to second modifications; and

determining, based on the analyzing of the record the first time, whether the first modifications are acceptable relative to a threshold, a requirement, a specification, or any combination thereof, resulting in a first determination,

wherein the first modifications and the second modifications are included as part of a plurality of tasks that are executed in respect of the SON, wherein the execution of the plurality of tasks is subject to a time limit, wherein a time that it would take to serially execute and test each of the tasks included in the plurality of tasks would exceed the time limit, and wherein the execution of the plurality of tasks occurs in an amount of time that is less than the time limit.

9. The device of claim **8**, wherein the first determination indicates that at least one modification included in the first modifications is unacceptable relative to the threshold, the requirement, the specification, or any combination thereof.

10. The device of claim **9**, wherein the operations further comprise:

initiating a timeout period based on the first determination indicating that the at least one modification included in the first modifications is unacceptable.

11. The device of claim **10**, wherein the operations further comprise:

analyzing the record a second time based on an expiration of the timeout period.

12. The device of claim **11**, wherein the operations further comprise:

determining, based on the analyzing of the record the second time, that the at least one modification included in the first modifications is acceptable relative to the threshold, the requirement, the specification, or any combination thereof, resulting in a second determination.

13. The device of claim **12**, wherein the second determination is based on an initiation of a remedial action to address the at least one modification.

14. The device of claim **13**, wherein the SON initiates the remedial action.

15. The device of claim **9**, wherein the operations further comprise:

initiating a remedial action based on the first determination.

16. The device of claim **15**, wherein the initiating of the remedial action comprises:

generating a command to reverse the at least one modification; and

transmitting the command to the SON.

17. The device of claim **15**, wherein the initiating of the remedial action comprises:

suspending or terminating functionality associated with an application that is associated with the SON.

18. The device of claim **15**, wherein the initiating of the remedial action comprises:

issuing a message, an alert, or a report directed to personnel associated with the SON.

19. The device of claim **8**, wherein the analyzing is based on a use of machine learning, artificial intelligence, or any combination thereof.

20. The device of claim **8**, wherein a first rate of modifications that are made to the SON is based on a second rate pertaining to analysis of the modifications.

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