US 20130067469A1

(19) United States

(12) Patent Application Publication

(10) Pub. No.: US 2013/0067469 A1

(43) Pub. Date: Mar. 14, 2013

Das et al.

(54) **LOAD BALANCING BY ENDPOINTS**

(75) Inventors: **Manuvir Das**, Hyderabad (IN); **Sudarshan Yadav**, Hyderabad (IN); **Arvind Kandhare**, Hyderabad (IN); **Sanjay Malpani**, Hyderabad (IN); **Ranjana Rathinam**, Hyderabad (IN); **Jayaraman Thiagarajan**, Hyderabad (IN)

(73) Assignee: **Microsoft Corporation**, Redmond, WA (US)

(21) Appl. No.: **13/232,894**

(22) Filed: **Sep. 14, 2011**

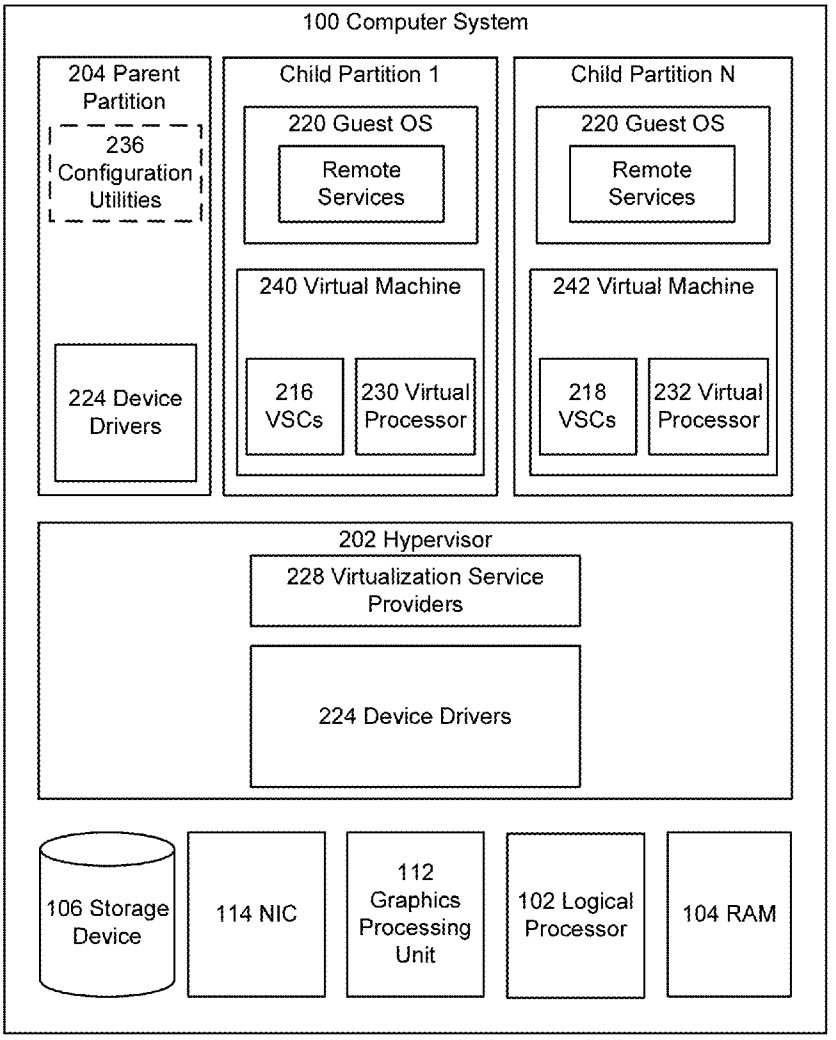
Publication Classification

(51) **Int. Cl.**
G06F 9/455 (2006.01)

(52) **U.S. Cl.**
USPC **718/1**

(57) **ABSTRACT**

A mechanism is provided for In a cloud computing infrastructure, a mechanism is provided for balancing client sessions across virtual machines such that the number of virtual machines is efficiently managed. In some embodiments, the total number of virtual machines is minimized to reduce power consumption, cooling, and other cost drivers, while assigning users across the sessions. In one embodiment, the sessions in a virtual machine with low activity are migrated to a virtual machine with higher session rates to allow for the shutdown of the low usage virtual machines. In another embodiment, new user sessions are assigned according to a minimum performance standard.



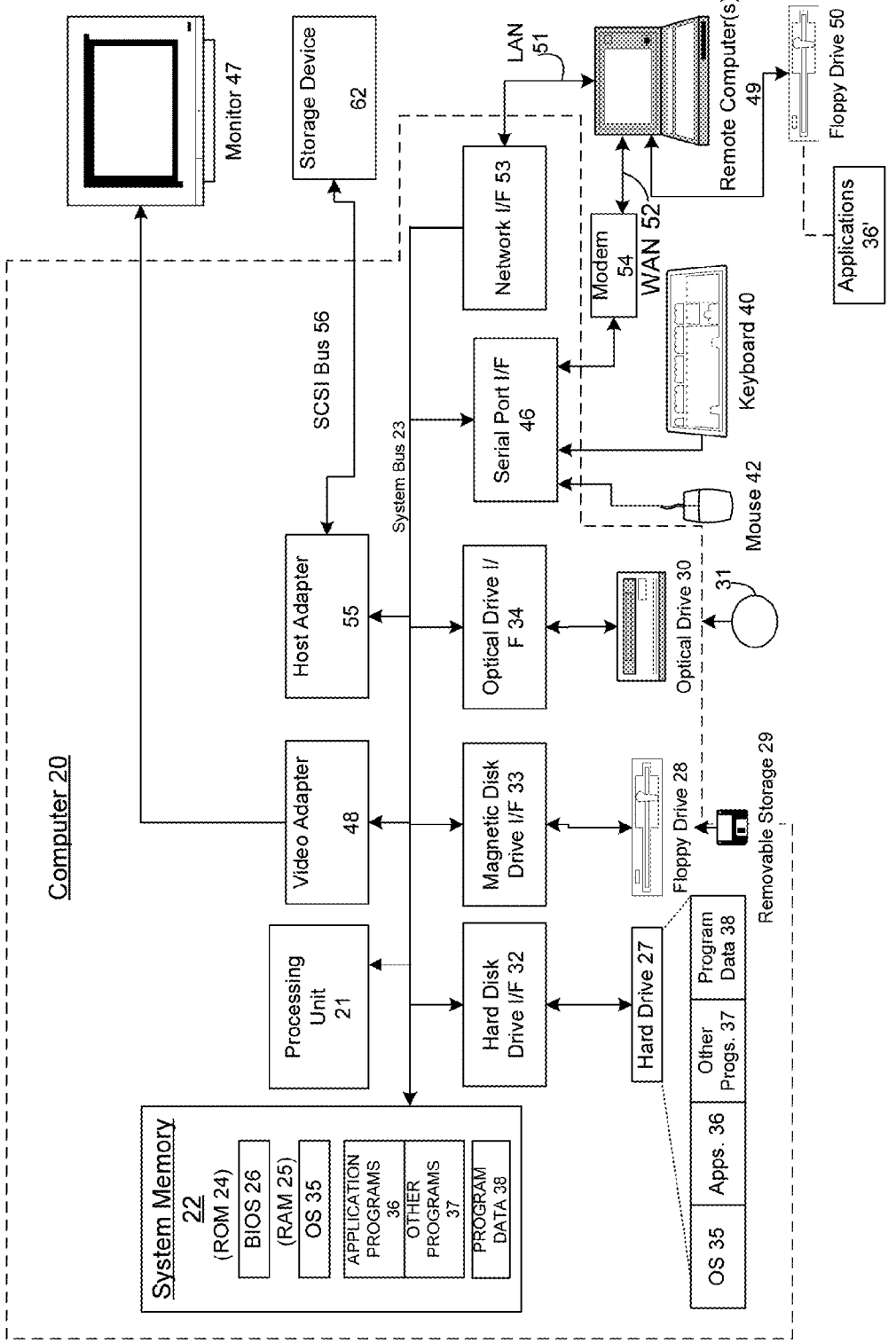

Computer 20
System Memory 22
(ROM 24)
BIOS 26
(RAM 25)
OS 35
APPLICATION PROGRAMS 36
OTHER PROGRAMS 37
PROGRAM DATA 38
Processing Unit 21
Video Adapter 48
Host Adapter 55
Hard Disk Drive I/F 32
Magnetic Disk Drive I/F 33
Optical Drive I/F 34
Serial Port I/F 46
Network I/F 53
Modem 54
WAN 52
LAN 51
Remote Computer(s) 49
Monitor 47
Storage Device 62
SCSI Bus 56
System Bus 23
Hard Drive 27
Floppy Drive 28
Optical Drive 30
Removable Storage 29
Keyboard 40
Mouse 42
Floppy Drive 50
Applications 36'
OS 35
Apps. 36
Other Progs. 37
Program Data 38

