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(71) Applicant: **ENTIT SOFTWARE LLC** [US/US]; 1140 Enterprise Way, Building G, Sunnyvale, CA 94089 (US).

(72) Inventors: **KORN, Amitay**; Altalef st No 5, Shabazi st No 26, 56100 Yehud (IL). **SIMAN-TOV, Avivi**; Altalef st No 5, Shabazi st No 26, 56100 Yehud (IL). **KOGAN, Olga**; Shabazi 26, 56100 Yehud (IL).

(74) Agents: **WOODS, Ariana** et al.; Hewlett Packard Enterprise, 3404 East Harmony Road, Mail Stop 79, Fort Collins, Colorado 80528 (US).

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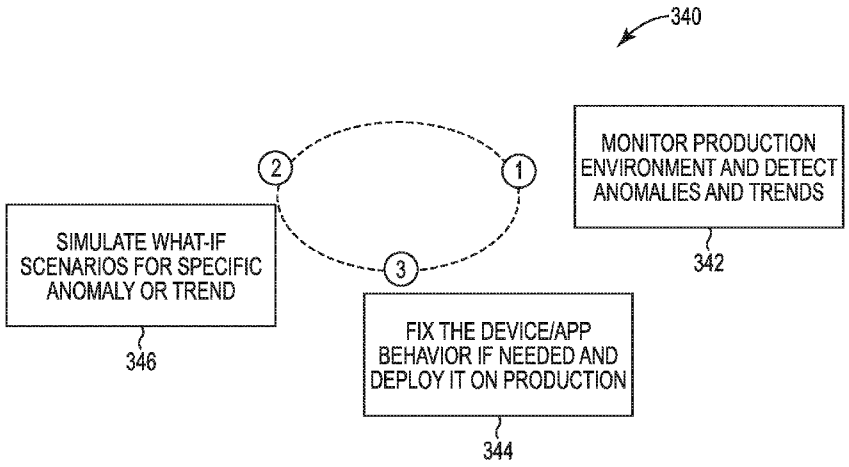

Fig. 3

(57) Abstract: Example implementations relate to simulating an environment. For example, a system for environment simulation may include a simulation engine to build an environment simulation to mimic portions of a real environment relevant to a detected anomaly trend, an acceleration engine to simulate, within the environment simulation, a scenario associated with the detected anomaly at a rate faster than the scenario occurs in the real environment, a abnormal behavior engine to detect a abnormal behavior associated with the scenario, and an adaptation engine to modify a device within the real environment to be adaptive to the scenario, based on the detected abnormal behavior.

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ENVIRONMENT SIMULATIONS

Background

[0001] Monitoring systems may be used to monitor resources and performance in a computer system. For example, monitoring systems may be used to keep track of system resources, such as central processing unit (CPU) usage and frequency and/or the amount of free random-access memory (RAM). They may also be used to display items such as free space on one or more hard drives, the temperature of the CPU, and/or other components, and networking information including a system IP address and/or current rates of upload and download.

Brief Description of the Drawings

[0002] Figure 1 is a block diagram of an example system for environment simulation consistent with the present disclosure.

[0003] Figure 2 is a block diagram of an example system for environment simulation, consistent with the present disclosure.

[0004] Figure 3 illustrates an example method for environment simulation consistent with the present disclosure.

[0005] Figure 4 illustrates an example method for environment simulation consistent with the present disclosure.

[0006] Figure 5 illustrates an example method for environment simulation consistent with the present disclosure.

Detailed Description

[0007] As the complexity of applications grows, especially in the age of Internet of Things (IoT), verifying that applications are working correctly in particular circumstances and under particular conditions has become increasingly challenging. Variability of data, contexts, conditions of the physical environment, sequences of possible application flows, etc. may be high enough that pre-defining every possible outcome and condition in the lab environment may be difficult. As a result, it may be difficult to respond in a timely manner when the unexpected occurs, thus making it challenging to provide a way to recover from faults or adapt to the new conditions without compromising the system.

[0008] Some approaches to monitoring systems include the use of predictive approaches to recognize faults and problems before they start to affect the system. However, if a system is not built to deal with the predicted or early detected problems quickly enough, the prediction may be useless. Other approaches utilize testing techniques that may provide a way to test in production, but those approaches may not be practical because of regulation, costs, or other reasons.

[0009] Some examples of the present disclosure may relate to determining root causes of abnormal behavior in simulations environments and fixing and adapting to the abnormal behavior. Examples may include determining potential anomalies in a real environment and accelerating the anomalies in an environment simulation. For instance, a potential anomaly

affecting an application may be overcompensated (e.g., be made more severe, be made more frequently occurring, and/or made to happen faster) in the environment simulation to see how the application may react in the real environment. Using what is learned in the environment simulation, the application may be modified, such that it is adaptive to the tested anomaly. The acceleration may allow for modification to the application (or real devices, etc.) before the anomaly happens in a real-world environment. Put another way, examples may combine real-time anomaly detection with testing application behaviors in an environment simulation that includes acceleration and/or overcompensation of the predicted/detected anomalies.

[0010] Figure 1 is a block diagram of an example system 100 for environment simulation consistent with the present disclosure. The system 100 may include a database 104, an environment simulation system 102, and/or a number of engines. For instance, the system 100 may include simulation engine 106, an acceleration engine 108, an abnormal behavior engine 110, and an adaptation engine 112. The environment simulation system 102 may be in communication with the database 104 via a communication link, and may include the number of engines. Put another way, the environment simulation system 102 may include simulation engine 106, acceleration engine 108, abnormal behavior engine 110, and adaptation engine 112. The environment simulation system 102 may include additional or fewer engines than illustrated to perform the various operations as will be described in further detail in connection with Figures 2-5.

