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### Leveraging machine learning to automate capacity reservations for application failover on cloud

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#### Abstract

Embodiments disclosed are directed to a computing system that performs operations for leveraging machine learning to automate capacity reservations for application failover in a cloud-based computing system. The computing system determines a simulated usage capacity of a set of applications executing in a first zone of a cloud-based computing system. The computing system then determines an amount of cloud-based computing instances in a second zone of the cloud-based computing system needed to maintain the simulated usage capacity in an event of a failover of the first zone. Subsequently, the computing system reserves the amount of cloud-based computing instances in the second zone.

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# Background/Summary

## TECHNICAL FIELD

(1) Embodiments relate to entity integration, specifically a system that leverages machine learning to automate capacity reservations for application failover in a cloud-based computing system.

## BACKGROUND

(2) Typically, capacity reservations for cloud-based computing instances are created manually, resulting in many mismatches compared to an enterprise's fleet of cloud-based computing instances. For instance, manual reservations involve the laborious task of altering one reservation at a time, which is subject to human errors and spans multiple days when the enterprise has thousands of reservations in its fleet. This ad-hoc approach is risky to the enterprise and may result in the unavailability of instances during an application failover.

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## Description

### BRIEF DESCRIPTION OF THE DRAWINGS

(1) The accompanying drawings, which are incorporated herein and form a part of the specification, illustrate embodiments of the present disclosure and, together with the description, further serve to explain the principles of the disclosure and to enable a person skilled in the art to make and use the embodiments.

(2) FIG. 1 illustrates an example system for leveraging machine learning to automate capacity reservations for application failover in a cloud-based computing system according to several embodiments.

(3) FIG. 2 illustrates an example method for leveraging machine learning to automate capacity reservations for application failover in a cloud-based computing system according to several embodiments.

(4) FIG. 3 illustrates an example architecture of components implementing an example system for leveraging machine learning to automate capacity reservations for application failover in a cloud-based computing system according to several embodiments.

(5) FIGS. 4A and 4B illustrate portions of an example dashboard generated by an example capacity reservation simulator according to some embodiments.

(6) FIG. 5 illustrates example metrics generated by an example capacity reservation simulator according to some embodiments.

### DETAILED DESCRIPTION

(7) Embodiments disclosed herein relate to systems and methods for entity integration. The systems and methods disclosed herein can achieve dynamic capacity reservations of cloud-based computing instances by utilizing a capacity reservation machine learning (ML) model to automate capacity reservations for application failover in a cloud-based computing system.

(8) In several embodiments, the present disclosure provides for a capacity reservation ML model that uses a capacity reservation linear regression technique to determine the capacity reservations required for application failover on the cloud. The capacity reservation ML model performs the data analysis on the current fleet of cloud-based computing instances, observing the trends of the various instance types in all of the cloud-based accounts and availability zones to make an estimate of the amount of needed capacity reservations. The estimate and other data provided by the capacity reservation ML model is then enriched and fed into an automation workflow to modify and align the capacity reservations.

(9) In one illustrative and non-limiting example, the capacity reservation ML model leverages a capacity reservation service and helps visualize the effects of its modifications against the instances

running over a period of 7 days, 30 days, and 60 days. In practice, the capacity reservation ML model has resulted in expanding the coverage from about 6% to about 80% and improving the utilization of the capacity reservations from about 8% to about 99% for the applications running in the cloud. Additionally, the capacity reservation ML model actively mitigates the risk associated with a potential disaster recovery event while minimizing the cost impacts to the enterprise.

(10) The following embodiments are described in sufficient detail to enable those skilled in the art to make and use the disclosure. It is to be understood that other embodiments are evident based on the present disclosure, and that system, process, or mechanical changes can be made without departing from the scope of an embodiment of the present disclosure.

(11) In the following description, numerous specific details are given to provide a thorough understanding of the disclosure. However, it will be apparent that the disclosure can be practiced without these specific details. In order to avoid obscuring an embodiment of the present disclosure, some circuits, system configurations, architectures, and process steps are not disclosed in detail.

(12) The drawings showing embodiments of the system are semi-diagrammatic, and not to scale. Some of the dimensions are for the clarity of presentation and are shown exaggerated in the drawing figures. Similarly, although the views in the drawings are for ease of description and generally show similar orientations, this depiction in the figures is arbitrary for the most part. Generally, the disclosure can be operated in any orientation.

(13) The term “module” or “unit” referred to herein can include software, hardware, or a combination thereof in an embodiment of the present disclosure in accordance with the context in which the term is used. For example, the software can be machine code, firmware, embedded code, or application software. Also for example, the hardware can be circuitry, a processor, a special purpose computer, an integrated circuit, integrated circuit cores, or a combination thereof. Further, if a module or unit is written in the system or apparatus claim section below, the module or unit is deemed to include hardware circuitry for the purposes and the scope of the system or apparatus claims.