FIG. 1

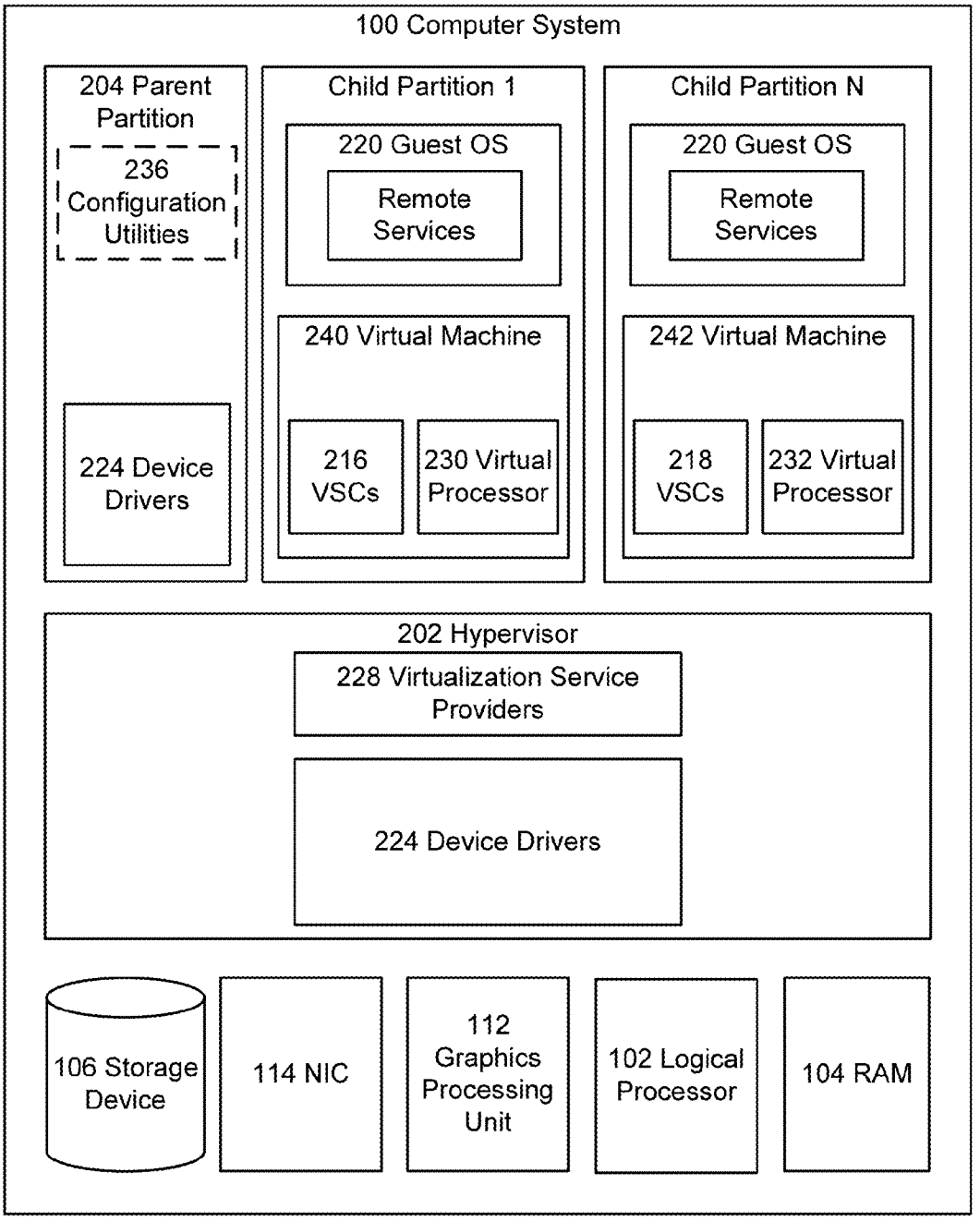

100 Computer System
204 Parent Partition
236 Configuration Utilities
224 Device Drivers
Child Partition 1
220 Guest OS
Remote Services
240 Virtual Machine
216 VSCs
230 Virtual Processor
Child Partition N
220 Guest OS
Remote Services
242 Virtual Machine
218 VSCs
232 Virtual Processor
202 Hypervisor
228 Virtualization Service Providers
224 Device Drivers
106 Storage Device
114 NIC
112 Graphics Processing Unit
102 Logical Processor
104 RAM

