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(54) **MAINTENANCE-COST-AWARE BILLING FOR CLOUD SERVICES**

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(2), (4) Date: **Jul. 31, 2012**

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G06Q 30/04 (2012.01)

(52) **U.S. Cl.**
USPC **705/34**; 705/28; 705/26.51; 370/310; 718/1; 717/170; 713/182

(58) **Field of Classification Search**
USPC 705/34, 28, 14.1, 26.51; 715/229; 717/170
See application file for complete search history.

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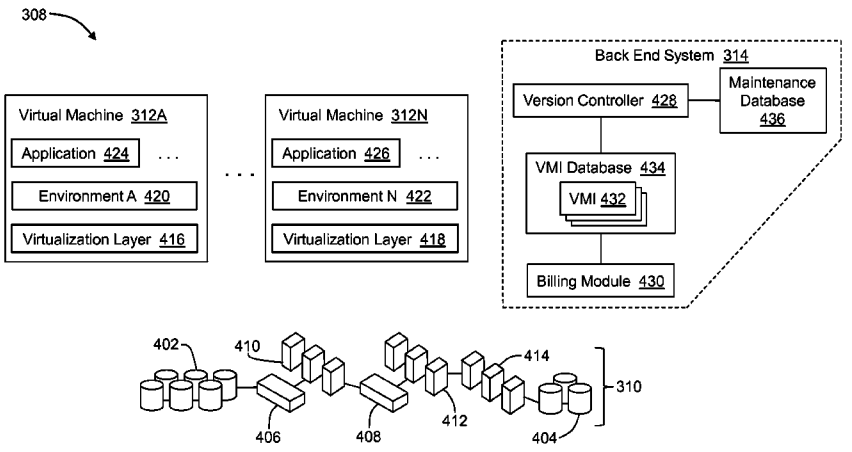
(57) **ABSTRACT**

In some examples, a method for performing maintenance-cost-aware billing is described. The method may include generating a version of a virtual machine image. The method may also include calculating a usage charge for usage of an instantiated virtual machine corresponding to the version of the virtual machine image. The calculation of the usage charge may be based on an age of the version of the virtual machine image.