(14) The term “service” or “services” referred to herein can include a collection of modules or units. A collection of modules or units can be arranged, for example, in software or hardware libraries or development kits in embodiments of the present disclosure in accordance with the context in which the term is used. For example, the software or hardware libraries and development kits can be a suite of data and programming code, for example pre-written code, classes, routines, procedures, scripts, configuration data, or a combination thereof, that can be called directly or through an application programming interface (API) to facilitate the execution of functions of the system.

(15) The modules, units, or services in the following description of the embodiments can be coupled to one another as described or as shown. The coupling can be direct or indirect, without or with intervening items between coupled modules, units, or services. The coupling can be by physical contact or by communication between modules, units, or services.

(16) FIG. 1 shows a system **100** for entity integration according to some embodiments. In several embodiments, system **100** can include a client device **110** associated with a user **102**, a client device **160** associated with a user **104**, a network **120**, a cloud server **130**, a first zone **140** including cloud-based computing instances **184** for executing applications **142** and applications **144**, and a second zone **150** including cloud-based computing instances **186** and cloud-based computing instances **188** for executing applications **152** and applications **154**. In several embodiments, the client device **110** can further include an application **112** which, in several embodiments, includes an authentication module **114** having access to a plurality of device attributes stored on, or in association with, the client device **110**. In several embodiments, the client device **160** can further include an application **162** which, in several embodiments, includes an authentication module **164** having access to a plurality of device attributes stored on, or in association with, the client device **160**. In several embodiments, the cloud server **130** can further include an authentication service

**132**, a capacity reservation simulator **134**, and a capacity reservation ML model **136**.

(17) The client device **110** and the client device **160** can be any of a variety of centralized or decentralized computing devices. For example, one or both of the client device **110** and the client device **160** can be a mobile device, a laptop computer, a desktop computer, or a point-of-sale (POS) device. In several embodiments, one or both of the client device **110** and the client device **160** can function as a stand-alone device separate from other devices of the system **100**. The term “stand-alone” can refer to a device being able to work and operate independently of other devices. In several embodiments, the client device **110** and the client device **160** can store and execute the application **112** and the application **162**, respectively.

(18) Each of the application **112** and the application **162** can refer to a discrete software that provides some specific functionality. For example, the application **112** can be a mobile application that allows the user **102** to perform some functionality, whereas the application **162** can be a mobile application that allows the user **104** to perform some functionality. The functionality can, for example and without limitation, allow the user **102**, the user **104**, or both to perform cloud-based application management operations (e.g., dynamically reserving cloud-based computing instances), banking, data transfers, or commercial transactions. In other embodiments, one or more of the application **112** and the application **162** can be a desktop application that allows the user **102** or the user **104** to perform these functionalities.

(19) In several embodiments, the client device **110** and the client device **160** can be coupled to the cloud server **130** via a network **120**. The cloud server **130** can be part of a backend computing infrastructure, including a server infrastructure of a company or institution, to which the application **112** and the application **162** belong. Although the cloud server **130** is described and shown as a single component in FIG. 1, in some embodiments, the cloud server **130** can comprise a variety of centralized or decentralized computing devices. For example, the cloud server **130** can include a mobile device, a laptop computer, a desktop computer, grid-computing resources, a virtualized computing resource, cloud computing resources, cloud-computing instances, peer-to-peer distributed computing devices, a server farm, or a combination thereof. The cloud server **130** can be centralized in a single room, distributed across different rooms, distributed across different geographical locations, or embedded within the network **120**. While the devices comprising the cloud server **130** can couple with the network **120** to communicate with the client device **110** and the client device **160**, the devices of the cloud server **130** can also function as stand-alone devices separate from other devices of the system **100**.

(20) In several embodiments, if the cloud server **130** can be implemented using cloud computing resources of a public or private cloud-based computing system or “cloud.” Examples of a public cloud include, without limitation, Amazon Web Services (AWS)<sup>™</sup>, IBM Cloud<sup>™</sup>, Oracle Cloud Solutions<sup>™</sup>, Microsoft Azure Cloud<sup>™</sup>, and Google Cloud<sup>™</sup>. A private cloud refers to a cloud environment similar to a public cloud with the exception that it is operated solely for a single organization.

(21) In several embodiments, the cloud server **130** can couple to the client device **110** to allow the application **112** to function. For example, in several embodiments, both the client device **110** and the cloud server **130** can have at least a portion of the application **112** installed thereon as instructions on a non-transitory computer readable medium. The client device **110** and the cloud server **130** can both execute portions of the application **112** using client-server architectures, to allow the application **112** to function.