FIG. 2

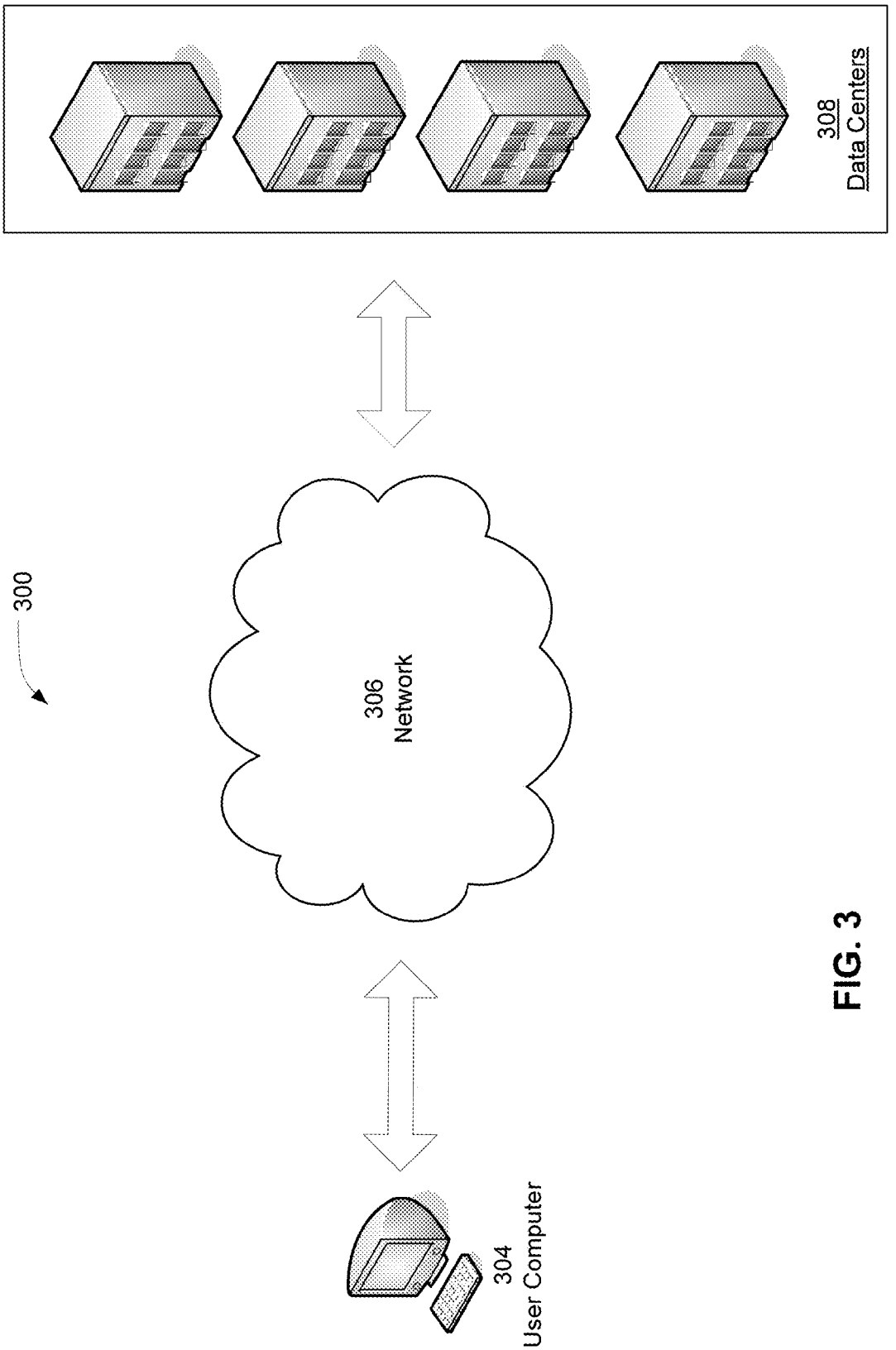


FIG. 3

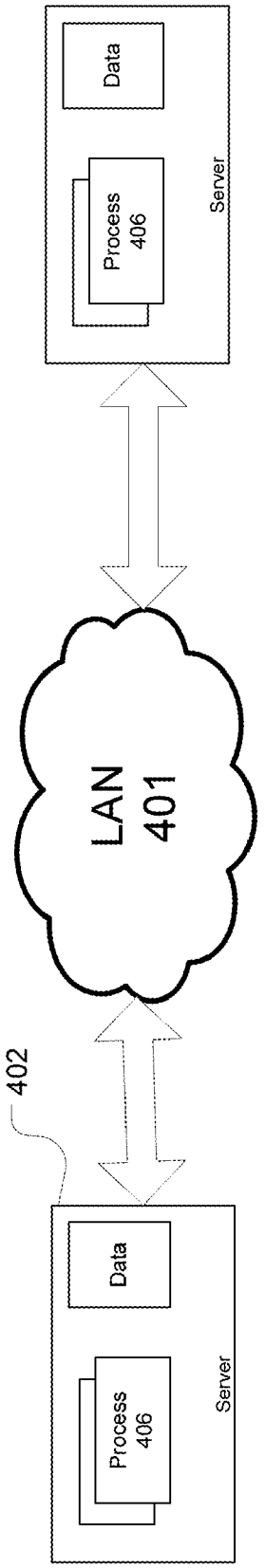


FIG. 4

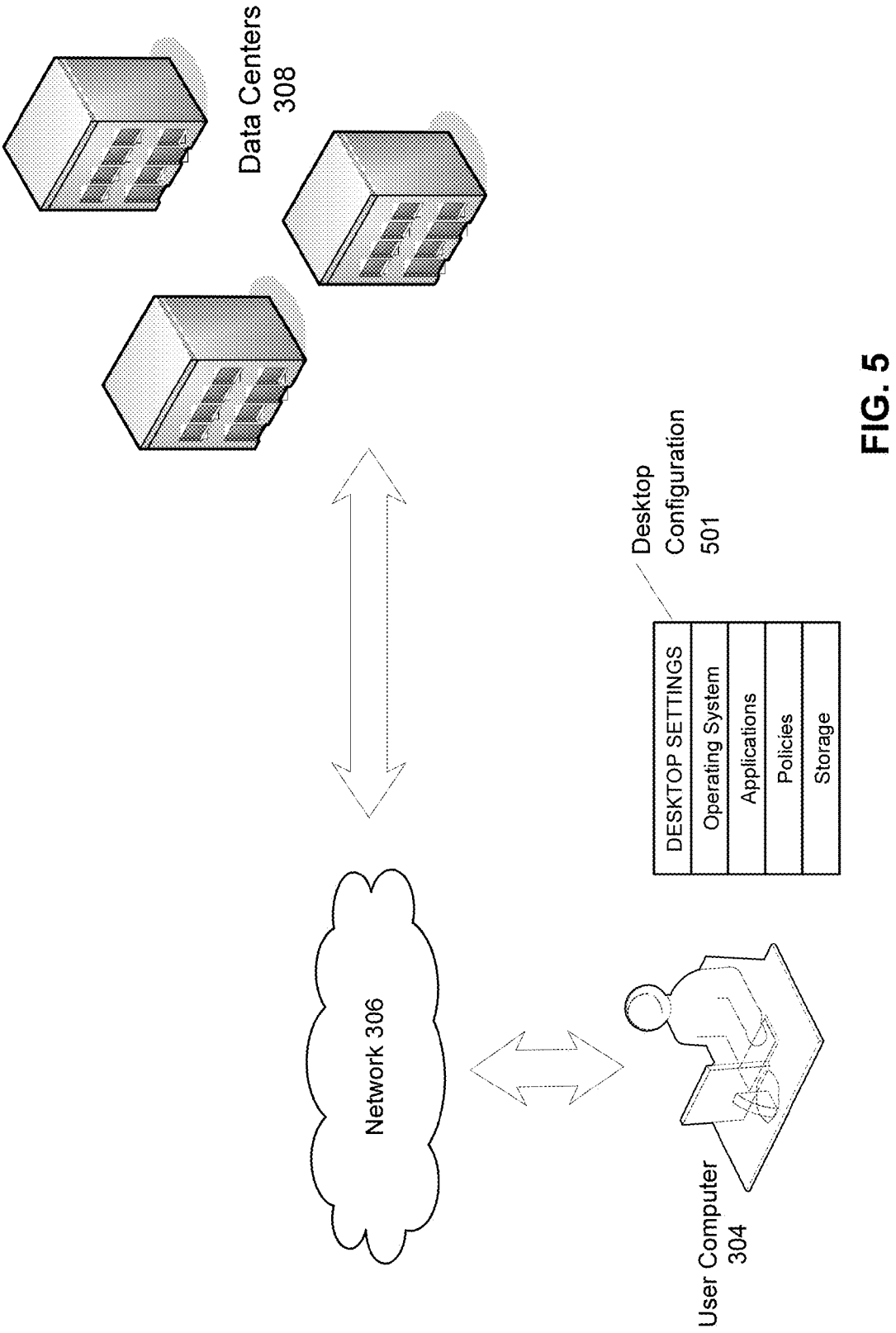

Data Centers
308
Desktop
Configuration
501
DESKTOP SETTINGS
Operating System
Applications
Policies
Storage
Network 306
User Computer
304

FIG. 5

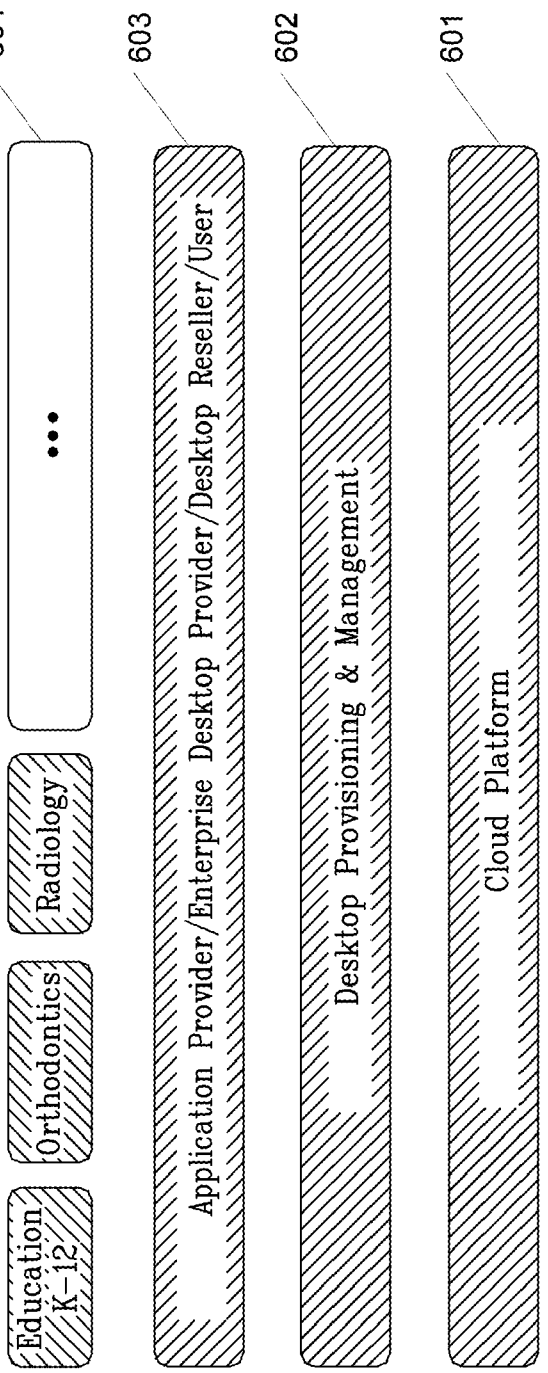

604
603
602
601
Education K-12
Orthodontics
Radiology
...
Application Provider/Enterprise Desktop Provider/Desktop Reseller/User
Desktop Provisioning & Management
Cloud Platform

FIG. 6

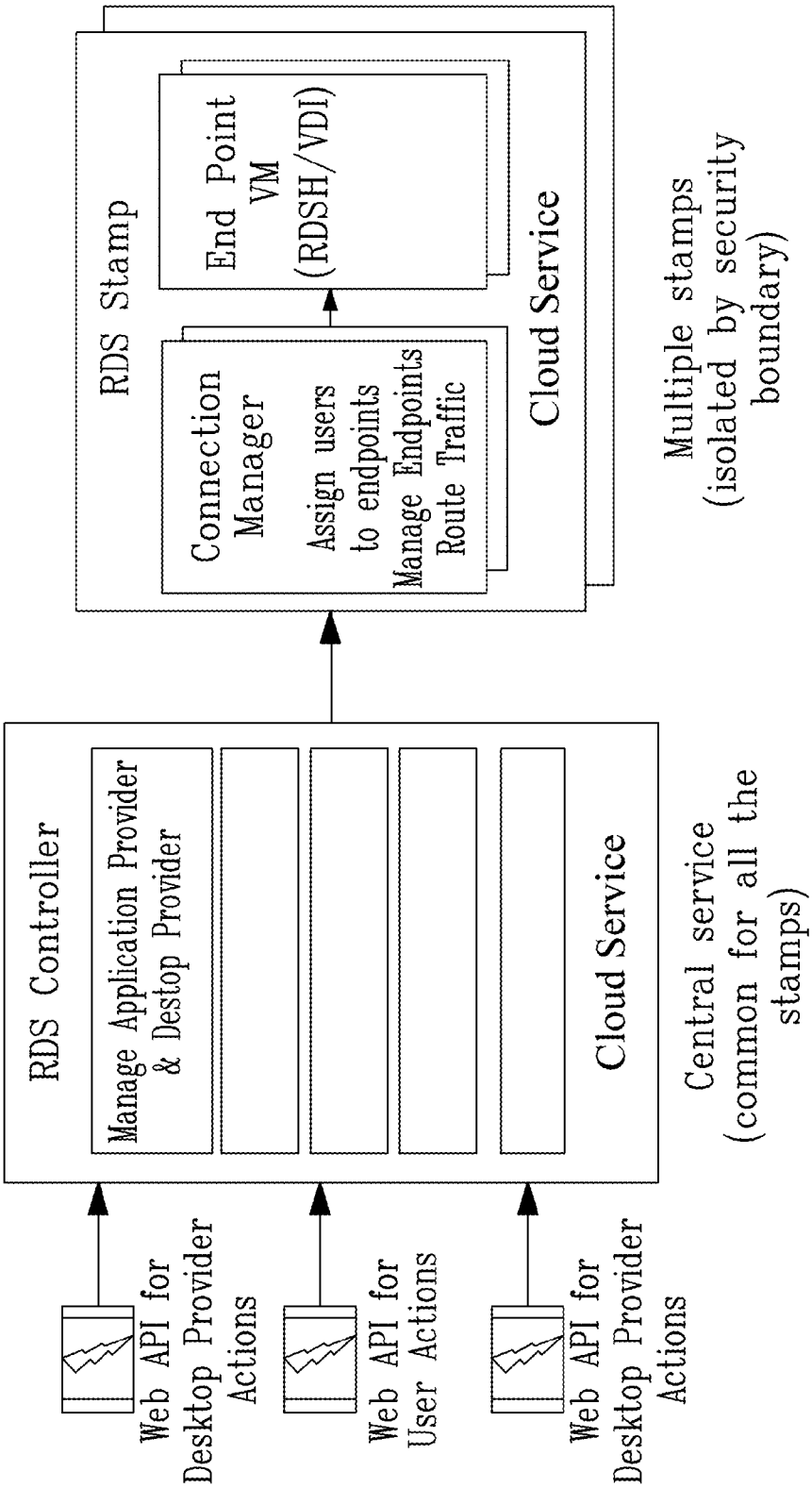

RDS Controller
Manage Application Provider & Destop Provider
Cloud Service
Central service (common for all the stamps)
Web API for Desktop Provider Actions
Web API for User Actions
Web API for Desktop Provider Actions
RDS Stamp
Connection Manager
Assign users to endpoints
Manage Endpoints
Route Traffic
End Point VM (RDSH/VDI)
Cloud Service
Multiple stamps (isolated by security boundary)