20 Claims, 5 Drawing Sheets



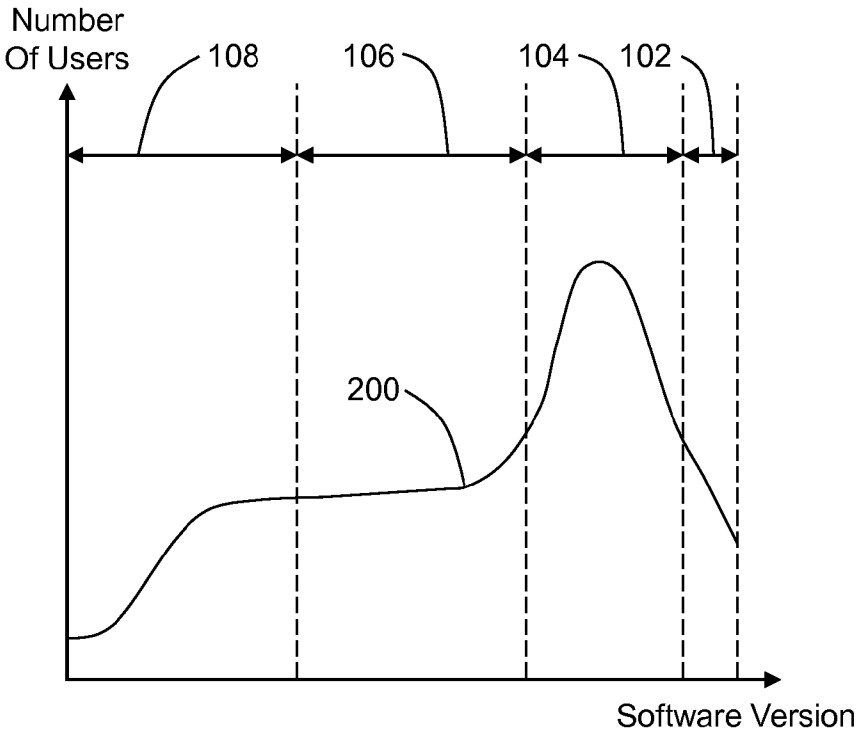

Number
Of Users
108
106
104
102
200
Software Version

FIG. 1

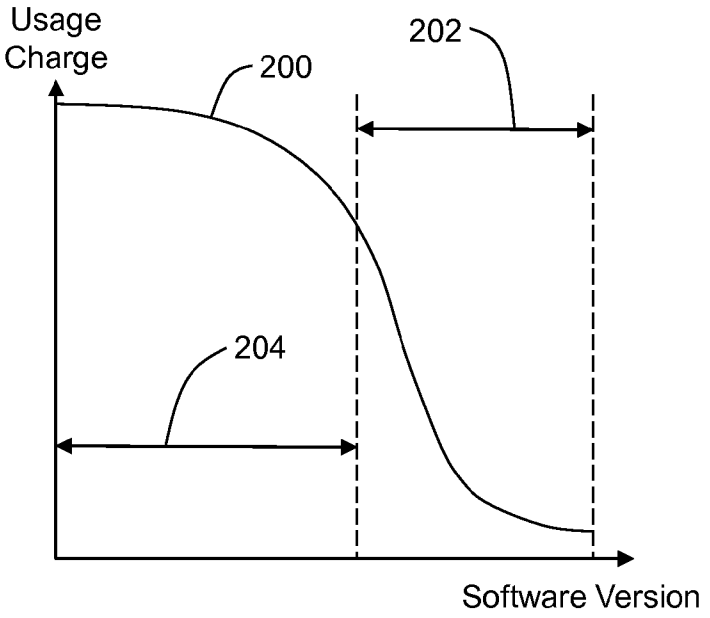

Usage
Charge
200
202
204
Software Version

FIG. 2

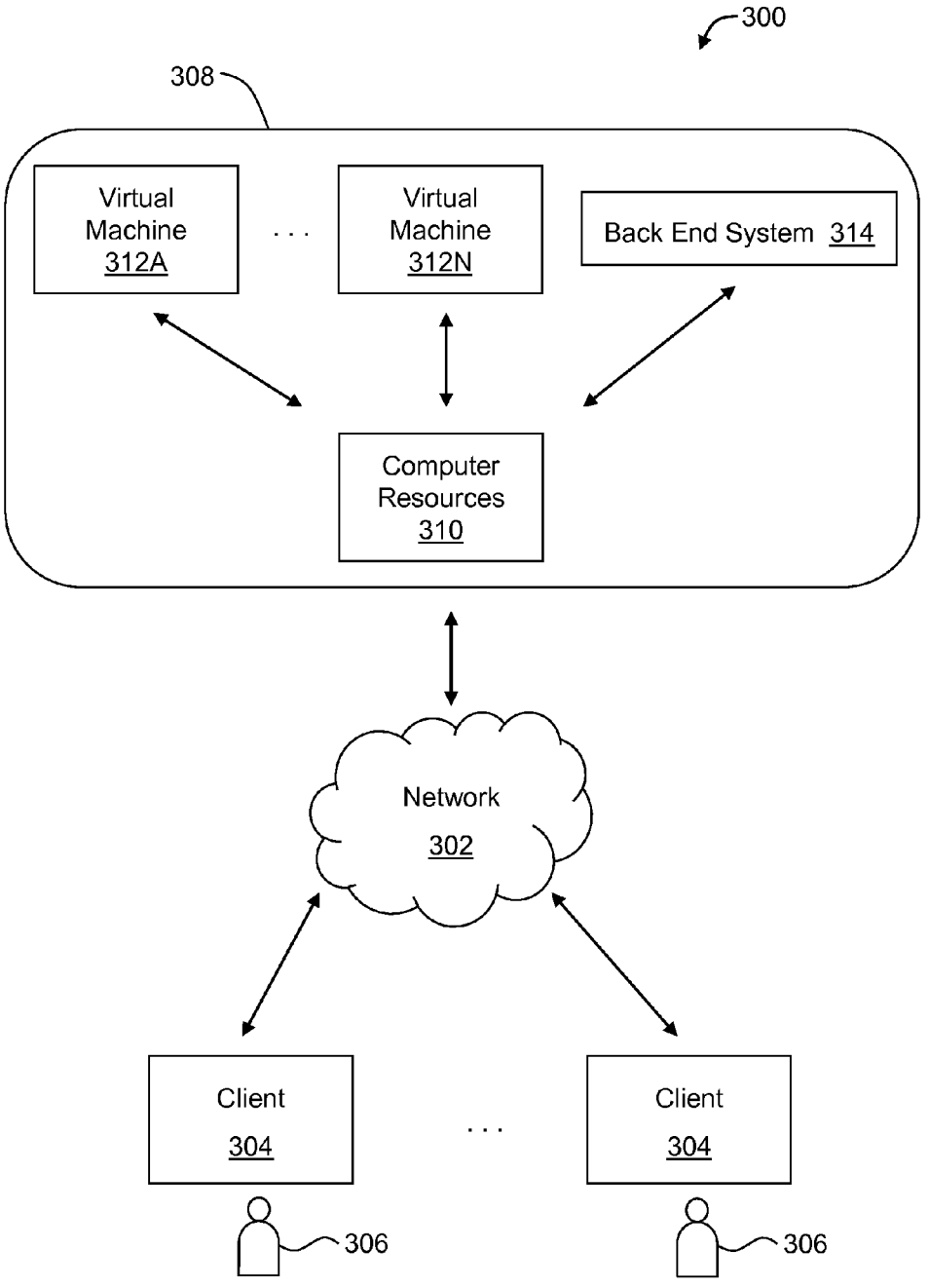

300
308
Virtual Machine 312A
Virtual Machine 312N
Back End System 314
Computer Resources 310
Network 302
Client 304
Client 304
306
306

FIG. 3

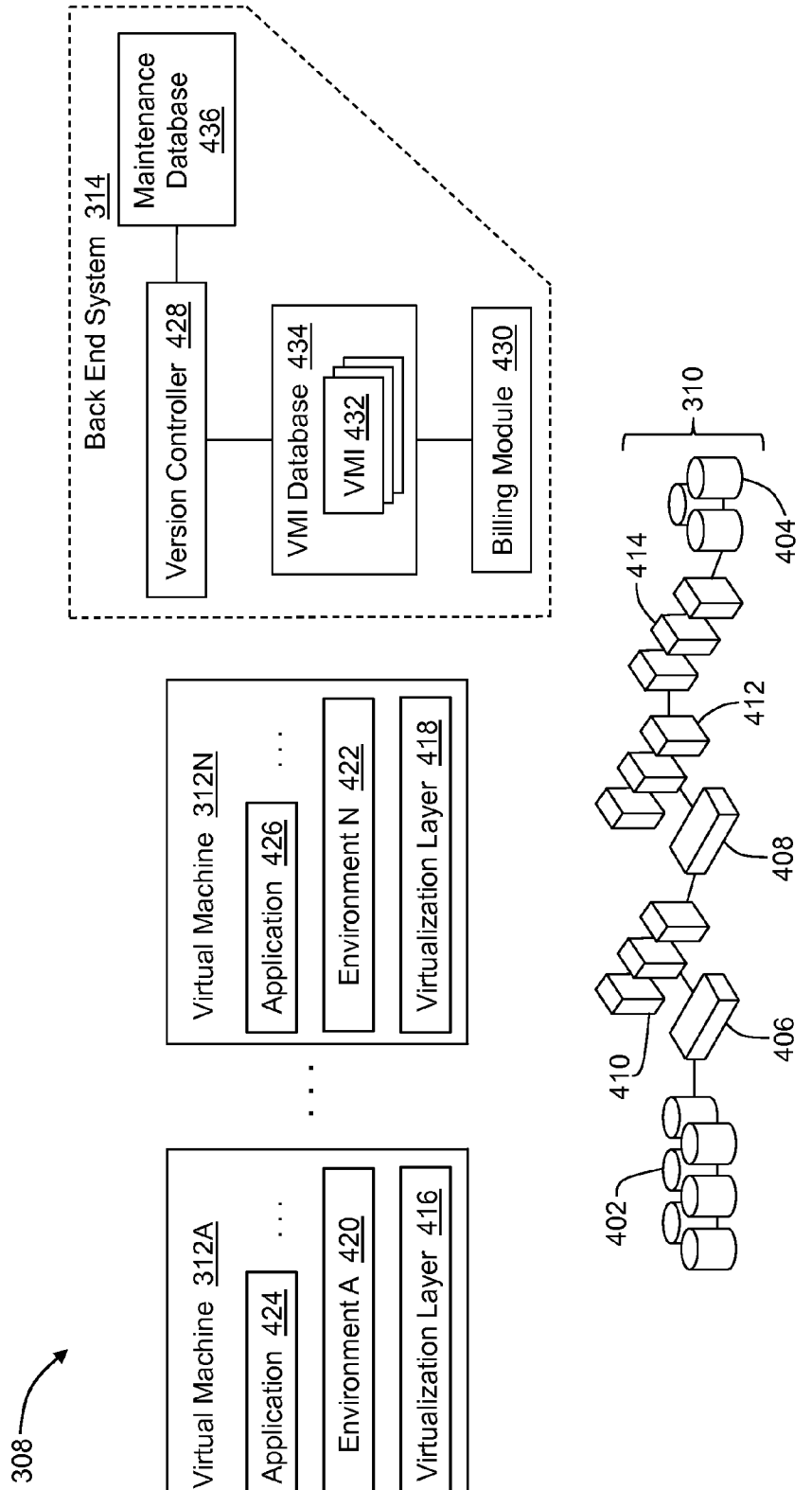

308
Back End System 314
Maintenance Database 436
Version Controller 428
VMI Database 434
VMI 432
Billing Module 430
Virtual Machine 312N
Application 426
Environment N 422
Virtualization Layer 418
Virtual Machine 312A
Application 424
Environment A 420
Virtualization Layer 416
310
414
412
408
406
410
402
404

FIG. 4

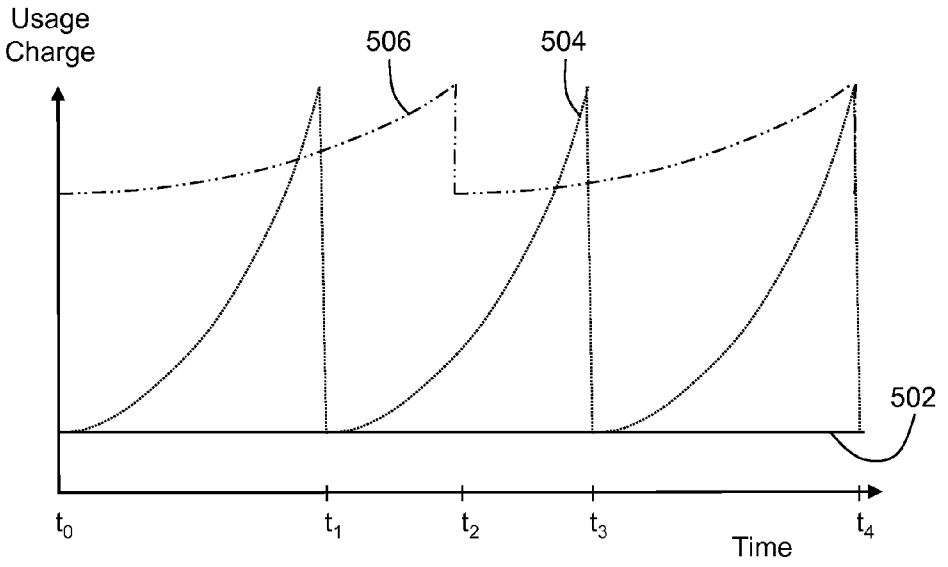

Usage Charge
506
504
502
t_0
t_1
t_2
t_3
t_4
Time

FIG. 5

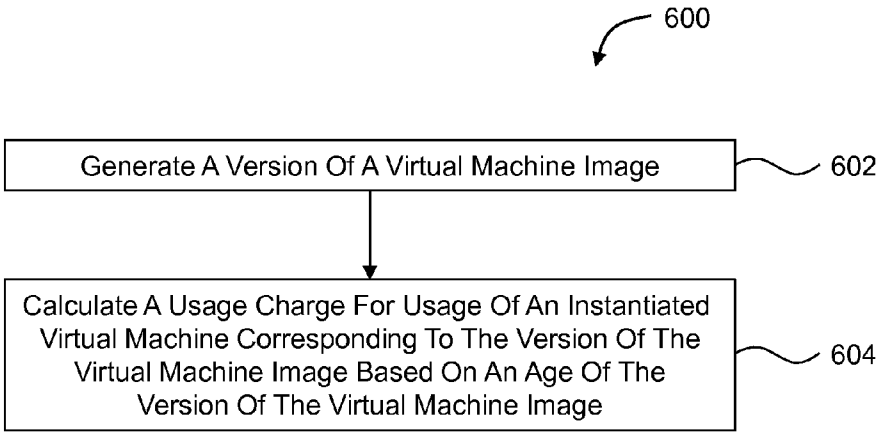

600
Generate A Version Of A Virtual Machine Image
602
Calculate A Usage Charge For Usage Of An Instantiated Virtual Machine Corresponding To The Version Of The Virtual Machine Image Based On An Age Of The Version Of The Virtual Machine Image
604