[0011] The number of engines may include a combination of hardware and programming, but at least hardware, to perform operations described herein. The number of engines may be stored in a memory resource and/or implemented as a hard-wired program, or "logic". As used herein, "logic" is an alternative or additional processing resource to perform a particular action and/or operation, described herein, which includes hardware, various forms of

transistor logic, application specific integrated circuits (ASICs), among others, as opposed to computer executable instructions or instructions stored in memory and executable by a processor.

[0012] For example, simulation engine 106, acceleration engine 108, abnormal behavior engine 110, and adaptation engine 112 may include a combination of hardware and programming, but at least hardware, to perform operations related to environment simulation. As used herein, a memory resource may include a computer readable medium, and/or a machine-readable medium, among other examples. Also, as used herein, hard-wired programming may refer to logic.

[0013] The simulation engine 106 may include hardware and/or a combination of hardware and programming, but at least hardware, to build an environment simulation to mimic portions of a real environment relevant to a detected anomaly trend. The acceleration engine 108 may include hardware and/or a combination of hardware and programming, but at least hardware, to simulate, within the environment simulation, a scenario associated with the detected anomaly at a rate faster than the scenario occurs in the real environment. In some examples, the acceleration engine may simulate the scenario associated with the detected anomaly at a more severe level than the scenario occurs in the real environment and/or simulate the scenario associated with the detected anomaly at a more frequent occurrence than the scenario occurs in the real environment. For example, by accelerating the scenario, it may happen in the environment simulation before it happens in the real-world environment, allowing for fixes to be made.

[0014] The abnormal behavior engine 110 may include hardware and/or a combination of hardware and programming, but at least hardware, to detect an abnormal behavior associated with the scenario. An abnormal behavior may include an anomaly, trend, or problem, among others that may occur within the system, application, etc. Such an abnormal behavior may include or cause

undesired impacts/outputs, failures, faults, and unexpected conditions, among others. In some examples, abnormal behavior module 110 may include a controller to execute a root cause analysis of an abnormal behavior that is detected while simulating a scenario in an accelerated way. Such an example may include the controller executing tools of debugging and monitoring to find a root cause of the abnormal behavior.

[0015] Further, the adaptation engine 112 may include hardware and/or a combination of hardware and programming, but at least hardware, to modify a device within the real environment to be adaptive to the scenario, based on the detected abnormal behavior. For instance, because the scenario was accelerated, the abnormal behavior may be detected earlier in the environment simulation than in a real-world environment, and a fix may be determined. This fix may be used to modify the device. In some examples, the adaptation engine may also modify the device in response to a predicted anomaly occurring in the real environment using the fix previously determined. In some examples, adaption engine 112 may include a controller to execute modification of code, configuration, etc. and preparing a fix to the abnormal behavior to be released and deployed in a production environment. This may include a plurality of executions including, for instance, development, testing, and release.

[0016] Environment simulation system 102 may also include a monitoring engine (not pictured) including hardware and/or a combination of hardware and programming, but at least hardware to detect an anomaly in the real environment based on predictions created using collected monitoring data. For instance, using the collected monitoring data, predictions may be made as to what may happen in the real environment based on previously collected or considered data, previous simulations, and other available information.

[0017] Environment simulation system 102 may combine real-time anomaly detection with testing of adaptive behaviors of an application under test by simulating discovered production trends and/or overcompensating those

trends (e.g., making them more severe, making them happen faster or more frequently, etc.). For instance, environment simulation system 102 may allow for an end-to-end approach for creating adaptive applications. Adaptive applications may be built that adapt to specific environment changes and become more resilient over time. This may be useful for anomalies/trends/problems/system behaviors that cannot be pre-defined or be known upfront and are specific to certain environments or conditions.

[0018] Figure 2 is a block diagram of an example system 220 for environment simulation, consistent with the present disclosure. System 220 may include a computing device that is capable of communicating with a remote system. In the example of Figure 2, system 220 includes a processor 222 and a machine-readable storage medium 224. Although the following descriptions refer to a single processor and a single machine-readable storage medium, the descriptions may also apply to a system with multiple processors and multiple machine-readable storage mediums. In such examples, the instructions may be distributed across multiple machine-readable storage mediums and the instructions may be distributed across multiple processors. Put another way, the instructions may be stored across multiple machine-readable storage mediums and executed across multiple processors, such as in a distributed computing environment.

[0019] Processor 222 may be a CPU, microprocessor, and/or other hardware device suitable for retrieval and execution of instructions stored in machine-readable storage medium 224. In the particular example shown in Figure 2, processor 222 may receive, determine, and send instructions 226, 228, 230, 232, 234 for environment simulation. As an alternative or in addition to retrieving and executing instructions, processor 222 may include an electronic circuit comprising a number of electronic components for performing the operations of the instructions in machine-readable storage medium 224. With respect to the executable instruction representations or boxes described

and shown herein, it should be understood that part or all of the executable instructions and/or electronic circuits included within one box may be included in a different box shown in the figures or in a different box not shown.

[0020] Machine-readable storage medium 224 may be any electronic, magnetic, optical, or other physical storage device that stores executable instructions. Thus, machine-readable storage medium 224 may be, for example, RAM, an Electrically-Erasable Programmable Read-Only Memory (EEPROM), a storage drive, an optical disc, and the like. Machine-readable storage medium 224 may be disposed within system 220, as shown in Figure 2. In this situation, the executable instructions may be "installed" on the system 220. Machine-readable storage medium 224 may be a portable, external or remote storage medium, for example, that allows system 220 to download the instructions from the portable/external/remote storage medium. In this situation, the executable instructions may be part of an "installation package". As described herein, machine-readable storage medium 224 may be encoded with executable instructions for monitoring network utilization.

[0021] Referring to Figure 2, prediction instructions 226, when executed by a processor such as processor 222, may cause system 220 to predict a plurality of anomalies within a system using collected monitoring data from a real system environment. For instance, information about data behavior may be collected, and using this data, normal behavior may be learned. Using this information, signs and trends that undesired outcomes may occur based on comparisons to the previously determined normal behavior.