FIG. 7

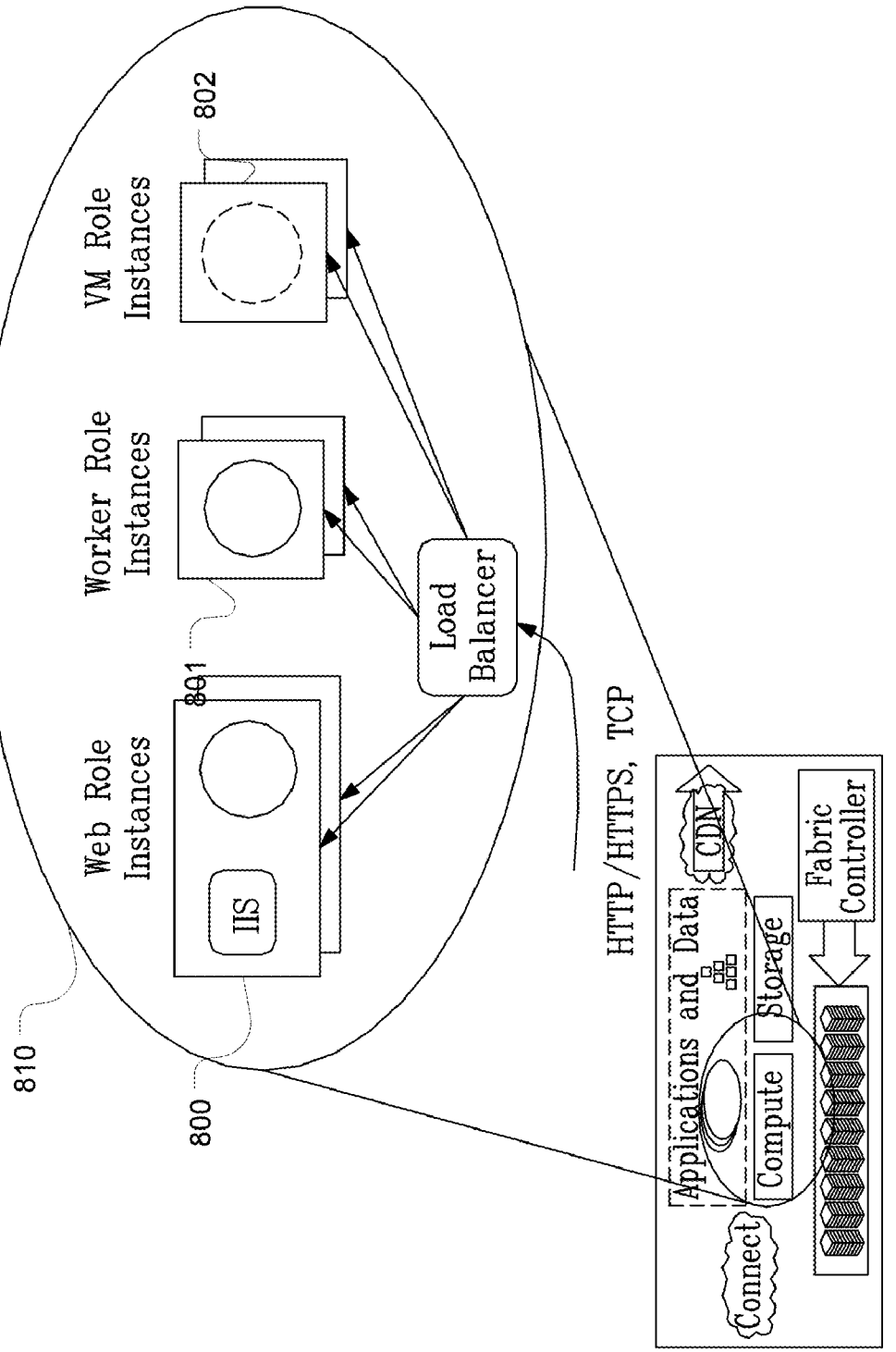

Web Role Instances
Worker Role Instances
VM Role Instances
IIS
Load Balancer
HTTP/HTTPS, TCP
Applications and Data
CDN
Storage
Compute
Fabric Controller
Connect
810
800
801
802

FIG. 8

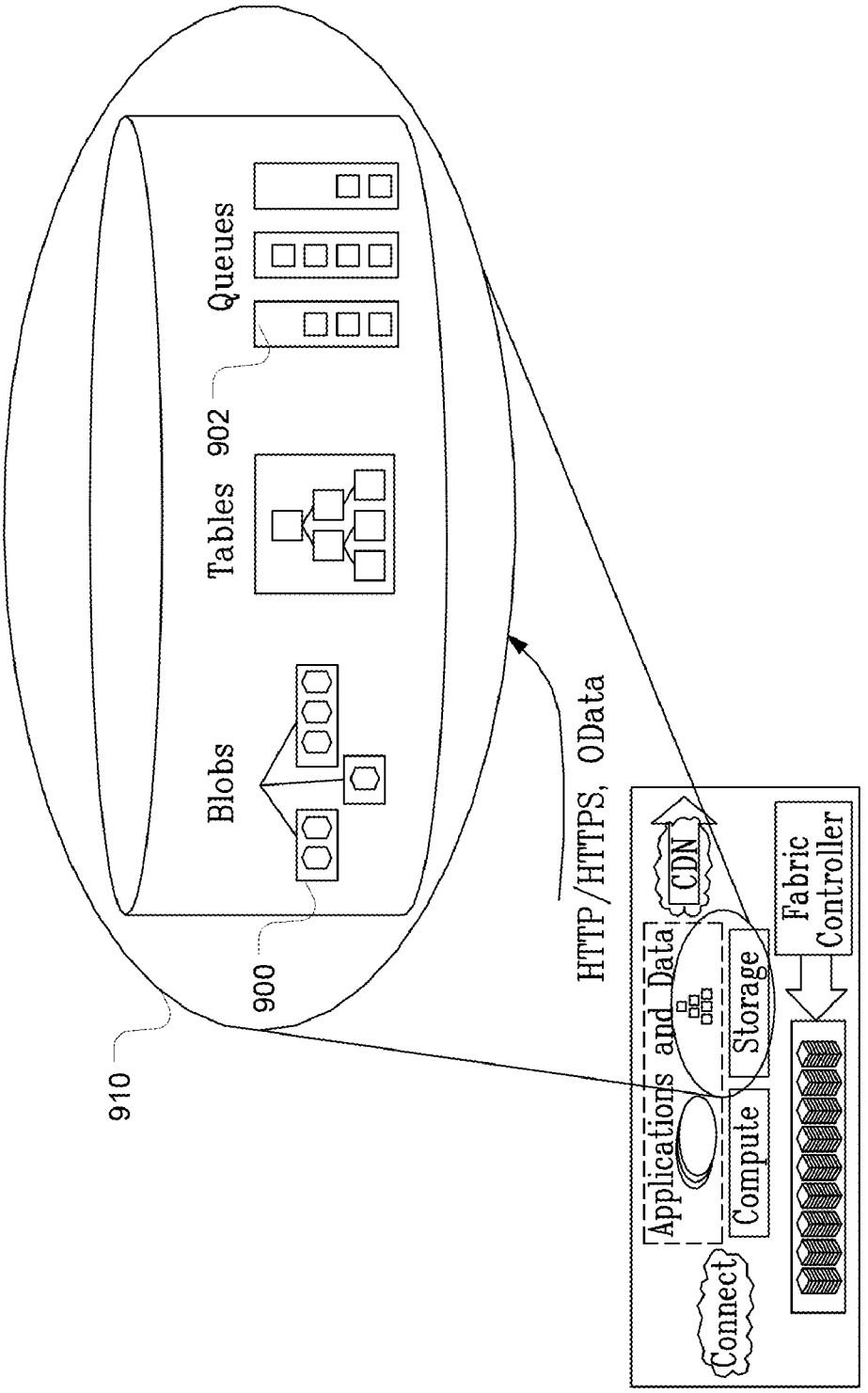

910
900
Blobs
Tables
902
Queues
HTTP/HTTPS, OData
Applications and Data
CDN
Storage
Compute
Connect
Fabric Controller