FIG. 6

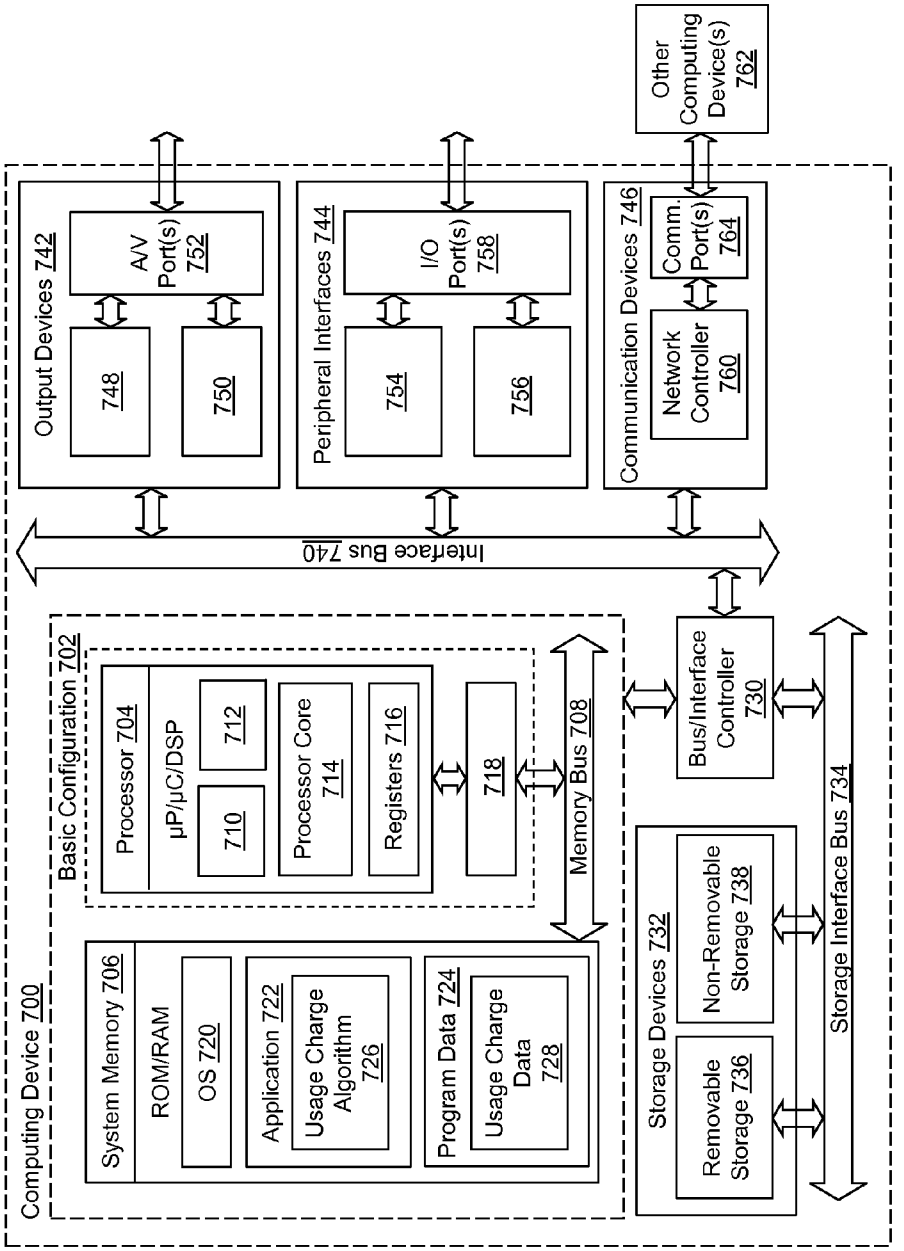

Computing Device 700
Basic Configuration 702
Processor 704
μP/μC/DSP
710
712
Processor Core 714
Registers 716
718
Memory Bus 708
System Memory 706
ROM/RAM
OS 720
Application 722
Usage Charge Algorithm 726
Program Data 724
Usage Charge Data 728
Interface Bus 740
Output Devices 742
A/V Port(s) 752
748
750
Peripheral Interfaces 744
I/O Port(s) 758
754
756
Communication Devices 746
Network Controller 760
Comm. Port(s) 764
Other Computing Device(s) 762
Bus/Interface Controller 730
Storage Devices 732
Removable Storage 736
Non-Removable Storage 738
Storage Interface Bus 734

FIG. 7

MAINTENANCE-COST-AWARE BILLING FOR CLOUD SERVICES

BACKGROUND

Unless otherwise indicated herein, the materials described herein are not prior art to the claims in the present application and are not admitted to be prior art by inclusion in this section.

Cloud computing environments may include software-as-a-service (SaaS) and platform-as-a-service (PaaS) environments. SaaS may provide a user with access to an application software package that may include, but is not limited to, e-mail, groupware, customer relationship management (CRM), and the like. PaaS may provide users with a computing platform on which user-specific applications may be deployed and executed.

When a SaaS environment is updated, business flows that users have constructed on the SaaS environment may have to be migrated to function properly in the updated SaaS environment, which may include one or more updated calling protocols, parameters, and/or Application Programming Interfaces (APIs). Analogously, when a PaaS environment is updated, user-deployed applications may have to be migrated to function properly in the updated PaaS environment, which may include updated middleware. Updates to SaaS/PaaS environments in some cases may be unavoidable, such as in response to discovering a security hole or for load distribution. Migration may be disruptive and/or costly for users.

In some cases, users who wish to continue using a specific version of a SaaS/PaaS environment and users who wish to use a latest version may coexist in a given cloud computing environment. As such, it is difficult to update the cloud computing environment all at once. Moreover, maintenance costs to maintain increasingly older versions of SaaS/PaaS environments typically increase with increasing age.

SUMMARY

Technologies described herein generally relate to maintenance-cost-aware billing for cloud computing environments.

In some examples, a method for performing maintenance-cost-aware billing is described. The method may include generating a version of a virtual machine image. The method may also include calculating a usage charge for usage of an instantiated virtual machine corresponding to the version of the virtual machine image. The calculation of the usage charge may be based on an age of the version of the virtual machine image.

In some examples, a computer storage medium having computer-executable instructions stored thereon that are executable by a computing device to perform operations is described. The operations may include generating a version of a virtual machine image. The operations may also include calculating a usage charge for usage of an instantiated virtual machine corresponding to the version of the virtual machine image. The calculation of the usage charge may be based on an age of the version of the virtual machine image.

In some examples, a back end system of a cloud service is described. The back end system may include a version controller and a billing module. The version controller may be configured to generate multiple versions of multiple virtual machine images. The billing module may be configured to calculate multiple usage charges for usage of multiple instantiated virtual machines corresponding to the versions of the virtual machine images. A calculation of each of the usage charges may be based on an age of a corresponding version of a corresponding virtual machine image.

The foregoing summary is illustrative only and is not intended to be in any way limiting. In addition to the illustrative aspects, embodiments, and features described above, further aspects, embodiments, and features will become apparent by reference to the drawings and the following detailed description.

BRIEF DESCRIPTION OF THE FIGURES

In the drawings:

FIG. **1** is a graph illustrating an example relationship between number of users and software versions in a cloud service;

FIG. **2** is a graph illustrating an example maintenance-cost-aware billing relationship between usage charges and software versions;

FIG. **3** is a block diagram of an example cloud computing environment in which embodiments of maintenance-cost-aware billing may be implemented;

FIG. **4** is a block diagram of an example embodiment of a cloud service of FIG. **3**;

FIG. **5** is a graph illustrative various example usage models that may be implemented in the cloud service of FIG. **3**;

FIG. **6** shows an example flow diagram of a method for performing maintenance-cost-aware billing; and

FIG. **7** is a block diagram illustrating an example computing device that is arranged for maintenance-cost-aware billing, all arranged in accordance with at least some embodiments described herein.