(22) In several embodiments, the cloud server **130** can couple to the client device **160** to allow the application **162** to function. For example, in several embodiments, both the client device **160** and the cloud server **130** can have at least a portion of the application **162** installed thereon as instructions on a non-transitory computer readable medium. The client device **160** and the cloud server **130** can both execute portions of the application **162** using client-server architectures, to allow the application **162** to function.

(23) In several embodiments, the cloud server **130** can transmit requests and other data to, and receive requests, indications, device attributes, and other data from, the authentication module **114** and the authentication module **164** (and in effect the client device **110** and the client device **160**, respectively) via the network **120**. The network **120** refers to a telecommunications network, such as a wired or wireless network. The network **120** can span and represent a variety of networks and network topologies. For example, the network **120** can include wireless communications, wired communications, optical communications, ultrasonic communications, or a combination thereof. For example, satellite communications, cellular communications, Bluetooth, Infrared Data Association standard (IrDA), wireless fidelity (Wi-Fi), and worldwide interoperability for microwave access (WiMAX) are examples of wireless communications that can be included in the network **120**. Cable, Ethernet, digital subscriber line (DSL), fiber optic lines, fiber to the home (FTTH), and plain old telephone service (POTS) are examples of wired communications that can be included in the network **120**. Further, the network **120** can traverse a number of topologies and distances. For example, the network **120** can include a direct connection, personal area network (PAN), local area network (LAN), metropolitan area network (MAN), wide area network (WAN), or a combination thereof. For illustrative purposes, in the embodiment of FIG. **1**, the system **100** is shown with the client device **110**, the client device **160**, and the cloud server **130** as end points of the network **120**. This, however, is an example and it is to be understood that the system **100** can have a different partition between the client device **110**, the client device **160**, the cloud server **130**, and the network **120**. For example, the client device **110**, the client device **160**, and the cloud server **130** can also function as part of the network **120**.

(24) In several embodiments, the client device **110** and the client device **160** can include at least the authentication module **114** and the authentication module **164**, respectively. In several embodiments, each of the authentication module **114** and the authentication module **164** can be a module of the application **112** and the application **162**, respectively. In several embodiments, the authentication module **114** and the authentication module **164** can enable the client device **110** and the client device **160**, respectively, and/or the application **112** and the application **162**, respectively, to receive requests and other data from, and transmit requests, device attributes, indications, and other data to, the authentication service **132**, the capacity reservation simulator **134**, the capacity reservation ML model **136**, and/or the cloud server **130** via the network **120**. In several embodiments, this can be done by having the authentication module **114** and the authentication module **164** couple to the authentication service **132** via an API to transmit and receive data as a variable or parameter.

(25) In several embodiments, the cloud server **130** can include at least the authentication service **132**, the capacity reservation simulator **134**, and the capacity reservation ML model **136**. In several embodiments, each of the authentication service **132**, the capacity reservation simulator **134**, and the capacity reservation ML model **136** can be implemented as a software application on the cloud server **130**. In several embodiments, the authentication service **132** can enable receipt of electronic information (e.g., device attributes, online account properties) from the authentication module **114** and the authentication module **164**. This can be done, for example, by having the authentication service **132** couple to the authentication module **114** and the authentication module **164** via a respective API to receive the electronic information as a variable or parameter. In several embodiments, the authentication service **132** can further enable storage of the electronic information in a local storage device or transmission (e.g., directly, or indirectly via the network **120**) of the electronic information to the first zone **140**, the second zone **150**, or both for storage and retrieval.

(26) The first zone **140** of the cloud-based computing system can be a first zone (e.g., availability zone, local zone, wavelength zone, outpost, etc.) having cloud-based computing instances **184** located in a first region (e.g., a geographic region such as the U.S. Eastern region). The cloud server **130** can launch cloud-based computing instances **184** in the first zone **140** to provide for the

execution of applications **142** and applications **144**.

(27) The second zone **150** of the cloud-based computing system can be a second zone (e.g., a different availability zone, local zone, wavelength zone, outpost, etc.) having cloud-based computing instances **184** and cloud-based computing instances **186** located in a second region (e.g., a different geographic region such as the U.S. Western region). The second zone **150** may not overlap geographically with any portion of the first zone **140**. The cloud server **130** can reserve cloud-based computing instances **186** in the second zone **150** to provide for the execution of applications **152** and applications **154** in the event of a failover of the first zone **140**. For example, applications **142** can be executing on the cloud-based computing instances **184** in the first zone **140**, and, if the cloud-based computing instances **184** fail, the cloud-based computing instances **186** in the second zone **150** can handle requests for the applications **142** (e.g., the applications **142** can, in effect, become the applications **152** executing on the cloud-based computing instances **184** in the second zone **150**).