[0022] Simulation instructions 228, when executed by a processor such as processor 222, may cause system 220 to simulate, within an environment simulation, conditions in which the predicted plurality of anomalies occurs. In some examples, the system 220 includes instructions executable by the processor 222 to simulate the conditions based on trends detected in the real environment using the collected monitoring data. For instance, specific

conditions where a problem or abnormal behavior is detected or predicted may be simulated. In such an example, an exact scenario may be simulated using trends predicted in the real environment. An exact scenario may be simulated because applications may be so complex that everything may not be tested.

[0023] For example, environment simulation may include deployment of devices, deployment of applications running on those devices, an associated network configuration, and integrations between the devices and/or with external backend systems. Additionally or alternatively, other associated hardware, software, etc. that may be used to reproduce a subset of the environment simulation that is relevant to the detected anomaly may be used.

[0024] In some examples, environment simulations may include setting states of the devices, input and output data streams, simulation of physical conditions, and/or a specific flow or sequence of actions as detected as the time of the anomaly. The environment simulation can be done by recording and then replaying the real data from the production systems, by mirroring the real data to the testing environment, and/or by generating synthetic data that may reproduce the production system behavior and the detected anomaly.

[0025]

[0026] Acceleration instructions 230, when executed by a processor such as processor 222, may cause system 220 to accelerate the conditions within the environment simulation. In some examples, the accelerations instructions 230, when executed by a processor such as processor 222, may cause system 220 to simulate the conditions at a rate faster than occurs in the real environment, simulate the conditions at a level more severe than occurs in the real environment, and simulate the conditions at a more frequent occurrence than in the real environment. In some examples, once environment simulation occurs, the anomaly, a trend, an abnormal trend, problem, abnormal behavior, etc. may be accelerated. This may allow for determinations and/or discoveries of anomalies, problems, abnormal behavior, trends, etc. before a determination

may be made in the real world. This allows for fixes available before issues occur in the real world. The implementation of the acceleration may depend on the type of the anomaly. This may include changing input or output data streams, modifying behavior of the anomaly by injecting more faults, and/or modifying the behavior of the anomaly to mimic certain physical conditions (e.g., a quick increase or decrease in the temperature measurements as reported by a temperature sensors), among others. Determination instructions 232, when executed by a processor such as processor 222, may cause system 220 to determine a solution to at least one of the predicted plurality of anomalies using information collected during the accelerated conditions. In some examples, the determination may include a temporary solution determination to the at least one of the predicted plurality of anomalies and/or a permanent solution determination to the at least one of the predicted plurality of anomalies. In some examples, determination instructions 232 may be executed a plurality of times to execute a root cause analysis of an abnormal behavior that is detected while simulating a scenario in an accelerated way. Such an example may include the controller executing tools of debugging and monitoring to find a root cause of the abnormal behavior. Additionally or alternatively, determination instructions 232 may be executed a plurality of times to determine a solution. For instance, a root cause analysis and/or a determination may be a process with a number of steps within the process.

[0027] Modification instructions 234, when executed by a processor such as processor 222, may cause system 220 to modify a device within the system to be adaptive to the at least one of the predicted plurality of anomalies based on the solution. For example, modification instructions 234, when executed by the processor may modify executable instructions associated with the device (e.g., code and/or code configuration) to fix abnormal behaviors. For instance, a device, application, environment, etc. (e.g., executable instructions associated with it) may be fixed using a fix determined during simulation. For instance,

changes may be made to executable instructions that affect how the device, application, environment, etc. performs in the real world. The executable instructions may include fixes to allow the device, application, environment, etc. to adapt to anomalies experienced in the environment simulation. In some examples, all devices, applications, etc. in an environment may be fixed or only a specific device(s), application(s), etc. may be fixed.

[0028] Figure 3 illustrates an example method 340 for environment simulation consistent with the present disclosure. At 342, a production environment may be monitored and anomalies and trends may be detected. For instance, monitoring data may be collected from a real environment, and predictions may be created based on the collected data. An environment simulation may be built or run to mimic parts of the real environment that are relevant to the detected anomaly and/or trend. For instance, input from sources and times relevant to the detected anomaly and/or trend may be used to run the environment simulation. The environment simulation may be built or run to reproduce behavior of a desired device, application, etc. as it would perform taking into account the detected anomaly and/or trend.

[0029] At 346, "what-if" scenarios may be simulated within the environment simulation for the detected anomaly and/or trend. The simulation may include accelerating the scenarios. For instance, acceleration may include making the scenarios happen faster or more frequently. This may provide a way for acceleration of events that may happen based on the predictions (e.g., system failure, faults, etc.). As discussed with respect to Figure 2, the implementation of the acceleration may depend on the type of the anomaly and/or trend. This may include changing input or output data streams, modifying behavior of the anomaly by injecting more faults, and/or modifying the behavior of the anomaly to mimic certain physical conditions, among others. The simulation may be performed by streaming the real data from the production environment to the environment simulation, among other

approaches. In some examples, problems may be determined for the tested scenarios before they happen in the real environment. For instance, because the environment simulation occurs at a pace faster than in the real environment, problems may be detected in the environment simulation first.

[0030] At 344, a device, application, system, etc. behavior may be fixed, if necessary, and the fix may be deployed. For instance, real-world devices may be modified proactively to be adaptive to the tested scenarios. Additionally or alternatively, the modification may be performed when predicted trends and/or anomalies begin to materialize in the real environment. For instance, associated executable instructions may be changed, updated, fixed, etc. to make the devices adapt to the discovered trends and/or anomalies.