DETAILED DESCRIPTION

In the following detailed description, reference is made to the accompanying drawings, which form a part hereof. In the drawings, similar symbols typically identify similar components, unless context dictates otherwise. The illustrative embodiments described in the detailed description, drawings, and claims are not meant to be limiting. Other embodiments may be utilized, and other changes may be made, without departing from the spirit or scope of the subject matter presented herein. It will be readily understood that the aspects of the present disclosure, as generally described herein, and illustrated in the Figures, can be arranged, substituted, combined, separated, and designed in a wide variety of different configurations, all of which are explicitly contemplated herein.

Some embodiments described herein generally relate to a maintenance-cost-aware billing model for cloud computing environments. Software constituting a software-as-a-service (SaaS) or platform-as-a-service (PaaS) environment may be versioned using virtual machine images (VMIs). Usage charges may be calculated based on the age of a given VMI. For instance, as a version of a VMI ages over the course of a maintenance period specified in an associated contract, usage charges for using a corresponding instantiated virtual machine may progressively increase from a lower value at the beginning of the maintenance period to a higher value at the end of the maintenance period. The increase in usage charges may be sufficient in some cases to partially or completely offset maintenances costs involved in maintaining the version of the VMI, and/or may be sufficient to make maintaining the version of the VMI profitable.

Accordingly, in some embodiments described herein, a cloud service provider can maintain older versions of SaaS and/or PaaS environments for users that desire to continue using a given version, without unfairly apportioning the growing cost of maintaining progressively older versions

amongst users that prefer to use newer versions, and without maintaining the progressively older versions at a financial loss. At the same time, embodiments of the maintenance-cost-aware billing described herein may attract floating users, e.g., users that can easily migrate between software versions, by charging lower usage charges to users of the latest and/or newer versions.

FIG. **1** is a graph illustrating an example relationship between number of users and software versions in a cloud service (not shown), arranged in accordance with at least some embodiments described herein. In particular, the graph shown in FIG. **1** includes a curve **100** representing number of users as a function of software version being used by each of the number of users. The example relationship illustrated in FIG. **1** suggests a tendency among users of certain software in which a relatively small number of early adopters use a latest version(s) **102** of the software, a greater number of users use a relatively new version(s) **104** of the software that may be more stable than the latest version(s) **102**, a relatively small number of locked-in users continue using an older version(s) **106** of the software, and a relatively smaller number of deeply locked-in users continue using an oldest version(s) **108** of the software.

The cost to maintain a particular version of software in the cloud service may increase with increasing age of the software version. Thus, it may be unfair to early adopters of the latest version(s) **102**, users of the relatively new version(s) **104**, and/or locked-in users of the older versions **106** to equally distribute costs associated with maintaining all versions **102**, **104**, **106**, **108** of the software. Accordingly, some embodiments described herein may charge increasingly higher usage charges for using increasingly older software versions, referred to herein as maintenance-cost-aware billing. For example, the users of the relatively new version(s) **104** of the software may be charged more than the early adopters of the latest version(s) **102** of the software. Similarly, the locked-in users of the older version(s) **106** of the software may be charged more than the users of the relatively new version(s) **104** of the software. Similarly, the deeply locked-in users of the oldest version(s) **108** of the software may be charged more than the locked-in users of the older version(s) **106** of the software.

Embodiments of maintenance-cost-aware billing may more fairly distribute maintenance costs amongst the users of the software versions **102**, **104**, **106**, **108** since users of older versions of the software, which have relatively higher maintenance costs, may be charged more than users of newer versions of the software. Moreover, since usage charges may be increasingly lower for increasingly newer software versions, embodiments of maintenance-cost-aware billing may incentivize users to migrate to the latest version **102** of the software. As such, the number of users of the latest version(s) **102** may increase. As the number of users of the latest version(s) **102** increases, security holes, bugs, and/or other problems may be discovered earlier, and may then be resolved earlier than might otherwise occur, potentially leading to a shorter time to development of a relatively more secure and stable latest version(s) **102**, e.g., a latest version(s) with relatively fewer security holes, bugs, and/or other problems. Shorter time to security and/or stability of the latest version(s) **102** of software may additionally attract floating users, e.g., users who can readily and easily migrate between software versions.

FIG. **2** is a graph illustrating an example maintenance-cost-aware billing relationship between usage charges and software versions, arranged in accordance with at least some embodiments described herein. In particular, FIG. **2** shows a curve **200** representing usage charge as a function of software version. In FIG. **2**, the software version may increase to the right, meaning age may increase to the left. As illustrated, usage charges may be relatively low for the latest, or highest, version of software, and may increase with increasing age. The curve **200** of FIG. **2** is only one example of a maintenance-cost-aware billing relationship between usage charges and software versions. Embodiments of maintenance-cost-aware billing may more generally include virtually any relationship in which usage charges increase with increasing software version age.

FIG. **2** additionally illustrates two example maintenance periods **202**, **204**, also referred to as product lifetimes. The maintenance period **202** may be suitable for users who are willing to periodically migrate to a particular version of software that is relatively new at the time of migration, but who also desire to continue using the particular version throughout the maintenance period **202** to avoid frequent migration and its associated difficulties. By periodically migrating to a particular version that is relatively new at the time of migration, usage charges may be reduced at the beginning of each maintenance period **202**, followed by increasing usage charges as the particular version ages until reaching the end of each maintenance period **202**.

The maintenance period **204** may be suitable for users that are unwilling to migrate as frequently as the users opting for the maintenance period **202**, and/or for users that are unwilling to migrate to a version of software that is so new that it may not be completely secure and/or stable. These users may also see a reduction in usage charges at the beginning of each maintenance period **204** as they migrate to a version of software that is newer than what they were using previously, but is already somewhat old, followed by an increase in usage charges with increasing age of the version of software. The maintenance periods **202**, **204** are provided by way of example only, and should not be construed to limit the embodiments described herein.

FIG. **3** is a block diagram of an example cloud computing environment **300** in which embodiments of maintenance-cost-aware billing may be implemented, arranged in accordance with at least some embodiments described herein. In the illustrated embodiment, the cloud computing environment **300** includes a network **302**, one or more client devices **304** and corresponding users **306**, and a cloud service **308**.

In general, the network **302** may include one or more wide area networks (WANs) and/or local area networks (LANs) that enable the client devices **304** and the cloud service **308** to communicate with each other. In some embodiments, the network **302** includes the Internet, including a global internetwork formed by logical and physical connections between multiple WANs and/or LANs. Alternately or additionally, the network **302** may include one or more cellular RF networks and/or one or more wired and/or wireless networks such as, but not limited to, 802.xx networks, Bluetooth access points, wireless access points, IP-based networks, or the like. The network **302** may also include servers that enable one type of network to interface with another type of network.

Each of the client devices **304** may execute an application (not shown) or other instructions configured to communicate through the network **302** with the cloud service **308**. The application executed on each client device **308** to communicate with the cloud service **308** may include an internet browser, or other suitable application. Each of the client devices **304** may include, but is not limited to, a desktop computer, a laptop computer, a mobile phone, a smartphone, a personal digital assistant (PDA), or other suitable client device.

The cloud service **308** of the cloud computing environment **300** may include computer resources **310**, one or more virtual machines **312**A-**312**N that are accessible to the users **306**, and a back end system **314**. Although not required, the cloud service **308** may include an AMAZON EC2-type cloud service.

By way of example, and not limitation, the computer resources **310** may include processing resources such as one or more central processing units (CPUs), storage resources such as one or more storage devices, other resources such as network interface controllers (NICs) or other communication interface devices, and/or other suitable computer resources.

Each of the virtual machines **312**A-**312**N may be associated with a corresponding one of the users **306**. The users **306** may broadly include individual users and/or organizations including one or more users. In general, the users **306** may operate the client devices **304** to access the virtual machines **312**A-**312**N running on the computer resources **310**.