(28) In several embodiments, the capacity reservation ML model **136** can use a capacity reservation linear regression technique to determine the capacity reservations required for application failover on the cloud. The capacity reservation ML model **136** can perform the data analysis on the current fleet of cloud-based computing instances, observing the trends of the various instance types in all of the cloud-based accounts and availability zones to estimate the amount of capacity reservations needed to protect the system **100** from the impact of a catastrophic failure, such as a power loss, within the first zone **140**. The capacity reservation simulator **134** can enrich the estimate and other data provided by the capacity reservation ML model **136** and feed that data into an automation workflow to modify and align the capacity reservations. Additionally, the capacity reservation simulator **134** can leverage a capacity reservation service of the cloud-based computing system and generate visualizations that illustrate the effects of modifications against the cloud-based computing instances **184** running in the first zone **140** over a period of 7 days, 30 days, and 60 days.

(29) In a variety of embodiments, the cloud server **130**, using the capacity reservation simulator **134** and the capacity reservation ML model **136**, can provide for leveraging machine learning to automate capacity reservations for application failover in the cloud-based computing system (e.g., AWS™, IBM Cloud™, Oracle Cloud Solutions™, Microsoft Azure Cloud™, Google Cloud™, etc.).

(30) In one illustrative example, the capacity reservation simulator **134** begins by determining (e.g., using the capacity reservation ML model **136**) a simulated usage capacity of the applications **142** executed in the first zone **140** of the cloud-based computing system. In one example, to determine the simulated usage capacity, the capacity reservation simulator **134** determines an amount of cloud-based computing instances **184** used by the applications **142** in the first zone **140** over predetermined durations of time (e.g., last hour, day, week, month, year, etc.). The capacity reservation simulator **134** then determines a set of instance types, a set of computing platforms, and a set of availability zones (e.g., multiple availability zones in one or more regions different from the first region associated with the first zone **140**) of the amount of cloud-based computing instances **184**. Subsequently, the capacity reservation simulator **134** determines (e.g., using the capacity reservation ML model **136**) the simulated usage capacity based on the amount of cloud-based computing instances **184**, the set of instance types, the set of computing platforms, and the set of availability zones.

(31) Continuing the example, the capacity reservation simulator **134** determines (e.g., using the capacity reservation ML model **136**) an amount of cloud-based computing instances **186** in the second zone **150** of the cloud-based computing system needed to maintain the simulated usage capacity in the event of a failover of the first zone **140**. Subsequently, the cloud server **130** reserves the amount of cloud-based computing instances **186** in the second zone **150**. For example, to reserve the amount of cloud-based computing instances **186**, the cloud server **130** generates a

capacity reservation request to reserve the amount of cloud-based computing instances **186** in the second zone **150** and transmits the request to a capacity reservation service of the cloud-based computing system.

(32) In several embodiments, the capacity reservation simulator **134** determines (e.g., using the capacity reservation ML model **136**) the simulated usage capacity of the applications **142** executing in the first zone **140** at a first time. The capacity reservation simulator **134** also determines (e.g., using the capacity reservation ML model **136**) a second simulated usage capacity of the applications **144** executing in the first zone **140** at a second time later than the first time. The capacity reservation simulator **134** then determines (e.g., using the capacity reservation ML model **136**) an amount of cloud-based computing instances **188** in the second zone **150** needed to maintain the first simulated usage capacity and the second simulated usage capacity in the event of the failover of the first zone **140**. The amount of cloud-based computing instances **188** can be less than the amount of cloud-based computing instances **186**. Subsequently, the cloud server **130** reserves the second amount of cloud-based computing instances **188** in the second zone **150**.

(33) In some aspects, system **100** described above significantly improves the state of the art from previous systems because it provides enhanced techniques for leveraging machine learning to automate capacity reservations for application failover in a cloud-based computing system. As a result, the amount of capacity reservations for application failover can be reduced substantially to more closely resemble the amount that is likely to be needed, substantially eliminating the reservation costs associated with unused reservations. Additionally, these capacity reservations are created automatically using machine learning techniques, resulting in fewer mismatches compared to an enterprise's fleet of cloud-based computing instances and reducing the errors, time, and system labor associated with altering thousands of capacity reservations at a time.

(34) FIG. 2 illustrates a method **200** of operating the system **100** to provide for leveraging machine learning to automate capacity reservations for application failover in a cloud-based computing system according to some embodiments. For example, method **200** indicates how the cloud server **130** operates (e.g., using the capacity reservation simulator **134** and the capacity reservation ML model **136**). The cloud-based computing system can include, for example, AWS™, IBM Cloud™, Oracle Cloud Solutions™, Microsoft Azure Cloud™, Google Cloud™, any other suitable public or private cloud-based computing system, or any combination thereof.