[0031] Figure 4 further illustrates an example method 450 for environment simulation consistent with the present disclosure. The elements illustrated in Figure 4 may correspond to elements in Figure 3. For instance elements in Figure 3 marked with a "1", "2", or "3" may correspond to elements in Figure 4 marked with a "1", "2", or "3", respectively. Method 450 illustrates example phases of the present disclosure. For instance, examples may occur during production 452 and during testing 454.

[0032] At 456, a trend and/or anomaly is detected on a production environment. The production environment may be a real-world production environment. At 462, the trend and/or anomaly is simulated in a testing scenario to cause a system, application, etc. failure in the environment simulation. The simulation may be accelerated, allowing for discovery of anomalies/trends at a faster rate than in a real-world environment. This may allow for determination of a fix within an environment simulation before the trend/anomaly occurs in the real environment.

[0033] At 464, the trend/anomaly issue or issues are fixed within the environment simulation, and at 466, the fix is deployed to fix the trend and/or

anomaly in the real production environment that was detected or predicted during simulation. At 458, if the fix does not work, simulation is repeated at 462.

[0034] A particular example of the present disclosure may include a deployment of a smart city. Part of the smart city deployment may be a smart lighting system that includes a camera collecting data about people using public transportation. This data may be analyzed to manage public transportation routes. In a particular example, developers of the system may have ignored situations such as construction workers closing a lane at 4 AM, a fact that may be discovered by monitoring cameras. In such an example, closing a lane may cause degradation of traffic speed after 7 AM and consequentially affect public transportation waiting times. For instance, the monitoring system may discover a trend of longer waiting times at certain hours or as a result of road work.

[0035] In such an example, predictive testing in accordance with the present disclosure may be used to simulate the smart lighting system in the environment simulation using physical or virtual devices (or a combination of both physical and virtual devices). "What-if" scenarios may be run, including a scenario of increased people traffic at a specific time to test an effectiveness of a transportation routing system for a specific location that detected the undesired trend (e.g., longer waiting times). Another example may include adjusting associated executable instructions such that they isolate the fact that a lane is closed, and that as a result traffic will be slower. This may be applied to the "what-if" scenarios, for instance. If a problem is discovered in the environment simulation, the transportation routing may be fixed and deployed on production devices before the trend may become more severe.

[0036] In the example above, the anomaly may be detected at the specific junction of the smart city deployment. The environment simulation may be built to include similar configuration of the smart lighting system devices deployed at this junction, the executable instructions associated with those

devices, connectivity, integrations between the devices, and/or with external systems such as backend systems that may run in cloud.

[0037] Additionally or alternatively, environment simulation may include setting states of the devices and input and output data streams and simulating of physical conditions such as closing one of the lanes. Environment simulation may additionally or alternatively include setting a specific flow or sequence of actions as detected as the time of the anomaly (e.g., slower traffic and increased number of people waiting for the transportation to arrive). Environment simulation in such an example can include recording and then replaying the real data from the production systems, by mirroring the real data to the testing environment, and/or by generating synthetic data that may reproduce the production system behavior and the detected anomaly.

[0038] Once the environment is simulated, the anomaly/trend may be accelerated depending on the type of the detected anomaly/trend. In the smart city example, the increased people traffic may be simulated by substituting the camera inputs with new images containing more crowded environment or by modifying the metric of the detected number of people after the processing of the camera inputs is completed, for instance. Figure 5 illustrates an example method 586 for environment simulation. At 588, method 586 may include monitoring data collected from a system in a real environment. The data may be used to learn normal behavior of the system in a real environment. The knowledge of this normal behavior may be used to predict trends, anomalies, etc.

[0039] At 590, method 586 may include detecting anomalies in the data and building predictions based on a trend determined during the monitoring. For instance, comparisons between a normal behavior and a current behavior may be made, predictions may be made based on the comparisons, and anomalies may be detected based on the predictions and comparisons.

[0040] Method 586, at 592 may include simulating a portion of the real environment, such that the at least a portion is relevant to the detected anomalies. At 594, method 586 may include testing a behavior of the real environment in the environment simulation at a time of anomaly detection while accelerating the trend. This may include running a testing scenario that simulates a behavior of the real environment at the time of a detected anomaly while accelerating the trend, for instance. Environment simulation may include deployment of certain applications, devices, services, connectivity, etc.

[0041] Performing accelerated simulations, in some examples, may include simulating a specific scenario and accelerating a determined behavior/trend. For instance, this may include certain application or device states, specific physical conditions, specific flows, specific sequence of actions, etc. In some examples, performing accelerated simulations and/or testing the behavior may include streaming data from the real environment to the environment simulation. The accelerated simulation may allow for issues to be detected in the environment simulation before they would be detected in the real-world environment, allowing for fixes and adaptations to be determined before the issue occurs in the real-world environment.

[0042] At 596, method 586 may include determining a root cause of an abnormal behavior in the environment simulation in response to determining that accelerating the trend caused the abnormal behavior. Fixes can be made based these detected abnormal behaviors, as noted above. Method 586, at 598, may include fixing the abnormal behavior and modifying the portion of the real environment to adapt to the abnormal behavior. For instance, the environment (or portion of) may be modified before the detected anomalies and the detected abnormal behaviors occur. In some examples, the environment (or portion of) may be modified in response to the detected anomalies and/or detected abnormal behaviors occurring in the real environment, in some

instances. For instance, the fix may be available, and when the abnormal behavior occurs in the real environment, the fix may be deployed.

[0043] In the foregoing detailed description of the present disclosure, reference is made to the accompanying drawings that form a part hereof, and in which is shown by way of illustration how examples of the disclosure may be practiced. These examples are described in sufficient detail to enable those of ordinary skill in the art to practice the examples of this disclosure, and it is to be understood that other examples may be utilized and that process, electrical, and/or structural changes may be made without departing from the scope of the present disclosure.