In some embodiments, the virtual machines **312**A-**312**N, or more particularly, corresponding VMIs, may be versioned and the cloud service **308** may implement maintenance-cost-aware billing such that usage charges, e.g., fees that are charged to the users **306**, may be based on the age, e.g., the version, of the virtual machine(s) **312**A-**312**N associated with each user **306**. The virtual machines **312**A-**312**N may be versioned in some embodiments by versioning software constituting a particular software-as-a-service (SaaS) or platform-as-a-service (PaaS) environment within the virtual machines **312** and/or by versioning corresponding virtualization software.

According to some embodiments, the usage charges may be higher for usage of older versions of the virtual machines **312**A-**312**N, and lower for usage of newer versions of the virtual machines **312**. Moreover, the usage charges over time for using a given version of any one of the virtual machines **312**A-**312**N may increase as the virtual machine **312**A-**312**N ages. For example, the usage charges may be calculated according to a graph, such as the graph of FIG. **2**, and/or according to a function in which usage charges increase with increasing age of the software. Accordingly, some embodiments described herein may incentivize users to migrate to newer versions of the virtual machines **312**A-**312**N, and/or may partially or completely offset the cost of maintaining aging versions of the virtual machines **312**A-**312**N, or may make such maintenance profitable.

As will be described in greater detail in the discussion of FIG. **4**, the back end system **314** may be configured to, among other things, generate versions of the virtual machines **312**A-**312**N, or more particularly may generate versions of the corresponding VMIs, according to contracts with the users **306** of the versions of the virtual machines **312**A-**312**N and/or according to contracts that are otherwise associated with the versions of the virtual machines **312**A-**312**N. The back end system **314** may also be configured to calculate usage charges for usage of the versions of the virtual machines **312**A-**312**N based on the age of each version.

FIG. **4** is a block diagram of an example embodiment of the cloud service **308** of FIG. **3**, arranged in accordance with at least some embodiments described herein. As illustrated in FIG. **4**, the computer resources **310** of the cloud service **308** may include storage devices **402**, **404**, networks and/or network devices **406**, **408**, and physical servers **410**, **412**, **414** or other computing devices.

The storage devices **402**, **404** may be implemented as primary storage within the computer resources **310** and may include nearly any type of storage device for digital data such as Random Access Memory (RAM), Read Only Memory (ROM), Electrically Erasable Programmable ROM (EEPROM), Compact Disc-ROM (CD-ROM) or other optical disk storage, magnetic disk storage, solid state storage or other storage devices.

The networks and/or network devices **406**, **408** may include one or more switches, routers, communication interfaces and/or other devices for facilitating communication between devices in the computer resources **310**.

The physical servers **410**, **412**, **414** may each include one or more CPUs and/or local storage devices.

A virtualization layer **416**, **418** may be provided in each virtual machine **312**A-**312**N to manage access to or "virtualize" the computer resources **310** for the virtual machine **312**A-**312**N. Examples of virtualization layers **416**, **418** may include, but are not limited to, VMware ESX, VMware GSX, Xen 3.0 (or other versions), or KVM, or other suitable virtualization layers.

Each virtual machine **312**A-**312**N may additionally include a particular SaaS or PaaS environment **420**, **422** (hereinafter individually "environment A **420**" and "environment N **422**," or collectively "environments A/N **420**, **422**"). Each of the environments A/N **420**, **422** may include any one of potentially multiple versions of software, such as an operating system, or the like, running on standardized hardware presented to the virtual machine **312**A-**312**N by the corresponding virtualization layer **416**, **418**. Alternately or additionally, each of the virtualization layers **416**, **418** may include any one of potentially multiple versions of the corresponding virtualization layer **416**, **418**. A given version of the environment A/N **420** or **422** and/or a given version of the corresponding virtualization layer **416** or **418** may constitute a given version of a corresponding VMI.

Each virtual machine **312**A-**312**N may additionally include one or more applications **424**, **426** configured to run in the corresponding environment A/N **420**, **422**. In some embodiments, when the environment A **420** or environment N **422** includes a SaaS environment, the one or more applications **424** or **426** in the corresponding virtual machine **312**A-**312**N may be deployed by a provider associated with the cloud service **308**. Alternately or additionally, when the environment A **420** or environment N **422** includes a PaaS environment, the one or more applications **424** or **426** in the corresponding virtual machine **312**A-**312**N may be deployed by a corresponding one of the users **306** of FIG. **3**, for example.

The back end system **314** includes one or more components that may be implemented in hardware and/or software in and/or on the computer resources **310**. For example, the back end system **314** may include a version controller **428** and a billing module **430**.

The version controller **428** may be configured to generate versions of VMIs **432** corresponding to the instantiated virtual machines **312**A-**312**N. In general, each VMI **432** may include binary code that, when executed by a processing device such as by a processing device of any of the physical servers **410**, **412**, **414**, causes a corresponding one of the virtual machines **312**A-**312**N to instantiate. The version controller **428** may be configured to generate a given version of a VMI **432** as directed by a corresponding one of the users **306** and/or in accordance with a contract associated with the user.

The billing module **430** may be configured to calculate usage charges for the instantiated virtual machines **312**A-**312**N corresponding to the versions of the VMIs **432**. A calculation of each of the usage charges may be based on an age of a corresponding version of a corresponding one of the VMIs **432**, where usage charges for usage of older versions are generally higher than usage chargers for usage of younger

versions of the same VMI **432**. For instance, the billing module **430** may be configured to calculate usage charges according to a graph, such as the graph of FIG. **2**, and/or according to a function in which usage charges increase with increasing age of the VMI **432**.

Each of the version controller **428** and the billing module **430** may include computer-executable instructions stored in a computer-readable medium, the computer-executable instructions being executable by a processing device, such as a processing device of any of the physical servers **410**, **412**, **414**, to perform one or more of the operations described herein. Alternately or additionally, one or both of the version controller **428** or the billing module **430** may be implemented in hardware.

As illustrated in FIG. **4**, the back end system **314** may further include a VMI database **434** and/or a maintenance database **436**. The VMI database **434** may be configured to store each of the versions of the VMIs **432** according to a corresponding maintenance period specified by a corresponding contract associated with a corresponding one of the VMIs **432**, such as a corresponding contract associated with a corresponding one of the users **306** of FIG. **3**.

The maintenance database **436** may be configured to store maintenance periods corresponding to the versions of the VMIs **432** stored in the VMI database **434**. A timestamp, a VMI **432** version number, or the like may be stored in the maintenance database **436** to designate the beginning of a maintenance period for a given contract, and the contract or data derived therefrom may also be stored in the maintenance database to specify the duration of the maintenance period. The duration may be defined in terms of time, such as in terms of a number of days, months, and/or years, and/or in terms of maintenance cycles, such as in terms of a number of security patches and/or hot fixes.

In general, a given version of a corresponding one of the VMIs **432** may be maintained for the duration of the maintenance period specified in a corresponding contract, at the end of which maintenance period the given version of the VMI **432** may be migrated to a newer version of the VMI **432**. The contract may additionally specify whether the newer version of the VMI **432** to which migration occurs at the end of the maintenance period is a latest version of the VMI **432**, or a non-latest version of the VMI **432** that may be more secure and/or stable than the latest version of the VMI **432**.

In operation, the version controller **428** may be configured to migrate each VMI **432** to a newer version of a corresponding one of the VMIs **432** according to a corresponding contract by, for each VMI **432**, determining from the maintenance database **436** when the corresponding maintenance period will expire. A particular newer version of the corresponding VMI **432** may be determined, also from the maintenance database **436** and/or the corresponding contract, to which the VMI **432** will be migrated at the end of the corresponding maintenance period. The newer version may be generated by the version controller **428** and stored in the VMI database **434**. The version controller **428** may determine that the corresponding maintenance period has expired and may initiate a corresponding new maintenance period. For example, the old timestamp, VMI **432** version number, or the like in the maintenance database **436** may be replaced by a new timestamp, VMI **432** version number, or the like to designate the beginning of the new maintenance period. The version controller **428** may then migrate the VMI **432** to the particular newer version of the corresponding VMI **432**.

As indicated previously, the particular newer version of the corresponding VMI **432** may include, in some embodiments, a latest version of the corresponding VMI **432**, in which case a first usage charge calculated at a beginning of the corresponding new maintenance period may have a first value that is relatively low. Alternately, the particular newer version of the corresponding VMI **432** may include a non-latest version of the corresponding VMI **432** such that the first usage charge calculated at the beginning of the corresponding new maintenance period may have a second value that is higher than the first value.