(35) In several embodiments, operation **202** operates to allow the cloud server **130** to determine a simulated usage capacity of a set of applications (e.g., applications **142**) executed in a first zone **140** of a cloud-based computing system. In several embodiments, to determine the simulated usage capacity at operation **202**, the cloud server **130** can determine an amount of cloud-based computing instances **184** used by the set of applications in the first zone over a plurality of predetermined durations of time. The cloud server **130** can further determine a set of instance types of the amount of cloud-based computing instances **184**. The cloud server **130** can further determine a set of computing platforms of the amount of cloud-based computing instances **184**. The cloud server **130** can further determine a set of availability zones of the amount of cloud-based computing instances **184**. The cloud server **130** can further determine the simulated usage capacity based on the amount of cloud-based computing instances **184**, the set of instance types, the set of computing platforms, and the set of availability zones.

(36) In several embodiments, operation **204** operates to allow the cloud server **130** to determine an amount of cloud-based computing instances **186** in a second zone **150** of the cloud-based computing system needed to maintain the simulated usage capacity in an event of a failover of the first zone **140**. In several embodiments, the first zone **140** can be distributed across a first geographic region (e.g., U.S. East (Northern Virginia) region “us-east-1”), and the second zone **150** can be distributed across a second geographic region (e.g., U.S. West (Northern California) region “us-west-1”) different from the first geographic region.

(37) In several embodiments, operation **206** operates to allow the cloud server **130** to reserve the



amount of cloud-based computing instances **186** in the second zone **150**. In several embodiments, to reserve the amount of cloud-based computing instances **186**, the cloud server **130** can generate a capacity reservation request to reserve the amount of cloud-based computing instances **186** in the second zone **150** and transmit the request to a capacity reservation service of the cloud-based computing system.

(38) Optionally, in several embodiments, the set of applications can be a first set of applications, the simulated usage capacity can be a first simulated usage capacity, and to determine the first simulated usage capacity at operation **202**, the cloud server **130** can determine the first simulated usage capacity of the first set of applications executing in the first zone **140** at a first time. One or more optional operations can operate to allow the cloud server **130** to determine a second simulated usage capacity of a second set of applications (e.g., applications **144**) executing in the first zone **140** at a second time later than the first time. The cloud server **130** can further determine an amount of cloud-based computing instances **188** in the second zone **150** needed to maintain the first simulated usage capacity and the second simulated usage capacity in the event of the failover of the first zone **140**. Subsequently, the cloud server **130** can reserve the second amount of cloud-based computing instances **188** in the second zone **150**. In several embodiments, the amount of cloud-based computing instances **188** can be less than the amount of cloud-based computing instances **186**.

(39) FIG. **3** is an architecture **300** of components implementing the system **100** according to some embodiments. The components can be implemented by any of the devices described with reference to the system **100**, such as the client device **110**, the client device **160**, the cloud server **130**, the first zone **140**, the second zone **150**, or a combination thereof. The components can be further implemented by any of the devices, structures, or functional units described with reference to the method **200**.

(40) In several embodiments, the components can include a control unit **302**, a storage unit **306**, a communication unit **316**, and a user interface **312**. The control unit **302** can include a control interface **304**. The control unit **302** can execute a software **310** (e.g., the application **112**, the authentication module **114**, the application **162**, the authentication module **164**, the authentication service **132**, or a combination thereof) to provide some or all of the machine intelligence described with reference to system **100**. In another example, the control unit **302** can execute a software **310** to provide some or all of the machine intelligence described with reference to method **200**.

(41) The control unit **302** can be implemented in a number of different ways. For example, the control unit **302** can be, or include, a processor, an application specific integrated circuit (ASIC), an embedded processor, a microprocessor, a hardware control logic, a hardware finite state machine (FSM), a digital signal processor (DSP), a field programmable gate array (FPGA), or a combination thereof.

(42) The control interface **304** can be used for communication between the control unit **302** and other functional units or devices of system **100** (e.g., the client device **110**, the client device **160**, the cloud server **130**, the first zone **140**, the second zone **150**, or a combination thereof). The control interface **304** can also be used for communication that is external to the functional units or devices of system **100**. The control interface **304** can receive information from the functional units or devices of system **100**, or from remote devices **320**, or can transmit information to the functional units or devices of system **100**, or to remote devices **320**. The remote devices **320** refer to units or devices external to system **100**.