[0044] The figures herein follow a numbering convention in which the first digit corresponds to the drawing figure number and the remaining digits identify an element or component in the drawing. Elements shown in the various figures herein can be added, exchanged, and/or eliminated so as to provide a number of additional examples of the present disclosure. In addition, the proportion and the relative scale of the elements provided in the figures are intended to illustrate the examples of the present disclosure, and should not be taken in a limiting sense. As used herein, "a number of" an element and/or feature can refer to one or more of such elements and/or features.

What is claimed is:

1. A system for environment simulation, comprising:

a simulation engine to build an environment simulation to mimic portions of a real environment relevant to a detected anomaly trend;

an acceleration engine to simulate, within the environment simulation, a scenario associated with the detected anomaly at a rate faster than the scenario occurs in the real environment;

an abnormal behavior engine to detect an abnormal behavior associated with the scenario; and

an adaptation engine to modify a device within the real environment to be adaptive to the scenario, based on the detected abnormal behavior.

2. The system of claim 1, further comprising a monitoring engine to detect an anomaly in the real environment based on predictions created using collected monitoring data.

3. The system of claim 1, further comprising the adaptation engine to modify the device in response to a predicted anomaly occurring in the real environment.

4. The system of claim 1, further comprising the acceleration engine to simulate the scenario associated with the detected anomaly at a more severe level than the scenario occurs in the real environment.

5. The system of claim 1, further comprising the acceleration engine to simulate the scenario associated with the detected anomaly at a more frequent occurrence than the scenario occurs in the real environment.

6. A non-transitory machine-readable medium storing instructions executable by a processor to:

predict a plurality of anomalies within a system using collected monitoring data from a real system environment;

simulate, within an environment simulation, conditions in which the predicted plurality of anomalies occurs;

accelerate the conditions within the environment simulation;

determine a solution to at least one of the predicted plurality of anomalies using information collected during the accelerated conditions; and

modify a device within the system to be adaptive to the at least one of the predicted plurality of anomalies based on the solution.

7. The medium of claim 6, further comprising instructions to determine a temporary solution to the at least one of the predicted plurality of anomalies.

8. The medium of claim 6, further comprising instructions to determine a permanent solution to the at least one of the predicted plurality of anomalies.

9. The medium of claim 6, further comprising instructions executable to simulate the conditions based on trends detected in the real environment using the collected monitoring data.

10. The medium of claim 6, wherein the instructions executable to accelerate the conditions within the environment simulation further comprise instructions executable to:

simulate the conditions at a rate faster than occurs in the real environment;

simulate the conditions at a level more severe than occurs in the real environment; and

simulate the conditions at a more frequent occurrence than in the real environment.

11. A method for environment simulation, comprising:

monitoring data collected from a system in a real environment;

detecting anomalies in the data and building predictions based on a trend determined during the monitoring;

simulating a portion of the real environment, such that the at least a portion is relevant to the detected anomalies;

testing a behavior of the real environment in the environment simulation at a time of anomaly detection while accelerating the trend;

determining a root cause of an abnormal behavior in the environment simulation in response to determining that accelerating the trend caused the abnormal behavior; and

fixing the abnormal behavior and modifying the portion of the real environment to adapt to the abnormal behavior.

12. The method of claim 11, further comprising testing the behavior by streaming data from the real environment to the environment simulation.

13. The method of claim 11, further comprising modifying the portion of the real environment before the detected anomalies and the abnormal behavior occur in the real environment.

14. The method of claim 11, further comprising modifying the portion of the real environment in response to the detected anomalies occurring in the real environment.

15. The method of claim 11, further comprising modifying the portion of the real environment in response to the abnormal behavior occurring in the real environment.

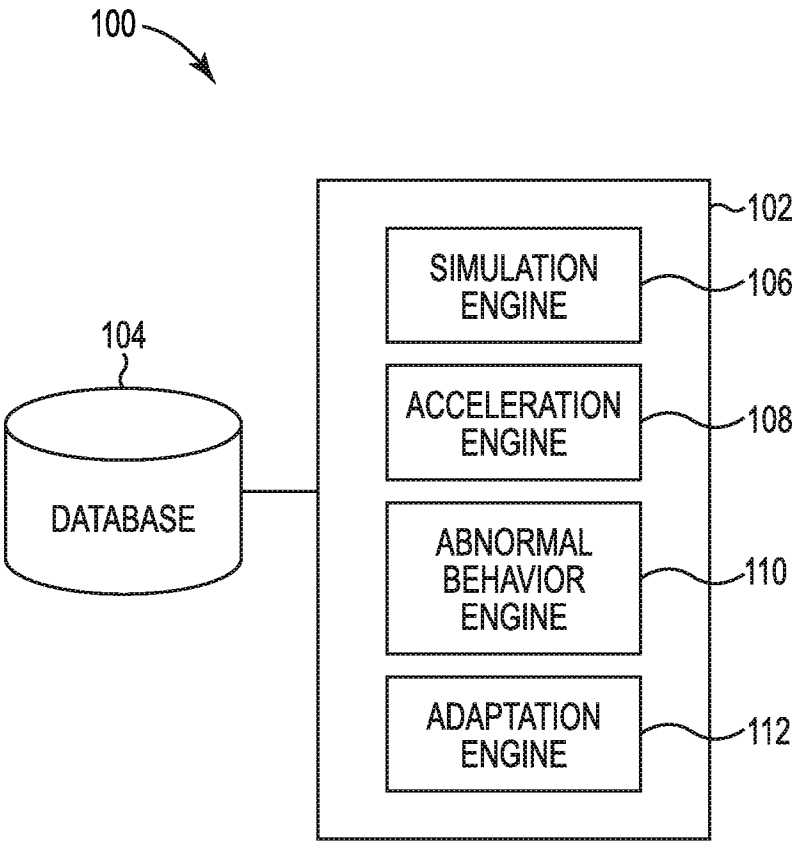
100
102
SIMULATION ENGINE
106
104
ACCELERATION ENGINE
108
DATABASE
ABNORMAL BEHAVIOR ENGINE
110
ADAPTATION ENGINE
112