FIG. 9

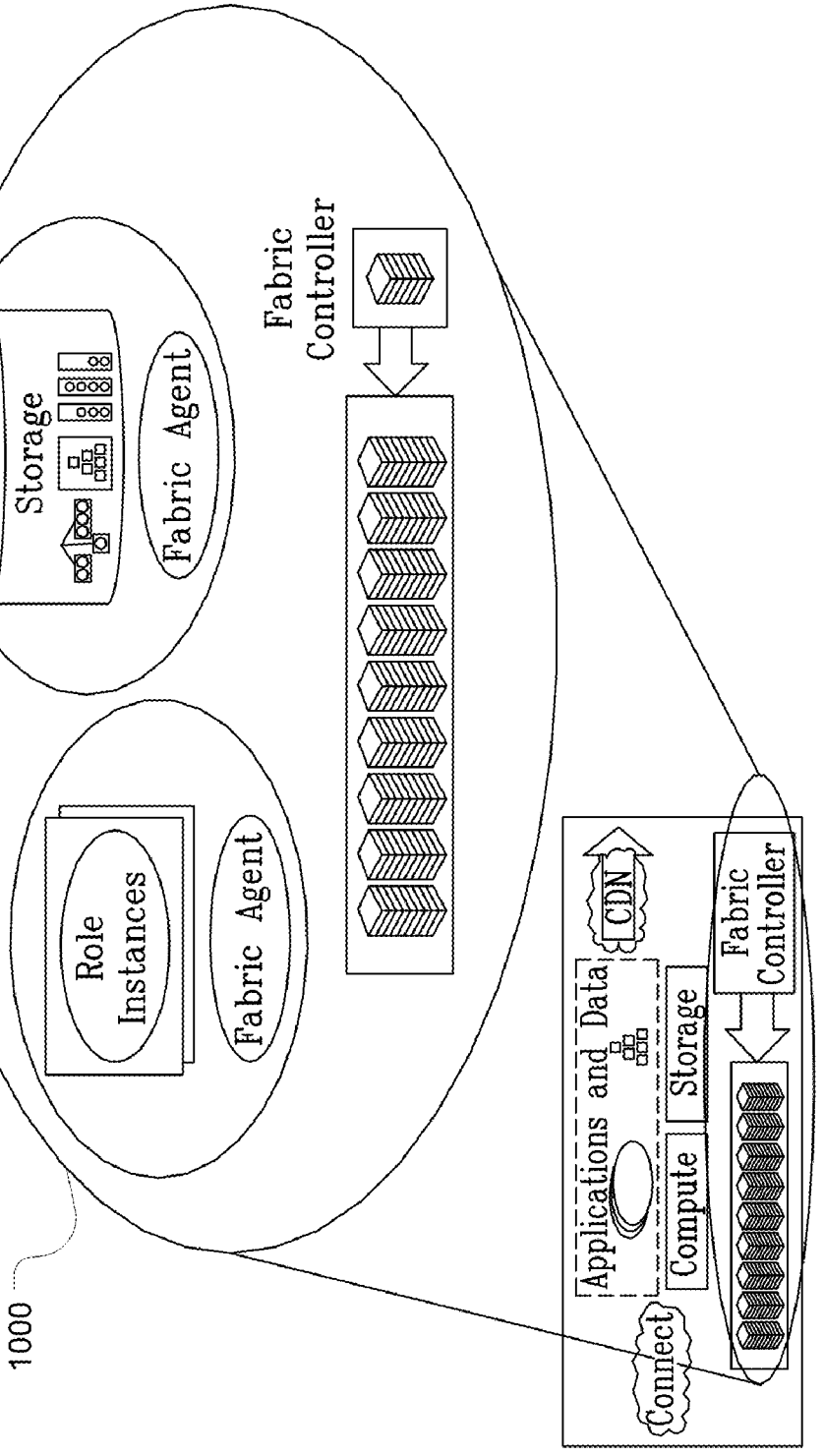

1000
Role Instances
Fabric Agent
Storage
Fabric Agent
Fabric Controller
Applications and Data
CDN
Compute
Storage
Fabric Controller
Connect