(43) The control interface **304** can be implemented in different ways and can include different implementations depending on which functional units or devices of system **100** or remote devices **320** are being interfaced with the control unit **302**. For example, the control interface **304** can be implemented with a pressure sensor, an inertial sensor, a microelectromechanical system (MEMS), optical circuitry, waveguides, wireless circuitry, wireline circuitry to attach to a bus, an application programming interface, or a combination thereof. The control interface **304** can be connected to a

communication infrastructure **322**, such as a bus, to interface with the functional units or devices of system **100** or remote devices **320**.

(44) The storage unit **306** can store the software **310**. For illustrative purposes, the storage unit **306** is shown as a single element, although it is understood that the storage unit **306** can be a distribution of storage elements. Also for illustrative purposes, the storage unit **306** is shown as a single hierarchy storage system, although it is understood that the storage unit **306** can be in a different configuration. For example, the storage unit **306** can be formed with different storage technologies forming a memory hierarchical system including different levels of caching, main memory, rotating media, or off-line storage. The storage unit **306** can be a volatile memory, a nonvolatile memory, an internal memory, an external memory, or a combination thereof. For example, the storage unit **306** can be a nonvolatile storage such as nonvolatile random access memory (NVRAM), Flash memory, disk storage, or a volatile storage such as static random access memory (SRAM) or dynamic random access memory (DRAM).

(45) The storage unit **306** can include a storage interface **308**. The storage interface **308** can be used for communication between the storage unit **306** and other functional units or devices of system **100**. The storage interface **308** can also be used for communication that is external to system **100**. The storage interface **308** can receive information from the other functional units or devices of system **100**, or from remote devices **320**, or can transmit information to the other functional units or devices of system **100** or to remote devices **320**. The storage interface **308** can include different implementations depending on which functional units or devices of system **100** or remote devices **320** are being interfaced with the storage unit **306**. The storage interface **308** can be implemented with technologies and techniques similar to the implementation of the control interface **304**.

(46) The communication unit **316** can enable communication to devices, components, modules, or units of system **100** or remote devices **320**. For example, the communication unit **316** can permit the system **100** to communicate between the client device **110**, the client device **160**, the cloud server **130**, the first zone **140**, the second zone **150**, or a combination thereof. The communication unit **316** can further permit the devices of system **100** to communicate with remote devices **320** such as an attachment, a peripheral device, or a combination thereof through the network **120**.

(47) As previously indicated, the network **120** can span and represent a variety of networks and network topologies. For example, the network **120** can include wireless communication, wired communication, optical communication, ultrasonic communication, or a combination thereof. For example, satellite communication, cellular communication, Bluetooth, IrDA, Wi-Fi, and WiMAX are examples of wireless communication that can be included in the network **120**. Cable, Ethernet, DSL, fiber optic lines, FTTH, and POTS are examples of wired communication that can be included in the network **120**. Further, the network **120** can traverse a number of network topologies and distances. For example, the network **120** can include direct connection, PAN, LAN, MAN, WAN, or a combination thereof.

(48) The communication unit **316** can also function as a communication hub allowing system **100** to function as part of the network **120** and not be limited to be an end point or terminal unit to the network **120**. The communication unit **316** can include active and passive components, such as microelectronics or an antenna, for interaction with the network **120**.

(49) The communication unit **316** can include a communication interface **318**. The communication interface **318** can be used for communication between the communication unit **316** and other functional units or devices of system **100** or to remote devices **320**. The communication interface **318** can receive information from the functional units or devices of system **100** or from the remote devices **320**, transmit information to the other functional units or devices of the system **100** or to remote devices **320**, or both. The communication interface **318** can include different implementations depending on which functional units or devices are being interfaced with the communication unit **316**. The communication interface **318** can be implemented with technologies and techniques similar to the implementation of the control interface **304**.

(50) The user interface **312** can present information generated by system **100**. In several embodiments, the user interface **312** allows a user to interface with the devices of system **100** or remote devices **320**. The user interface **312** can include an input device and an output device. Examples of the input device of the user interface **312** can include a keypad, buttons, switches, touchpads, soft-keys, a keyboard, a mouse, or any combination thereof to provide data and communication inputs. Examples of the output device can include a display interface **314**. The control unit **302** can operate the user interface **312** to present information generated by system **100**. The control unit **302** can also execute the software **310** to present information generated by system **100**, or to control other functional units of system **100**. The display interface **314** can be any graphical user interface such as a display, a projector, a video screen, or any combination thereof.

(51) Having described some example embodiments in general terms, the following example embodiments are provided to further illustrate an example use case of some example embodiments. In some instances, the following example embodiments provide examples of how the systems disclosed herein may leverage machine learning to automatically reserve cloud-based computing instances in a cloud-based computing system for use in the event of application failover.