Fig. 1

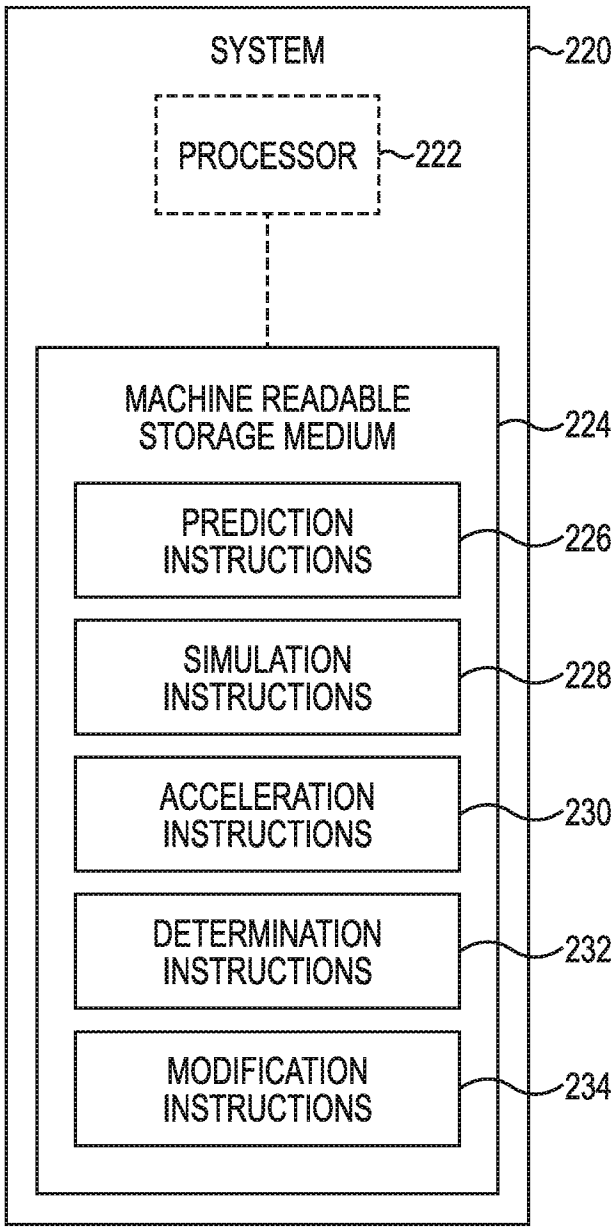
SYSTEM
220
PROCESSOR
222
MACHINE READABLE STORAGE MEDIUM
224
PREDICTION INSTRUCTIONS
226
SIMULATION INSTRUCTIONS
228
ACCELERATION INSTRUCTIONS
230
DETERMINATION INSTRUCTIONS
232
MODIFICATION INSTRUCTIONS
234

Fig. 2

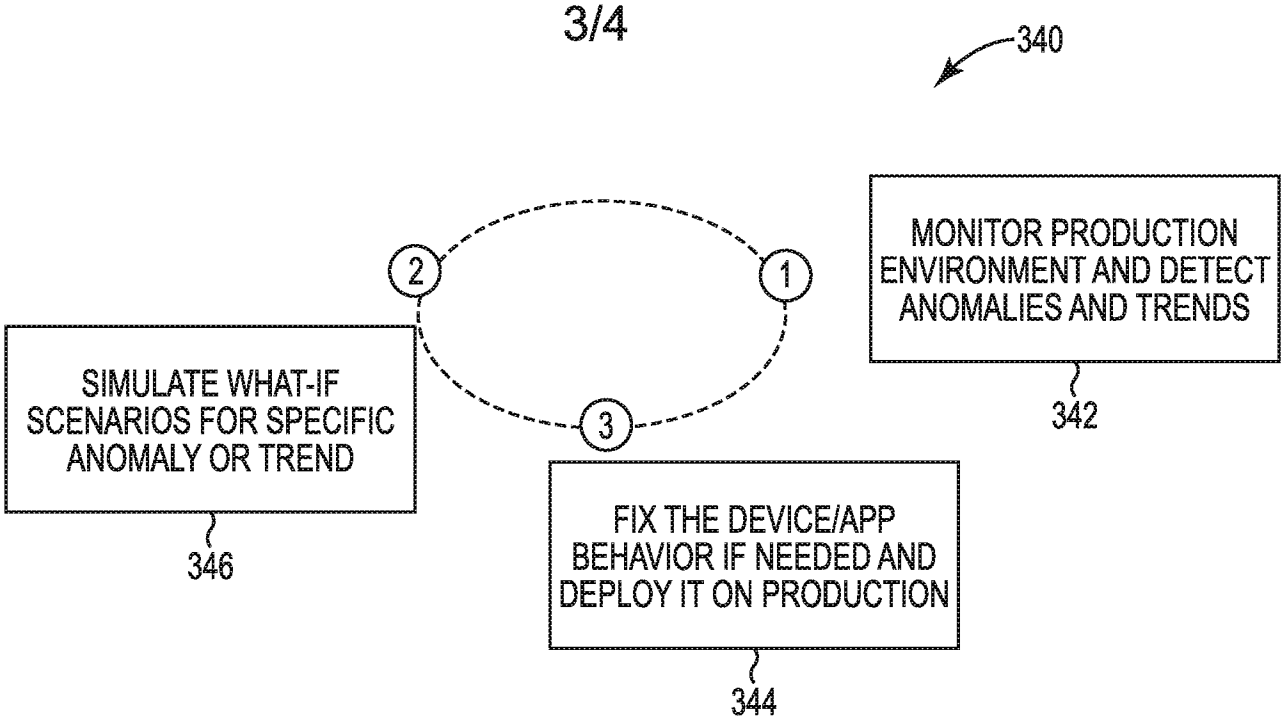
340
MONITOR PRODUCTION ENVIRONMENT AND DETECT ANOMALIES AND TRENDS
342
SIMULATE WHAT-IF SCENARIOS FOR SPECIFIC ANOMALY OR TREND
346
FIX THE DEVICE/APP BEHAVIOR IF NEEDED AND DEPLOY IT ON PRODUCTION
344
1
2
3