FIG. **5** is a graph illustrating various example usage models that may be implemented in the cloud service **308** of FIG. **3**, arranged in accordance with at least some embodiments described herein. In particular, FIG. **5** shows three usage models **502**, **504**, **506** representing usage charges over time for three different maintenance periods which may be specified in corresponding contracts. The usage models **502**, **504**, **506** may be calculated in some embodiments according to a graph or function in which usage charges increase with increasing age of a corresponding VMI, such as according to the graph of FIG. **2**.

The first usage model **502** may correspond to a maintenance period of zero in which a corresponding user migrates to the latest version of a corresponding VMI immediately and/or soon after the latest version is released. The first usage model **502** may be suitable for, e.g., developers and/or floating users. Because the user in the first usage model **502** migrates to the latest version immediately or soon after release of the latest version, and because usages charges for usage of the latest version may be lower than usage charges for usage of any non-latest versions, the usage charges over time under the first usage model **502** may remain steady and low for the user.

The second usage model **504** may correspond to a maintenance period of one year in which a corresponding user migrates to the latest version of a corresponding VMI once per year. The second usage model **504** may be suitable for the average business user, for example. In FIG. **5**, time t_0 may represent an initial time, time t_1 may represent one year from time t_0, time t_3 may represent one year from time t_1, and time t_4 may represent one year from time t_3. Thus, the ranges t_0-t_1, t_1-t_3 and t_3-t_4 may correspond to one-year maintenance periods of the second usage model **504**.

As illustrated in FIG. **5**, the usage charges of each maintenance period t_0-t_1, t_1-t_3 and t_3-t_4 of the second usage model **504** are the lowest at the beginning of each maintenance period t_0-t_1, t_1-t_3 and t_3-t_4 after migrating to (or beginning with) the latest version of the corresponding VMI. As the corresponding version of the VMI ages during each maintenance period t_0-t_1, t_1-t_3 and t_3-t_4, however, the usage charges increase until the end of the maintenance period t_0-t_1, t_1-t_3 and t_3-t_4 when the usage charges are at their highest, followed by a drastic decrease at the beginning of the next maintenance period t_0-t_1, t_1-t_3 and t_3-t_4 after migrating again to a latest version.

The third usage model **506** may correspond to a maintenance period of one-and-a-half years in which a corresponding user migrates to a relatively newer non-latest version of a corresponding VMI once every year-and-a-half. The third usage model **506** may be suitable for relatively conservative users who desire a relatively secure and/or stable SaaS/PaaS environment. In FIG. **5**, time t_2 may represent one-and-a-half years from time t_0, and time t_4 may represent one-and-a-half years from time t_2. Thus, the ranges t_0-t_2 and t_2-t_4 may correspond to one-and-a-half year maintenance periods of the third usage model **506**.

As illustrated in FIG. **5**, the usage charges of each maintenance period t_0-t_2 and t_2-t_4 of the third usage model **506** are the lowest at the beginning of each maintenance period t_0-t_2

and t_2-t_4 after migrating to (or beginning with) the relatively newer non-latest version of the corresponding VMI. As the corresponding version of the VMI ages during each maintenance period t_0-t_2 and t_{244}, however, the usage charges increase until the end of the maintenance period t_0-t_2 and t_2-t_4 when the usage charges are at their highest, followed by a decrease at the beginning of the next maintenance period t_0-t_2 and t_2-t_4 after migrating again to a relatively newer non-latest version.

FIG. **6** shows an example flow diagram of a method **600** for performing maintenance-cost-aware billing, arranged in accordance with at least some embodiments described herein. The method **600** may be performed in whole or in part by, e.g., the back end system **314** of FIGS. **3-4**. The method **600** includes various operations, functions or actions as illustrated by one or more of blocks **602** and/or **604**. The method **600** may begin at block **602**.

In block **602** ("Generate A Version Of A Virtual Machine Image"), a version of a VMI is generated. For example, the version controller **428** of the back end system **314** may generate the version of the VMI by capturing a snapshot of the corresponding VMI and storing the version of the VMI in the VMI database **434**. The version of the VMI may be generated as requested by a corresponding user.

Alternately or additionally, the version of the VMI may be generated in accordance with a contract associated with the VMI. For example, if the contract specifies migration to a particular version, e.g., latest or non-latest, the version of the VMI may be automatically generated at the beginning of a new corresponding maintenance period or at the end of a corresponding current maintenance period, or the like. Block **602** may be followed by block **604**.

In block **604** ("Calculate A Usage Charge For Usage Of An Instantiated Virtual Machine Corresponding To The Version Of The Virtual Machine Image Based On An Age Of The Version Of The Virtual Machine Image"), a usage charge is calculated for usage of an instantiated virtual machine corresponding to the version of the VMI based on an age of the version of the VMI. The usage charge may be calculated according to a function or graph in which a greater age corresponds to a higher usage charge. For instance, the graph may include the graph of FIG. **2**. Alternately or additionally, the function or graph may be configured to incentivize early migration to a latest version of the VMI by, e.g., charging less for usage of the latest version than for usage of older versions.

Alternately or additionally, the usage charge may be calculated according to an arc tangent function generally of the form $f(x)=A\cdot\arctan(x-B)+\pi(A/2)$. In this and other embodiments, $f(x)$ is the calculated usage charge in a range including a minimum charge $C_{min}\leq f(x)\leq$ a maximum charge C_{max}, x is the age of the version of the VMI in a domain including a minimum age $x_{min}\leq x\leq$ a maximum age x_{max}, and A and B are constants such that $f(x_{min})=C_{min}$ and $f(x_{max})=C_{max}$.

One skilled in the art will appreciate that, for this and other processes and methods disclosed herein, the functions performed in the processes and methods may be implemented in differing order. Furthermore, the outlined steps and operations are only provided as examples, and some of the steps and operations may be optional, combined into fewer steps and operations, or expanded into additional steps and operations without detracting from the essence of the disclosed embodiments.

For example, the method **600** may further include calculating, over the course of a maintenance period of the VMI specified in a contract associated with the VMI, multiple usage charges for the instantiated virtual machine corresponding to the version of the VMI, wherein each of the usage charges is based on a corresponding age of the version of the VMI. The usage charges may be configured to be sufficient to completely offset maintenance costs associated with maintaining the version of the VMI over the course of the maintenance period. Alternately or additionally, the usage charges may be further configured to be sufficiently large that maintaining the version of the VMI according to the specified maintenance period is profitable.

In some embodiments, the method **600** may further include maintaining the VMI over the course of the maintenance period.

Alternately or additionally, the method **600** may further include iterating as follows. A current version of a VMI may be automatically migrated to a newer version of the VMI at an end of a current maintenance period. A new maintenance period may be initiated. Over the course of the new maintenance period, multiple usage charges may be calculated for usage of an instantiated virtual machine corresponding to the newer version of the VMI, where each of the usage charges may be based on a corresponding age of the newer version of the VMI.

In these and other embodiments, a given newer version of the VMI image may include a latest version of the VMI, and a first usage charge calculated at the beginning of a corresponding new maintenance period may have a first value that is relatively low. For instance, the second usage model **504** of FIG. **5** provides an example in which the newer version at the beginning of each maintenance period is the latest version and the first usage charge at the beginning of each maintenance period is relatively low. In the foregoing example, it is understood that the newer version of the VMI image may only qualify as the latest version for a portion, e.g., the beginning, of the corresponding new maintenance period until another latest version is released.

Alternately, the given newer version of the VMI image may include a non-latest version of the VMI image such that the first usage charge calculated at the beginning of the corresponding new maintenance period has a second value that is higher than the first value. For instance, the third usage model **506** of FIG. **5** provides an example in which the newer version at the beginning of each maintenance period is a non-latest version and the first usage charge at the beginning of each maintenance period is a second value that is higher than first value for the latest version at the beginning of each maintenance period for the second usage model **504**.

Some embodiments disclosed herein include a computer storage medium having computer-executable instructions stored thereon that are executable by a computing device to perform operations included in the method **600** of FIG. **6**, such as the operations illustrated by blocks **602** and/or **604** in FIG. **6**, and/or variations thereof. The computer storage medium may be included in one or more of the storage devices **402**, **404** of FIG. **4** and/or in one or more local storage devices of the physical servers **410**, **412**, **414** of FIG. **4**.