(52) “On-demand capacity reservations (ODCR) simulator” is an illustrative example use case wherein the systems disclosed herein use an ODCR linear regression ML technique to determine the ODCRs required for application failover in AWS™. ODCR is a service offered by AWS™ to reserve compute capacity for Amazon elastic compute cloud (EC2) instances in a specific availability zone for any duration, ensuring the availability of the instances whenever it is needed.

(53) The ODCR simulator can utilize an ODCR ML model to perform the data analysis on an enterprise's current EC2 fleet, observing the trends of the various EC2 instance types in all of the AWS virtual private cloud (VPC) accounts and availability zones to estimate the amount of ODCRs needed to protect the system from the impact of a catastrophic failure, such as a power loss, within any of those availability zones or their regions. The ODCR simulator can enrich the estimate and other data provided by the ODCR ML model and feed that data into an automation workflow to modify and align the ODCRs. In one example, the ODCR simulator can determine a set of instance types (e.g., EC2 instance types such as Mac, T4g, T3, T3a, T2, M6g, M6i, M5, M5a, M5n, M5zn, M4, A1, C6g, C6gn, C5, C5a, C5n, C4, R6g, R5, R5a, R5b, R5n, R4, X2gd, X1e, X1, high memory, z1d, P4, P3, P2, Inf1, G4dn, G4ad, G3, F1, VT1, I3, I3en, D2, D3, D3en, H1, etc.), a set of computing platforms (e.g., Amazon Linux, Ubuntu, Windows Server, Red Hat Enterprise Linux, SUSE Linux Enterprise Server, openSUSE Leap, Fedora, Fedora CoreOS, Debian, CentOS, Gentoo Linux, Oracle Linux, and FreeBSD, etc.), and a set of availability zones of the amount of cloud-based computing instances. The ODCR simulator can then determine a simulated usage capacity based on the amount of cloud-based computing instances, the set of instance types, the set of computing platforms, and the set of availability zones.

(54) FIGS. **4A** and **4B** illustrate example ODCR simulator dashboard **400** produced by an example ODCR simulator. As shown in FIGS. **4A** and **4B**, the example ODCR simulator dashboard **400** provides visualizations that illustrate the effects of ODCR modifications against multiple EC2 instance types. As shown in FIG. **4B**, the ODCR simulator has resulted in expanding the current simulated ODCR coverage about 75.4% and improving the current simulated ODCR utilization to 99.07%.

(55) FIG. **5** includes a chart **500** that illustrates example coverage and utilization metrics generated by the example ODCR simulator. As shown in FIG. **5**, the ODCR simulator, using the ODCR ML model, has produced a trend of increasing utilization, coverage, and savings since it began simulating and automating ODCRs in about Month 1. For instance, the chart **500** shows that the ODCR simulator, using the ODCR ML model, has resulted in expanding the coverage from about 7% in Month 1 to about 98% in Month 8 and improving the utilization of the ODCRs from about 2% in Month 1 to about 93% in Month 8 for the applications running in AWS™.

(56) The above detailed description and embodiments of the disclosed systems and methods are not

intended to be exhaustive or to limit the disclosed systems or methods to the precise form disclosed above. For instance, while specific examples for the system **100** are described above for illustrative purposes, various equivalent modifications are possible within the scope of the system **100**, as those skilled in the relevant art will recognize. Additionally, while processes and methods are presented in a given order, alternative implementations can perform routines having steps, or employ systems having processes or methods, in a different order, and some processes or methods can be deleted, moved, added, subdivided, combined, or modified to provide alternative or sub-combinations. Each of these processes or methods can be implemented in a variety of different ways. Also, while processes or methods are at times shown as being performed in series, these processes or blocks can instead be performed or implemented in parallel, or can be performed at different times.

(57) The embodiments of the present disclosure, such as the system **100**, are cost-effective, highly versatile, and accurate, and can be implemented by adapting components for ready, efficient, and economical manufacturing, application, and utilization. Another important aspect of the embodiments of the present disclosure is that they valuably support and service the trend of reducing costs, simplifying systems, and/or increasing system performance.

(58) These and other valuable aspects of the embodiments of the present disclosure consequently further the state of the technology to at least the next level. While the disclosed embodiments have been described as the best mode of implementing the system **100**, it is to be understood that many alternatives, modifications, and variations will be apparent to those skilled in the art in light of the descriptions herein. Accordingly, it is intended to embrace all such alternatives, modifications, and variations that fall within the scope of the included claims. All matters set forth herein or shown in the accompanying drawings are to be interpreted in an illustrative and non-limiting sense.

Accordingly, the disclosure is not to be restricted except in light of the attached claims and their equivalents.