FIG. 10

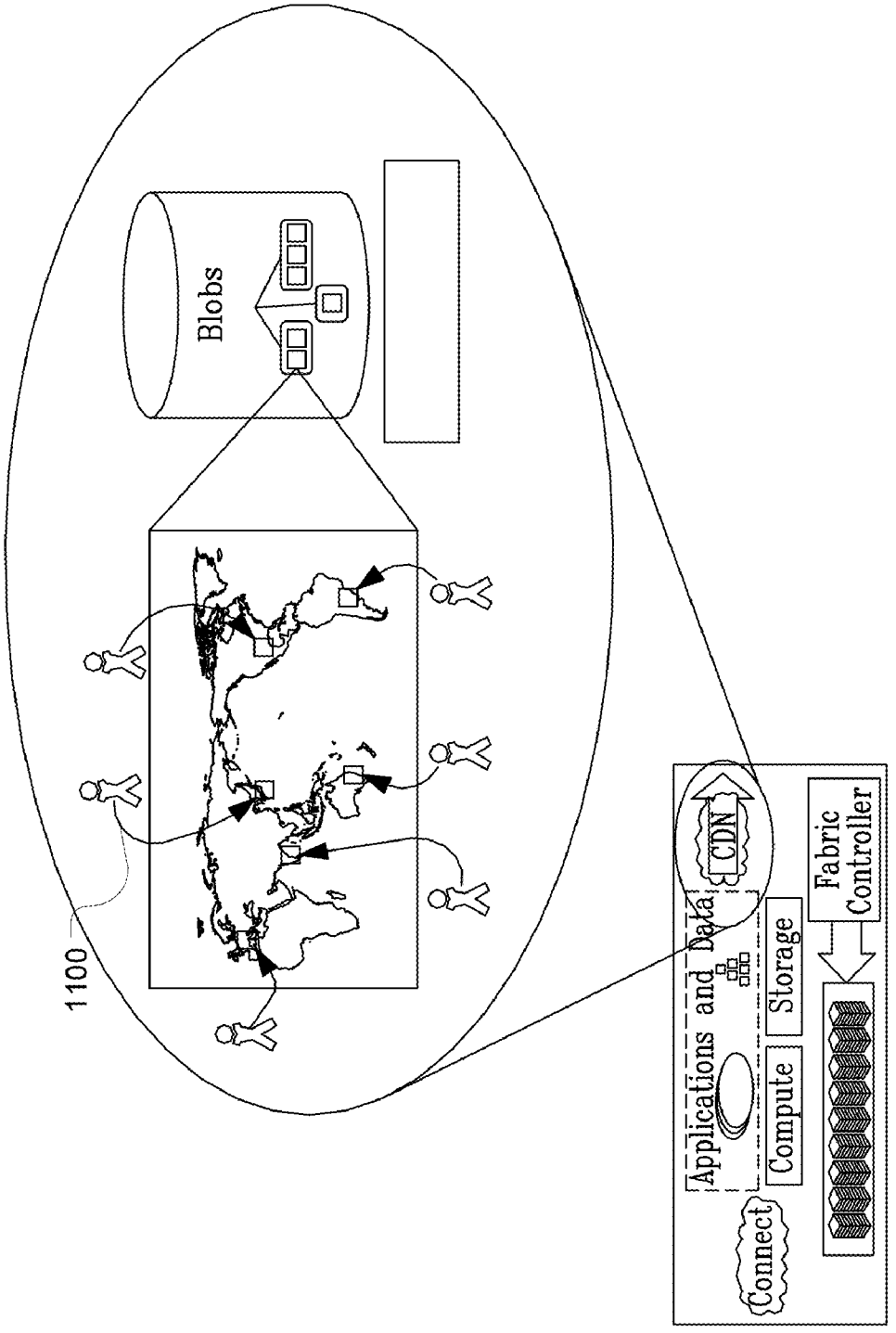

Blobs
1100
Applications and Data
CDN
Compute
Storage
Fabric Controller
Connect

FIG. 11

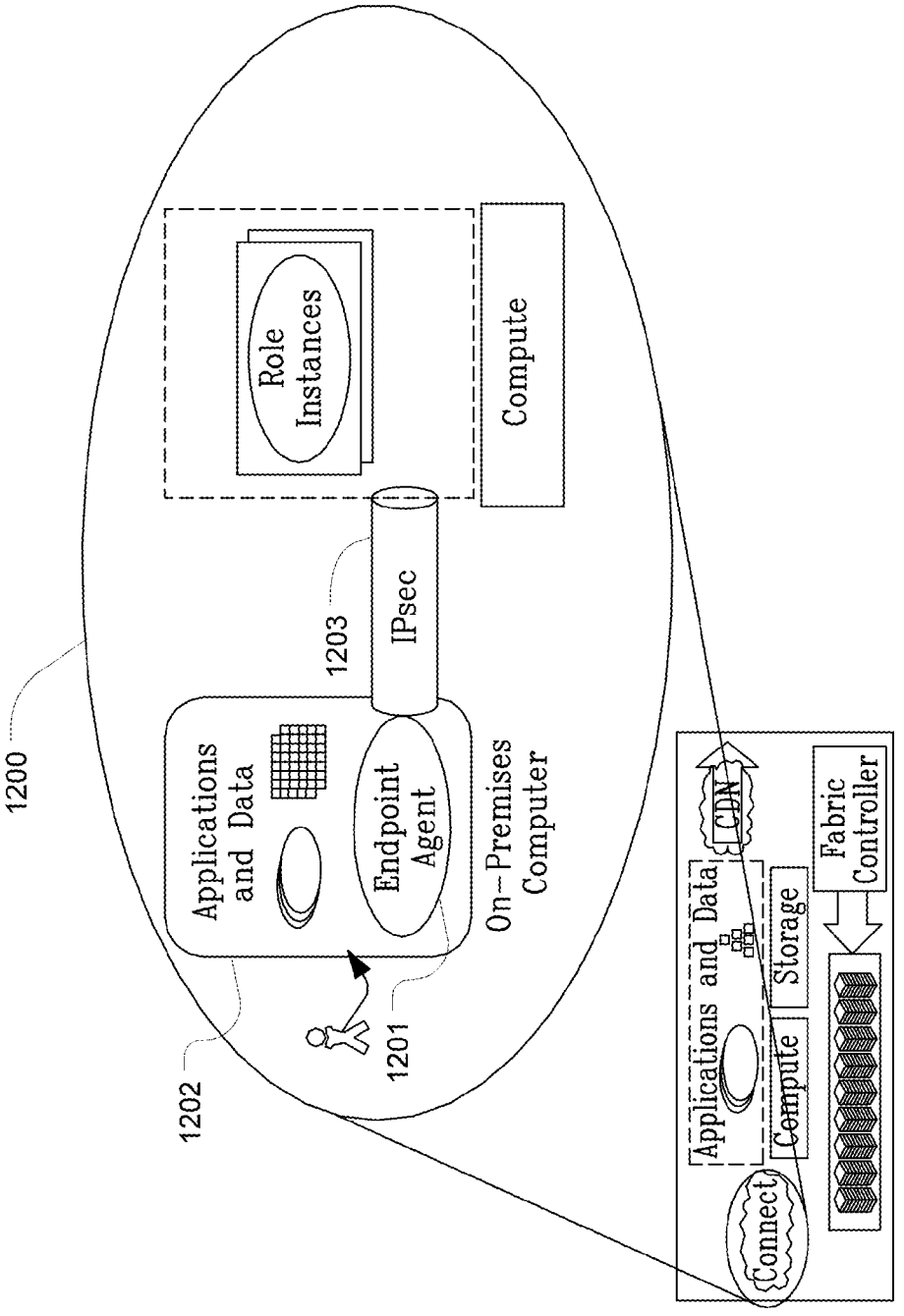

1200
Role Instances
Compute
1203
IPsec
Applications and Data
Endpoint Agent
On-Premises Computer
1201
1202
Connect
Applications and Data
Compute
Storage
CDN
Fabric Controller

FIG. 12

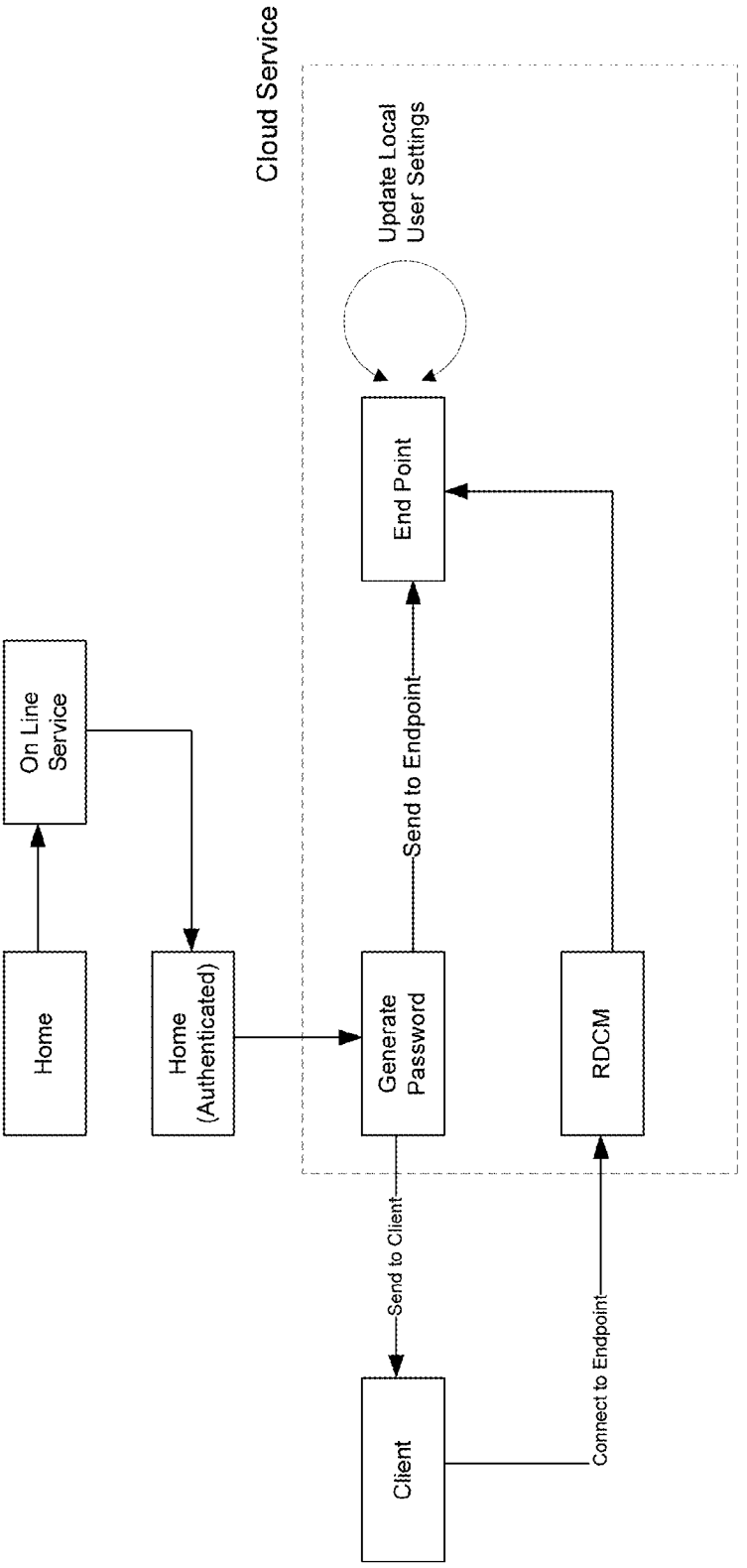

Cloud Service
Update Local User Settings
End Point
Send to Endpoint
On Line Service
Home
Home (Authenticated)
Generate Password
RDCM
Send to Client
Connect to Endpoint
Client