Accordingly, some embodiments of maintenance-cost-aware billing described herein charge users increasingly more for using increasingly older versions of software. As such, usage of the latest version of software may be the least expensive which may attract floating users who can readily perform migration. Alternately or additionally, users may be incentivized to migrate to the latest version of software, which may lead to more users migrating to the latest version earlier than would otherwise occur, which in turn may ultimately lead to a latest version that is more secure and/or more stable earlier than would otherwise occur.

Some of the disclosed embodiments may provide a pricing model that is fair to both users who wish to continue using a

specific version of software and to users who wish to periodically and/or constantly migrate to a newer version. In particular, users who wish to continue using a specific version of software can pay increasingly higher usage charges to offset increasingly higher maintenance costs as the specific version of software ages.

In some embodiments, the increasing usages charges for usage of increasingly older versions of software may be sufficient to at least partially or completely offset maintenance costs associated with maintaining the increasingly older versions of software throughout corresponding maintenance periods. Alternately or additionally, the increasing usage charges for usage of increasingly older versions of software may be sufficient to make maintaining the increasingly older versions of software through corresponding maintenance periods profitable.

FIG. **7** is a block diagram illustrating an example computing device **700** that is arranged for maintenance-cost-aware billing, arranged in accordance with at least some embodiments described herein. The computing device **700** may be included in the computer resources **310** of FIGS. **3** and **4**, for example. In a very basic configuration **702**, the computing device **700** typically includes one or more processors **704** and a system memory **706**. A memory bus **708** may be used for communicating between the processor **704** and the system memory **706**.

Depending on the desired configuration, the processor **704** may be of any type including but not limited to a microprocessor (μP), a microcontroller (μC), a digital signal processor (DSP), or any combination thereof. The processor **704** may include one more levels of caching, such as a level one cache **710** and a level two cache **712**, a processor core **714**, and registers **716**. An example processor core **714** may include an arithmetic logic unit (ALU), a floating point unit (FPU), a digital signal processing core (DSP Core), or any combination thereof. An example memory controller **718** may also be used with the processor **704**, or in some implementations the memory controller **718** may be an internal part of the processor **704**.

Depending on the desired configuration, the system memory **706** may be of any type including but not limited to volatile memory (such as RAM), non-volatile memory (such as ROM, flash memory, etc.) or any combination thereof. The system memory **706** may include an OS **720**, one or more applications **722**, and program data **724**. The application **722** may include a usage charge algorithm **726** that is arranged to perform the functions as described herein including those described with respect to the method **600** of FIG. **6**. The application **722** may correspond to one or more of the version controller **428** and/or billing module **430** of FIG. **4**, for example. The program data **724** may include usage charge data **728** that may be useful for configuring the usage charge algorithm **726** as is described herein. For instance, the usage charge data **728** may include a graph or function in which a greater age corresponds to a higher usage charge, such as the graph of FIG. **2**, and from which usage charges may be calculated based on age. In some embodiments, the application **722** may be arranged to operate with the program data **724** on the OS **720** such that implementations of maintenance-cost-aware billing methods such as the method **600** of FIG. **6** may be provided as described herein. This described basic configuration **702** is illustrated in FIG. **7** by those components within the inner dashed line.

The computing device **700** may have additional features or functionality, and additional interfaces to facilitate communications between the basic configuration **702** and any required devices and interfaces. For example, a bus/interface controller **730** may be used to facilitate communications between the basic configuration **702** and one or more data storage devices **732** via a storage interface bus **734**. The data storage devices **732** may be removable storage devices **736**, non-removable storage devices **738**, or a combination thereof. Examples of removable storage and non-removable storage devices include magnetic disk devices such as flexible disk drives and hard-disk drives (HDD), optical disk drives such as compact disk (CD) drives or digital versatile disk (DVD) drives, solid state drives (SSD), and tape drives to name a few. Example computer storage media may include volatile and nonvolatile, removable and non-removable media implemented in any method or technology for storage of information, such as computer readable instructions, data structures, program modules, or other data.

The system memory **706**, removable storage devices **736** and non-removable storage devices **738** are examples of computer storage media. Computer storage media includes, but is not limited to, RAM, ROM, EEPROM, flash memory or other memory technology, CD-ROM, digital versatile disks (DVD) or other optical storage, magnetic cassettes, magnetic tape, magnetic disk storage or other magnetic storage devices, or any other medium which may be used to store the desired information and which may be accessed by the computing device **700**. Any such computer storage media may be part of the computing device **700**.

The computing device **700** may also include an interface bus **740** for facilitating communication from various interface devices (e.g., output devices **742**, peripheral interfaces **744**, and communication devices **746**) to the basic configuration **702** via the bus/interface controller **730**. Example output devices **742** include a graphics processing unit **748** and an audio processing unit **750**, which may be configured to communicate to various external devices such as a display or speakers via one or more A/V ports **752**. Example peripheral interfaces **744** include a serial interface controller **754** or a parallel interface controller **756**, which may be configured to communicate with external devices such as input devices (e.g., keyboard, mouse, pen, voice input device, touch input device, etc.) or other peripheral devices (e.g., printer, scanner, etc.) via one or more I/O ports **758**. An example communication device **746** includes a network controller **760**, which may be arranged to facilitate communications with one or more other computing devices **762** over a network communication link via one or more communication ports **764**.

The network communication link may be one example of a communication media. Communication media may typically be embodied by computer readable instructions, data structures, program modules, or other data in a modulated data signal, such as a carrier wave or other transport mechanism, and may include any information delivery media. A "modulated data signal" may be a signal that has one or more of its characteristics set or changed in such a manner as to encode information in the signal. By way of example, and not limitation, communication media may include wired media such as a wired network or direct-wired connection, and wireless media such as acoustic, radio frequency (RF), microwave, infrared (IR) and other wireless media. The term computer readable media as used herein may include both storage media and communication media.

The computing device **700** may be implemented as a portion of a small-form factor portable (or mobile) electronic device such as a cell phone, a personal data assistant (PDA), a personal media player device, a wireless web-watch device, a personal headset device, an application specific device, or a hybrid device that include any of the above functions. The

computing device **700** may also be implemented as a personal computer including both laptop computer and non-laptop computer configurations.

The present disclosure is not to be limited in terms of the particular embodiments described herein, which are intended as illustrations of various aspects. Many modifications and variations can be made without departing from its spirit and scope, as will be apparent to those skilled in the art. Functionally equivalent methods and apparatuses within the scope of the disclosure, in addition to those enumerated herein, will be apparent to those skilled in the art from the foregoing descriptions. Such modifications and variations are intended to fall within the scope of the appended claims. The present disclosure is to be limited only by the terms of the appended claims, along with the full scope of equivalents to which such claims are entitled. It is to be understood that the present disclosure is not limited to particular methods, reagents, compounds, compositions or biological systems, which can, of course, vary. It is also to be understood that the terminology used herein is for the purpose of describing particular embodiments only, and is not intended to be limiting.

With respect to the use of substantially any plural and/or singular terms herein, those having skill in the art can translate from the plural to the singular and/or from the singular to the plural as is appropriate to the context and/or application. The various singular/plural permutations may be expressly set forth herein for sake of clarity.

It will be understood by those within the art that, in general, terms used herein, and especially in the appended claims (e.g., bodies of the appended claims) are generally intended as "open" terms (e.g., the term "including" should be interpreted as "including but not limited to," the term "having" should be interpreted as "having at least," the term "includes" should be interpreted as "includes but is not limited to," etc.). It will be further understood by those within the art that if a specific number of an introduced claim recitation is intended, such an intent will be explicitly recited in the claim, and in the absence of such recitation no such intent is present. For example, as an aid to understanding, the following appended claims may contain usage of the introductory phrases "at least one" and "one or more" to introduce claim recitations. However, the use of such phrases should not be construed to imply that the introduction of a claim recitation by the indefinite articles "a" or "an" limits any particular claim containing such introduced claim recitation to embodiments containing only one such recitation, even when the same claim includes the introductory phrases "one or more" or "at least one" and indefinite articles such as "a" or "an" (e.g., "a" and/or "an" should be interpreted to mean "at least one" or "one or more"); the same holds true for the use of definite articles used to introduce claim recitations. In addition, even if a specific number of an introduced claim recitation is explicitly recited, those skilled in the art will recognize that such recitation should be interpreted to mean at least the recited number (e.g., the bare recitation of "two recitations," without other modifiers, means at least two recitations, or two or more recitations). Furthermore, in those instances where a convention analogous to "at least one of A, B, and C, etc." is used, in general such a construction is intended in the sense one having skill in the art would understand the convention (e.g., "a system having at least one of A, B, and C" would include but not be limited to systems that have A alone, B alone, C alone, A and B together, A and C together, B and C together, and/or A, B, and C together, etc.). In those instances where a convention analogous to "at least one of A, B, or C, etc." is used, in general such a construction is intended in the sense one having skill in the art would understand the convention (e.g., "a system having at least one of A, B, or C" would include but not be limited to systems that have A alone, B alone, C alone, A and B together, A and C together, B and C together, and/or A, B, and C together, etc.). It will be further understood by those within the art that virtually any disjunctive word and/or phrase presenting two or more alternative terms, whether in the description, claims, or drawings, should be understood to contemplate the possibilities of including one of the terms, either of the terms, or both terms. For example, the phrase "A or B" will be understood to include the possibilities of "A" or "B" or "A and B."