## Claims

1. A computer-implemented method for adaptive reserving of computing instances in a cloud-based computing system, the computer-implemented method comprising: determining, by one or more computing devices, a first simulated usage capacity of a first set of applications executing in a first zone of the cloud-based computing system at an initial time using a machine learning model; determining, by the one or more computing devices, a first amount of cloud-based computing instances in a second zone of the cloud-based computing system needed to maintain the first simulated usage capacity in an event of a failover of the first zone; determining, by the one or more computing devices, a second simulated usage capacity of a second set of applications executing in the first zone at a later time than the initial time using the machine learning model, wherein the second set of applications is different from the first set of applications; determining, by the one or more computing devices, a second amount of cloud-based computing instances in the second zone needed to maintain the first and second simulated usage capacities in the event of a failover of the first zone; reserving, by the one or more computing devices, the second amount of cloud-based computing instances in the second zone when the second amount is less than the first amount; and dynamically modifying the reserved second amount of cloud-based computing instances in the second zone when the reserved amount does not align with current data trends continuously provided from the machine learning model.

2. The computer-implemented method of claim 1, wherein the reserving comprises generating, by the one or more computing devices, a capacity reservation request to reserve the second amount of cloud-based computing instances in the second zone.

3. The computer-implemented method of claim 2, wherein the reserving further comprises transmitting, by the one or more computing devices, the request to a capacity reservation service of

the cloud-based computing system.

4. The computer-implemented method of claim 1, wherein: the first zone is distributed across a first geographic region; and the second zone is distributed across a second geographic region different from the first geographic region.

5. The computer-implemented method of claim 1, wherein further comprising: reserving, by the one or more computing devices, the first amount of cloud-based computing instances in the second zone.

6. A non-transitory computer readable medium including instructions for causing a processor to perform operations for adaptive reserving of computing instances in a cloud-based computing system, the operations comprising: determining a first simulated usage capacity of a first set of applications executing in a first zone of the cloud-based computing system at an initial time using a machine learning model; determining a first amount of cloud-based computing instances in a second zone of the cloud-based computing system needed to maintain the first simulated usage capacity in an event of a failover of the first zone; determining a second simulated usage capacity of a second set of applications executing in the first zone at a later time than the initial time using the machine learning model, wherein the second set of applications is different from the first set of applications; determining a second amount of cloud-based computing instances in the second zone needed to maintain the first and second simulated usage capacities in the event of a failover of the first zone; reserving the second amount of cloud-based computing instances in the second zone when the second amount is less than the first amount; and dynamically modifying the reserved second amount of cloud-based computing instances in the second zone when the reserved amount does not align with current data trends continuously provided from the machine learning model.

7. The non-transitory computer readable medium of claim 6, wherein to perform the reserving, the operations comprise generating a capacity reservation request to reserve the second amount of cloud-based computing instances in the second zone.

8. The non-transitory computer readable medium of claim 6, wherein to perform the reserving, the operations further comprise transmitting the request to a capacity reservation service of the cloud-based computing system.

9. The non-transitory computer readable medium of claim 6, wherein: the first zone is distributed across a first geographic region; and the second zone is distributed across a second geographic region different from the first geographic region.

10. The non-transitory computer readable medium of claim 6, further comprising: reserving the first amount of cloud-based computing instances in the second zone.

11. A computing system for adaptive reserving of computing instances in a cloud-based computing system, comprising: one or more memories; at least one processor coupled to the one or more memories and configured to perform operations comprising: determining a first simulated usage capacity of a first set of applications executed in a first zone of the cloud-based computing system at an initial time using a machine learning model; determining a first amount of cloud-based computing instances in a second zone of the cloud-based computing system needed to maintain the first simulated usage capacity in an event of a failover of the first zone; determining a second simulated usage capacity of a second set of applications executing in the first zone at a later time than the initial time using the machine learning model, wherein the second set of applications is different from the first set of applications; determining a second amount of cloud-based computing instances in the second zone needed to maintain the first and second simulated usage capacities in the event of a failover of the first zone; reserving the second amount of cloud-based computing instances in the second zone when the second amount is less than the first amount; and dynamically modifying the reserved second amount of cloud-based computing instances in the second zone when the reserved amount does not align with current data trends continuously provided from the machine learning model.

12. The computing system of claim 11, wherein to perform the reserving, the operations comprise

generating a capacity reservation request to reserve the second amount of cloud-based computing instances in the second zone.

13. The computing system of claim 11, wherein to perform the reserving, the operations further comprise transmitting the request to a capacity reservation service of the cloud-based computing system.

14. The computing system of claim 11, wherein: the first zone is distributed across a first geographic region; and the second zone is distributed across a second geographic region different from the first geographic region.

15. The computing system of claim 11, further comprising: reserving the first amount of cloud-based computing instances in the second zone.

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