FIG. 13

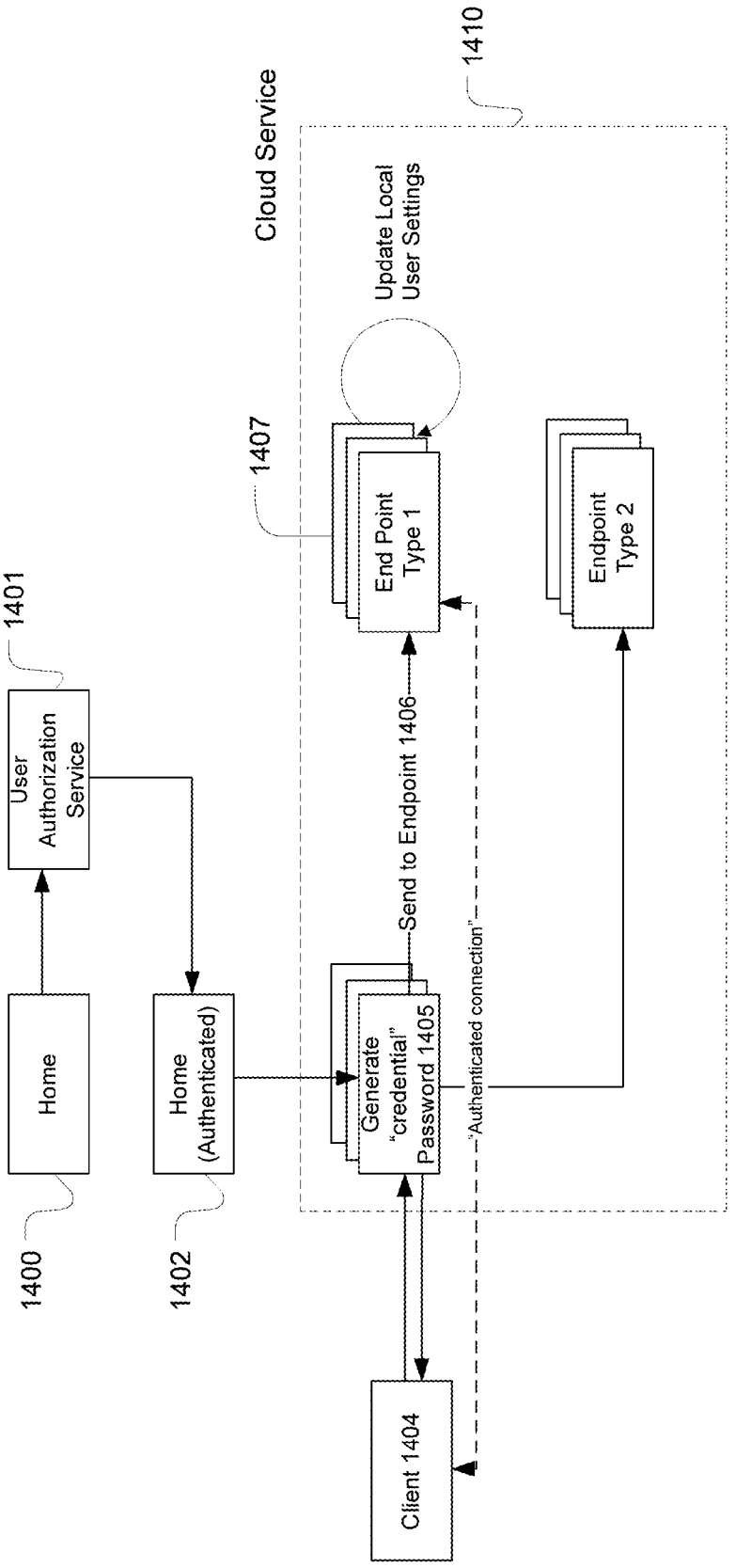

1410
Cloud Service
Update Local User Settings
1407
End Point Type 1
Endpoint Type 2
1401
User Authorization Service
Send to Endpoint 1406
Home
Home (Authenticated)
Generate "credential" Password 1405
"Authenticated connection"
1400
1402
Client 1404

FIG. 14

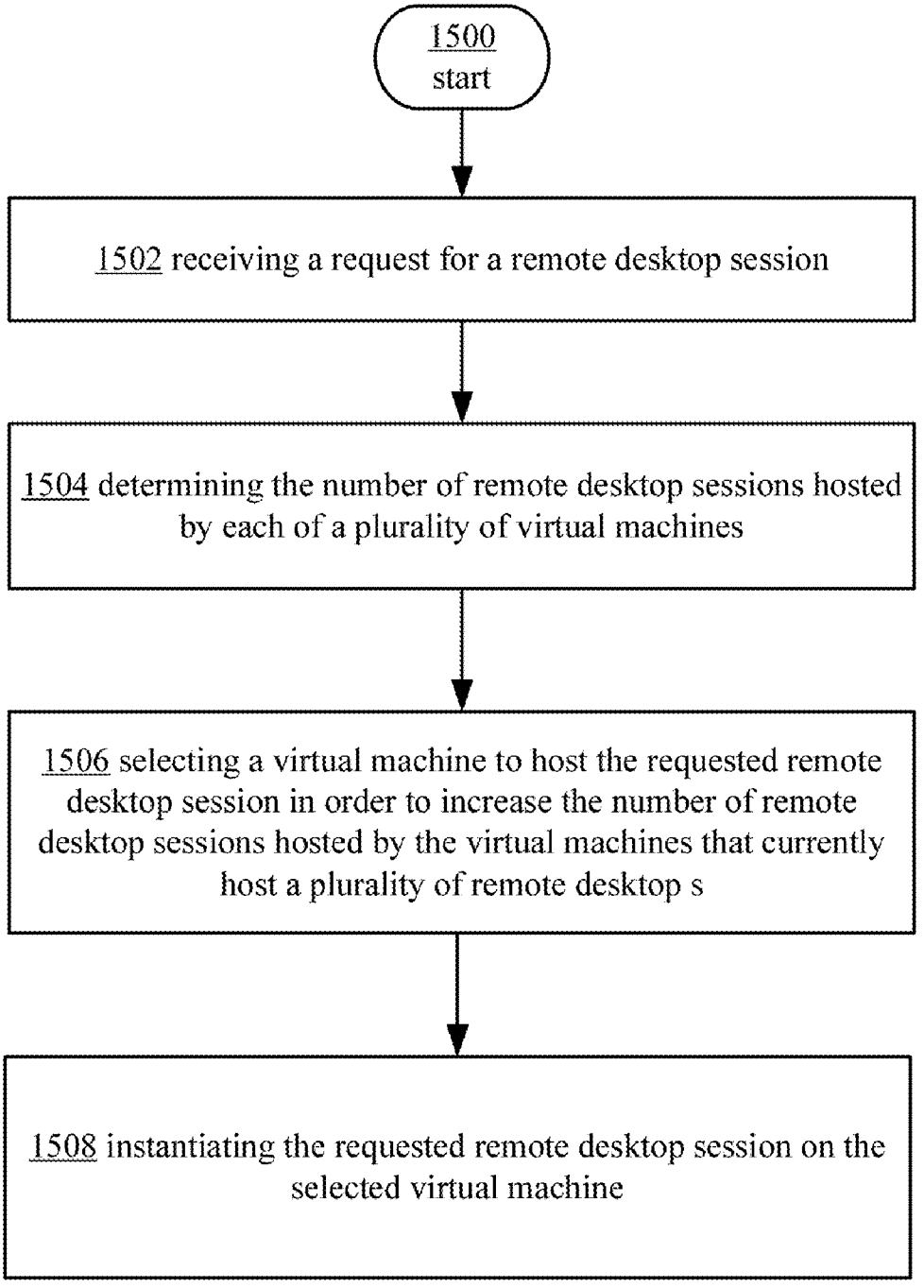

1500
start
1502 receiving a request for a remote desktop session
1504 determining the number of remote desktop sessions hosted by each of a plurality of virtual machines
1506 selecting a virtual machine to host the requested remote desktop session in order to increase the number of remote desktop sessions hosted by the virtual machines that currently host a plurality of remote desktop s
1508 instantiating the requested remote desktop session on the selected virtual machine

FIG. 15

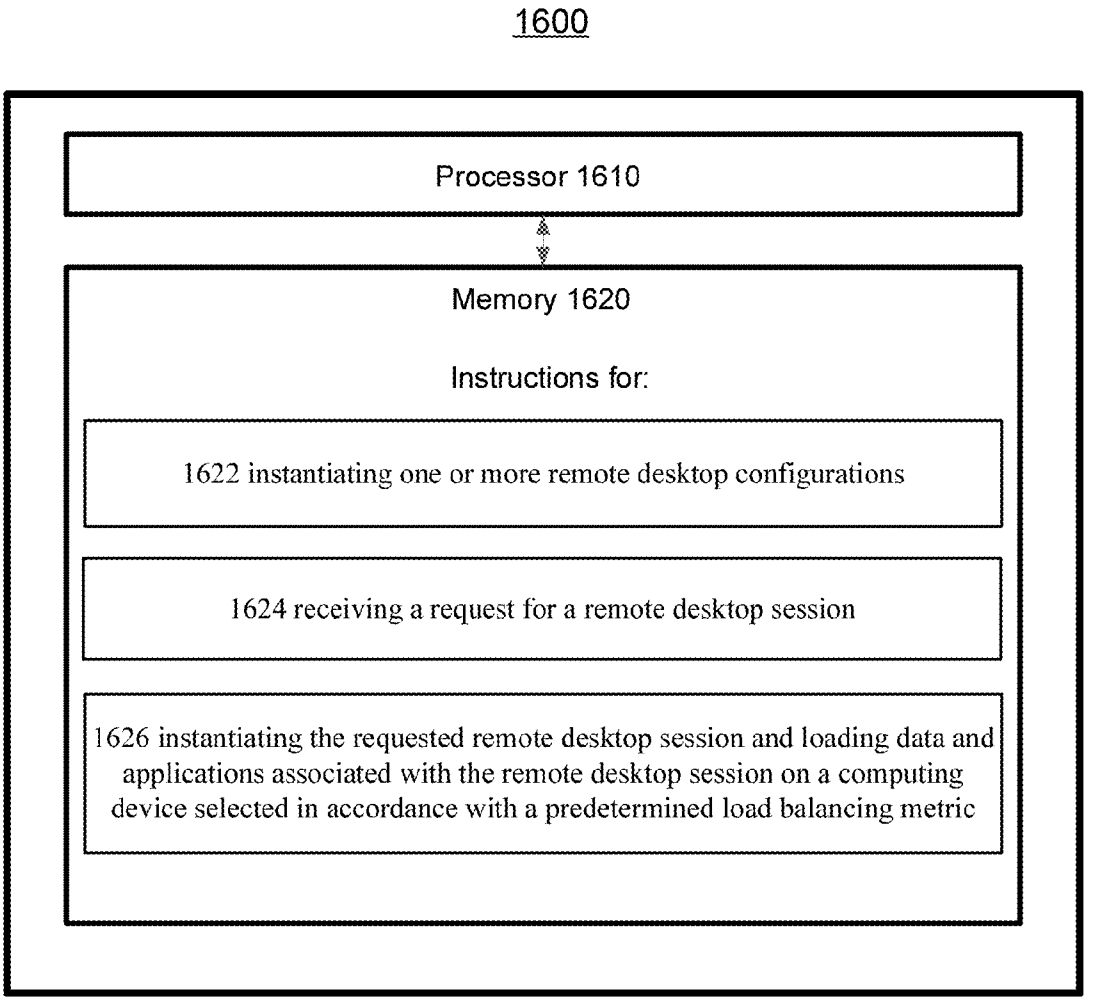

1600
Processor 1610
Memory 1620
Instructions for:
1622 instantiating one or more remote desktop configurations
1624 receiving a request for a remote desktop session
1626 instantiating the requested remote desktop session and loading data and applications associated with the remote desktop session on a computing device selected in accordance with a predetermined load balancing metric