In addition, where features or aspects of the disclosure are described in terms of Markush groups, those skilled in the art will recognize that the disclosure is also thereby described in terms of any individual member or subgroup of members of the Markush group.

As will be understood by one skilled in the art, for any and all purposes, such as in terms of providing a written description, all ranges disclosed herein also encompass any and all possible sub ranges and combinations of sub ranges thereof. Any listed range can be easily recognized as sufficiently describing and enabling the same range being broken down into at least equal halves, thirds, quarters, fifths, tenths, etc. As a non-limiting example, each range discussed herein can be readily broken down into a lower third, middle third and upper third, etc. As will also be understood by one skilled in the art all language such as "up to," "at least," and the like include the number recited and refer to ranges which can be subsequently broken down into sub ranges as discussed above. Finally, as will be understood by one skilled in the art, a range includes each individual member. Thus, for example, a group having 1-3 cells refers to groups having 1, 2, or 3 cells. Similarly, a group having 1-5 cells refers to groups having 1, 2, 3, 4, or 5 cells, and so forth.

From the foregoing, it will be appreciated that various embodiments of the present disclosure have been described herein for purposes of illustration, and that various modifications may be made without departing from the scope and spirit of the present disclosure. Accordingly, the various embodiments disclosed herein are not intended to be limiting, with the true scope and spirit being indicated by the following claims.

The invention claimed is:

1. A method for performing maintenance-cost-aware billing, the method comprising:

generating, by a processor, a version of a virtual machine image; and

calculating, by the processor, a usage charge for usage of an instantiated virtual machine corresponding to the version of the virtual machine image based on an age of the version of the virtual machine image.

2. The method of claim **1**, further comprising calculating, over the course of a maintenance period of the virtual machine image specified in a contract associated with the virtual machine image, a plurality of usage charges for usage of the instantiated virtual machine corresponding to the version of the virtual machine image, wherein each of the plurality of usage charges is based on a corresponding age of the version of the virtual machine image.

3. The method of claim **2**, wherein the plurality of usage charges are configured to be sufficient to completely offset maintenance costs associated with maintaining the version of the virtual machine image over the course of the maintenance period.

4. The method of claim **3**, wherein the plurality of usage charges are further configured to be sufficiently large that

maintaining the version of the virtual machine image according to the specified maintenance period is profitable.

5. The method of claim **2**, further comprising iterating as follows:

automatically migrating to a relatively newer version of the virtual machine image at an end of a current maintenance period;

initiating a new maintenance period; and

calculating, over the course of the new maintenance period, a plurality of usage charges for usage of an instantiated virtual machine corresponding to the relatively newer version of the virtual machine image, wherein each of the plurality of usage charges is based on a corresponding age of the relatively newer version of the virtual machine image.

6. The method of claim **5**, wherein:

a given relatively newer version of the virtual machine image comprises a latest version of the virtual machine image and a first usage charge calculated at a beginning of a corresponding new maintenance period has a first value; or

the given relatively newer version of the virtual machine image comprises a non-latest version of the virtual machine image such that the first usage charge calculated at the beginning of the corresponding new maintenance period has a second value that is higher than the first value.

7. The method of claim **1**, wherein the usage charge is calculated according to a function or graph in which a greater age corresponds to a higher usage charge.

8. The method of claim **1**, wherein the usage charge is calculated according to an arc tangent function generally of the form $f(x)=A\cdot\arctan(x-B)+\pi(A/2)$, where f(x) is the calculated usage charge in a range including a minimum charge $C_{min}\leq f(x)\leq$ a maximum charge C_{max}, x is the age of the version of the virtual machine image in a domain including a minimum age $x_{min}\leq x\leq$ a maximum age x_{max}, and A and B are constants such that $f(x_{min})=C_{min}$ and $f(x_{max})=C_{max}$.

9. A computer storage medium having computer-executable instructions stored thereon that are executable by a computing device to perform operations comprising:

generating a version of a virtual machine image; and

calculating a usage charge for usage of an instantiated virtual machine corresponding to the version of the virtual machine image based on an age of the version of the virtual machine image.

10. The computer storage medium of claim **9**, further comprising computer executable instructions that are executable by the computing device to perform operations comprising calculating, over the course of a maintenance period of the virtual machine image specified in a contract associated with the virtual machine image, a plurality of usage charges for usage of the instantiated virtual machine corresponding to the version of the virtual machine image, wherein each of the plurality of usage charges is based on a corresponding age of the version of the virtual machine image.

11. The computer storage medium of claim **10**, wherein the plurality of usage charges are configured to be sufficient to completely offset maintenance costs associated with maintaining the version of the virtual machine image over the course of the maintenance period.

12. The computer storage medium of claim **10**, further comprising computer executable instructions that are executable by the computing device to perform operations comprising iterating as follows:

automatically migrating to a relatively newer version of the virtual machine image at an end of a current maintenance period;

initiating a new maintenance period; and

calculating, over the course of the new maintenance period, a plurality of usage charges for usage of an instantiated virtual machine corresponding to the relatively newer version of the virtual machine image, wherein each of the plurality of usage charges is based on a corresponding age of the relatively newer version of the virtual machine image.

13. The computer storage medium of claim **12**, wherein:

a given relatively newer version of the virtual machine image comprises a latest version of the virtual machine image and a first usage charge calculated at a beginning of a corresponding new maintenance period has a first value; or

the given relatively newer version of the virtual machine image comprises a non-latest version of the virtual machine image such that the first usage charge calculated at the beginning of the corresponding new maintenance period has a second value that is higher than the first value.

14. The computer storage medium of claim **9**, wherein the usage charge is calculated according to a function or graph in which a greater age corresponds to a higher usage charge.

15. A back end system of a cloud service, the back end system comprising:

a version controller configured to generate a plurality of versions of a plurality of virtual machine images; and

a billing module configured to calculate a plurality of usage charges for usage of a plurality of instantiated virtual machines corresponding to the plurality of versions of the plurality of virtual machine images, wherein a calculation of each of the plurality of usage charges is based on an age of a corresponding version of a corresponding virtual machine image.

16. The back end system of claim **15**, further comprising a virtual machine image database configured to store each of the plurality of versions of the plurality of virtual machine images, each being stored according to a corresponding maintenance period specified by a corresponding contract.

17. The back end system of claim **16**, further comprising a maintenance database configured to store a plurality of maintenance periods corresponding to the plurality of versions of the plurality of virtual machine images.

18. The back end system of claim **15**, wherein the version controller is further configured to migrate each virtual machine image to a newer version of a corresponding virtual machine image according to a corresponding contract by, for each virtual machine image:

determining when the corresponding maintenance period will expire;

determining a particular newer version of the corresponding virtual machine image to which the virtual machine image will be migrated at the end of the corresponding maintenance period;

generating the particular newer version of the corresponding virtual machine image;

determining that the corresponding maintenance period has expired;

initiating a corresponding new maintenance period; and

migrating the virtual machine image to the particular newer version of the corresponding virtual machine image.

19. The back end system of claim **18**, wherein:

the particular newer version of the corresponding virtual machine image comprises a latest version of the corresponding virtual machine image and a first usage charge

calculated at a beginning of the corresponding new maintenance period has a first value; or

the particular newer version of the corresponding virtual machine image comprises a non-latest version of the corresponding virtual machine image such that the first usage charge calculated at the beginning of the corresponding new maintenance period has a second value that is higher than the first value.

20. The back end system of claim **15**, wherein the billing module is configured to calculate the plurality of usage charges according to a function or graph configured to incentivize early migration to a latest version of each of the plurality of virtual machine images.

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