Fig. 3

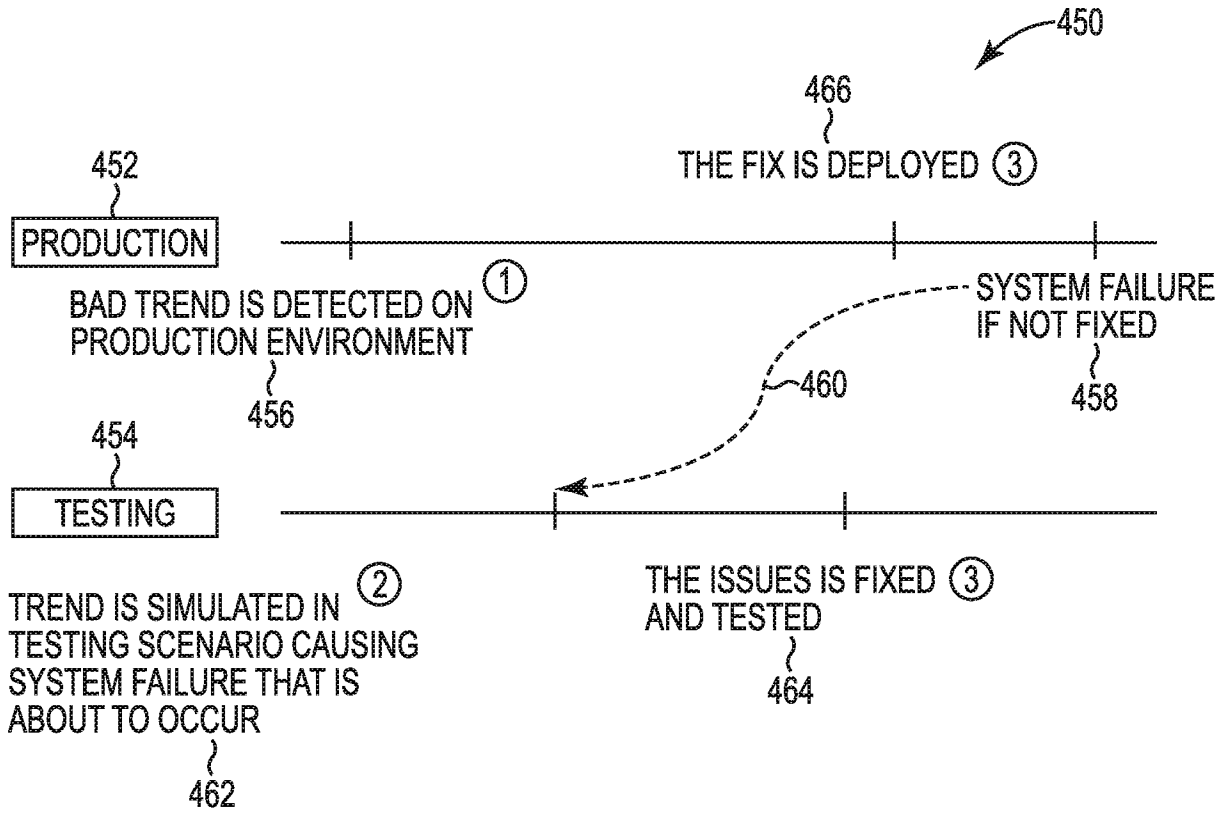
450
466
THE FIX IS DEPLOYED 3
452
PRODUCTION
1
BAD TREND IS DETECTED ON PRODUCTION ENVIRONMENT
456
SYSTEM FAILURE IF NOT FIXED
458
460
454
TESTING
2
TREND IS SIMULATED IN TESTING SCENARIO CAUSING SYSTEM FAILURE THAT IS ABOUT TO OCCUR
462
THE ISSUES IS FIXED 3
AND TESTED
464

Fig. 4

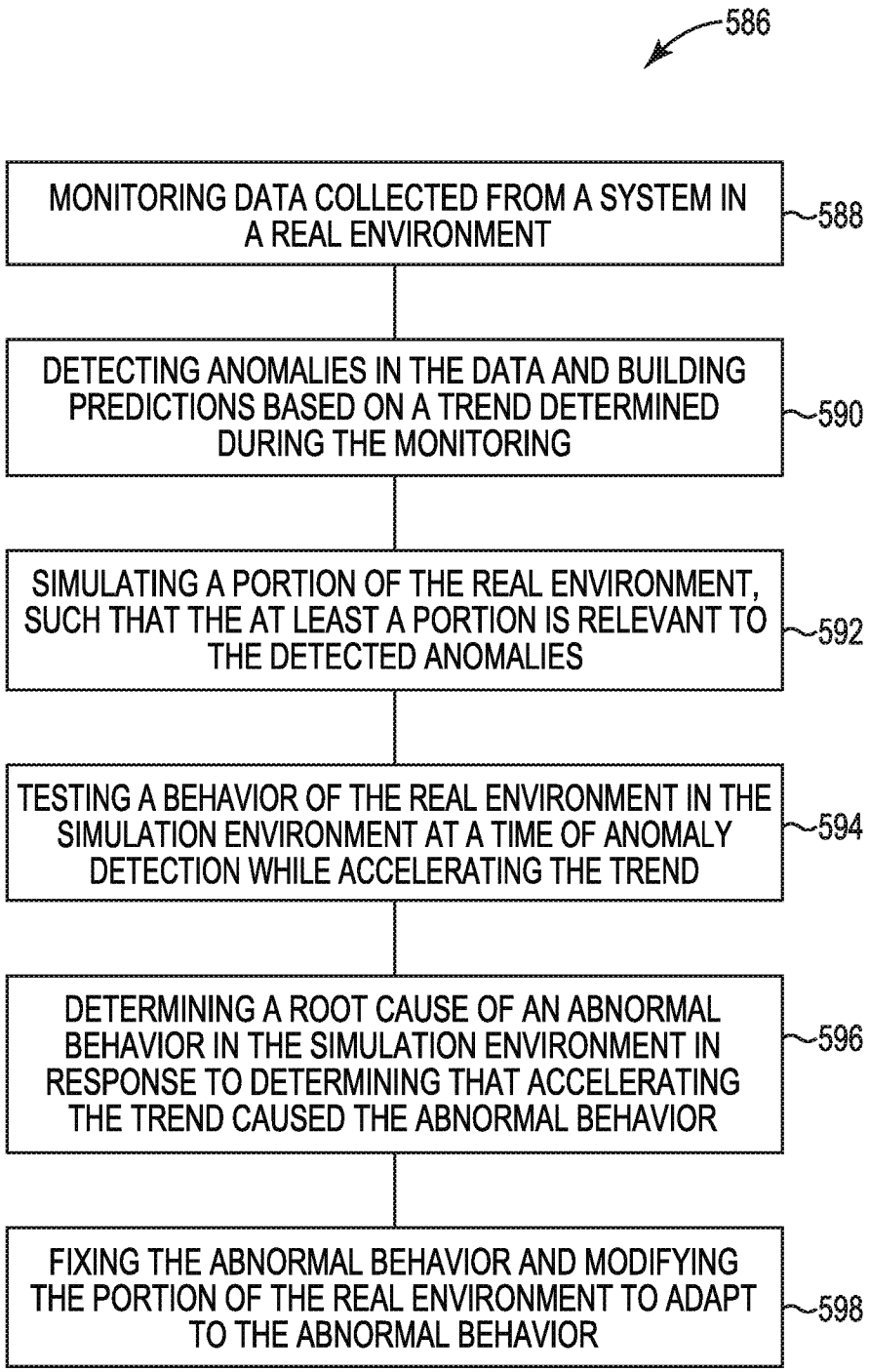
586
MONITORING DATA COLLECTED FROM A SYSTEM IN A REAL ENVIRONMENT
588
DETECTING ANOMALIES IN THE DATA AND BUILDING PREDICTIONS BASED ON A TREND DETERMINED DURING THE MONITORING
590
SIMULATING A PORTION OF THE REAL ENVIRONMENT, SUCH THAT THE AT LEAST A PORTION IS RELEVANT TO THE DETECTED ANOMALIES
592
TESTING A BEHAVIOR OF THE REAL ENVIRONMENT IN THE SIMULATION ENVIRONMENT AT A TIME OF ANOMALY DETECTION WHILE ACCELERATING THE TREND
594
DETERMINING A ROOT CAUSE OF AN ABNORMAL BEHAVIOR IN THE SIMULATION ENVIRONMENT IN RESPONSE TO DETERMINING THAT ACCELERATING THE TREND CAUSED THE ABNORMAL BEHAVIOR
596
FIXING THE ABNORMAL BEHAVIOR AND MODIFYING THE PORTION OF THE REAL ENVIRONMENT TO ADAPT TO THE ABNORMAL BEHAVIOR
598

Fig. 5

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US2016/018260

A. CLASSIFICATION OF SUBJECT MATTER

G06Q 10/06(2012.01)i, G06Q 10/04(2012.01)i, G06Q 50/04(2012.01)i, G06Q 50/30(2012.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
G06Q 10/06; G06G 7/48; H04B 17/00; G01M 13/02; G06F 11/00; G06F 9/45; H04N 17/00; G06Q 10/04; G06Q 50/04; G06Q 50/30

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Korean utility models and applications for utility models
Japanese utility models and applications for utility models

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
eKOMPASS(KIPO internal) & Keywords: real, environment, mimic, simulation, predict, anomaly, acceleration, modify, solution

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y A	US 2010-0192223 A1 (OSMAN ABDOUL ISMAEL et al.) 29 July 2010 See paragraphs [0037],[0080], claims 1,12,25 and figures 1,4.	1-5 6-15
Y	US 2006-0161416 A1 (FRANCESCO TRAMONTANA) 20 July 2006 See claims 1,4,10,12,16,37,52,56 and figures 1-4.	1-15
Y	KR 10-0173214 B1 (LG ELECTRONICS INC.) 15 May 1999 See abstract, page 2, lines 23-30 and claim 1.	1-15
Y	US 2004-0181376 A1 (WYLCI FABLES et al.) 16 September 2004 See paragraphs [0010],[0081], claim 1 and figure 1.	2,6-15
A	KR 10-2010-0080965 A (NAM, JONG CHUL) 14 July 2010 See paragraphs [0001],[0015], claims 1-9 and figure 1.	1-15

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier application or patent but published on or after the international filing date
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"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents,such combination being obvious to a person skilled in the art
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
16 November 2016 (16.11.2016)	**16 November 2016 (16.11.2016)**

Name and mailing address of the ISA/KR
International Application Division
Korean Intellectual Property Office
189 Cheongsa-ro, Seo-gu, Daejeon, 35208, Republic of Korea
Facsimile No. +82-42-481-8578

Authorized officer
KANG, Min Jeong
Telephone No. +82-42-481-8131

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.
PCT/US2016/018260

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