FIG. 16

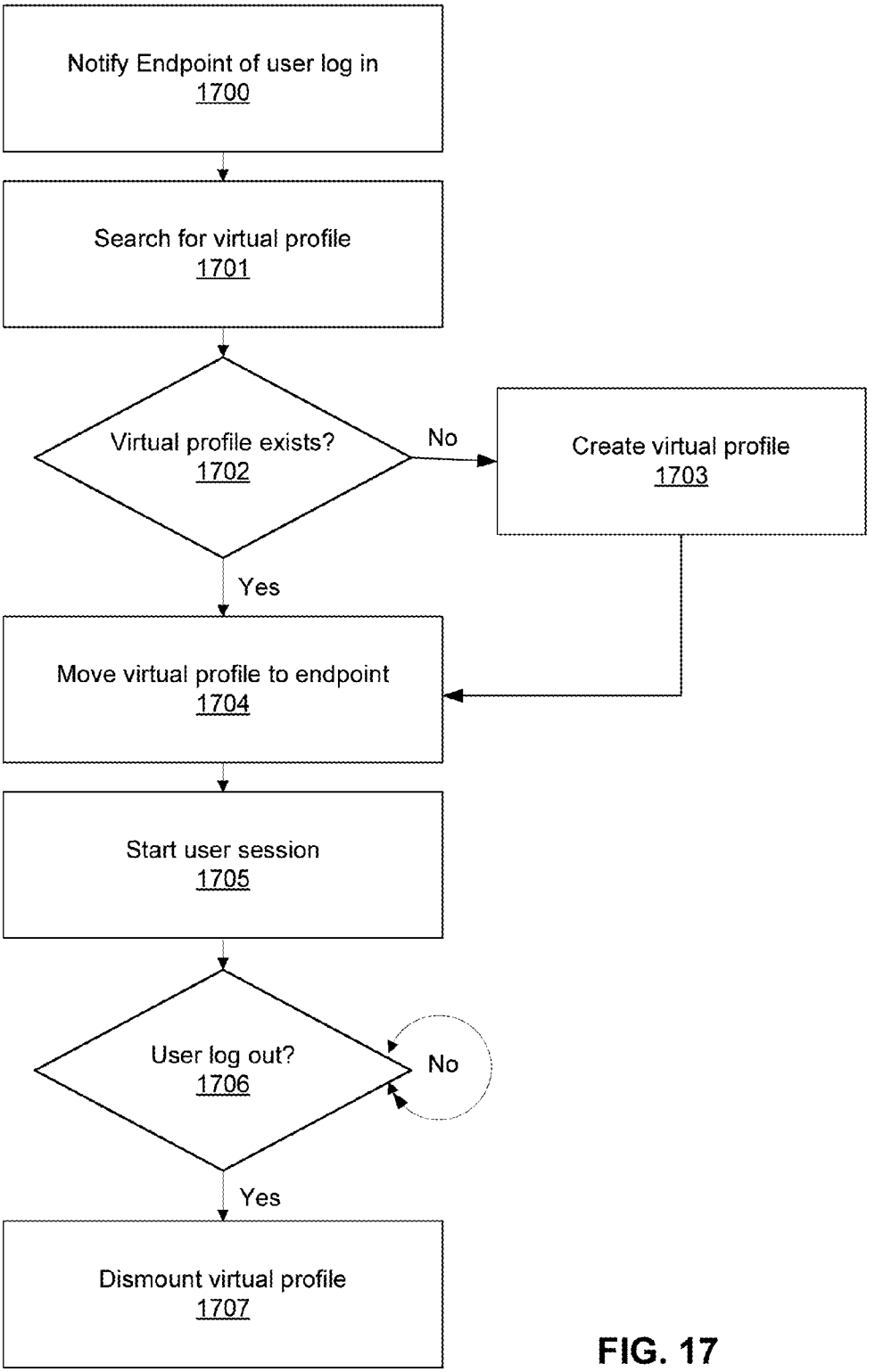

Notify Endpoint of user log in
1700
Search for virtual profile
1701
Virtual profile exists?
1702
No
Create virtual profile
1703
Yes
Move virtual profile to endpoint
1704
Start user session
1705
User log out?
1706
No
Yes
Dismount virtual profile
1707

FIG. 17

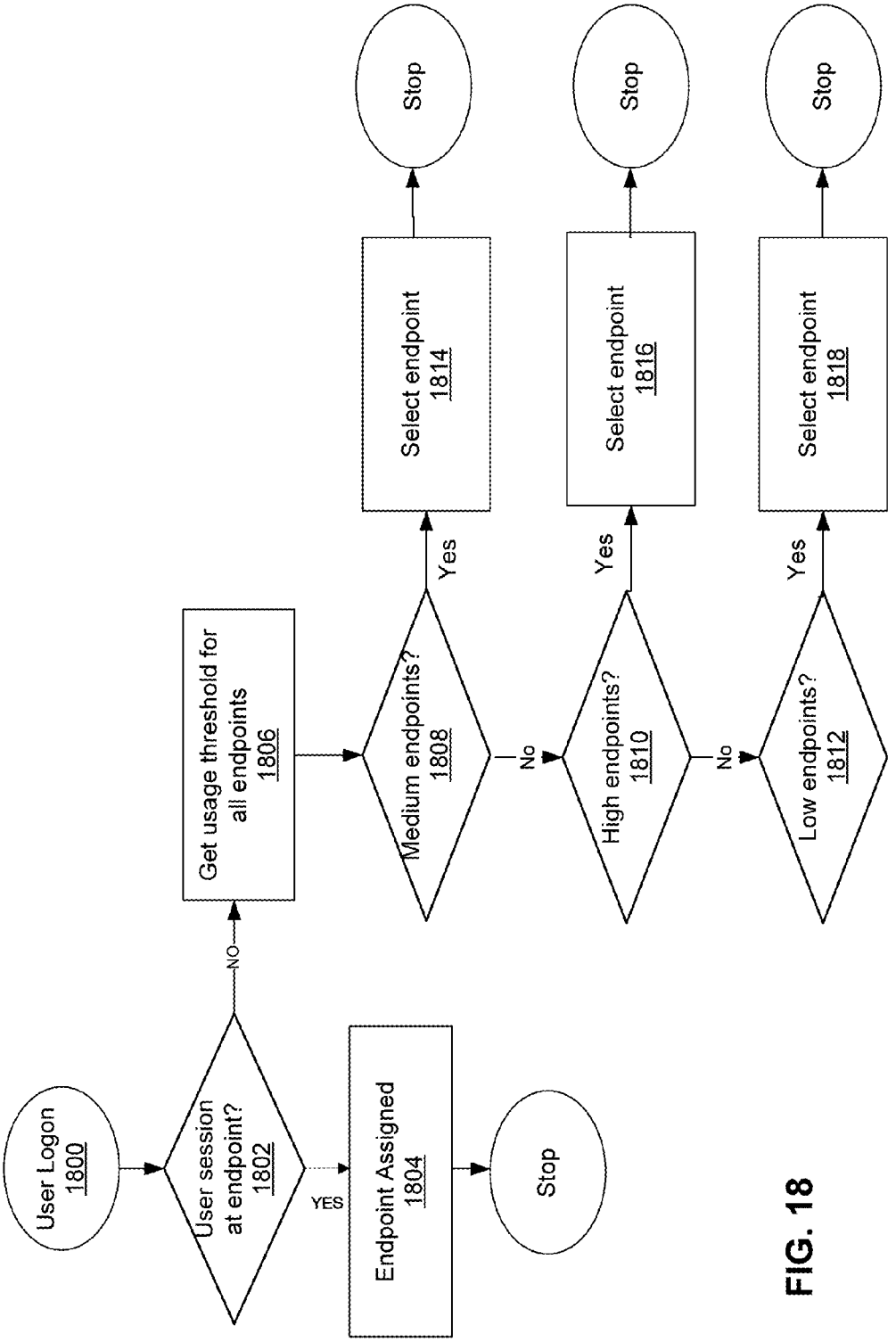

User Logon
1800
User session at endpoint?
1802
YES
NO
Endpoint Assigned
1804
Stop
Get usage threshold for all endpoints
1806
Medium endpoints?
1808
Yes
No
High endpoints?
1810
Yes
No
Low endpoints?
1812
Yes
Select endpoint
1814
Select endpoint
1816
Select endpoint
1818
Stop
Stop
Stop

FIG. 18

LOAD BALANCING BY ENDPOINTS

BACKGROUND

[0001] One increasingly popular form of networking may generally be referred to as remote presentation systems, which can use protocols such as Remote Desktop Protocol (RDP) and Independent Computing Architecture (ICA) to share a desktop and other applications executing on a server with a remote client. Cloud computing refers to a computing environment for enabling on-demand network access to a shared pool of computing resources. Many cloud computing services involve virtualized resources such as those described above and may take the form of web-based tools or applications that run on a server in the cloud but that users can access and use through a web browser as if the web-based tools or applications were programs installed locally on their own computers. The virtualized resources are typically hosted in computing systems located in a computing data center.

SUMMARY

[0002] Disclosed are methods and systems for balancing client sessions across virtual machines such that the number of virtual machines is efficiently managed. In some embodiments, the total number of virtual machines is minimized to reduce power consumption, cooling, and other cost drivers, while assigning users across the sessions. In one embodiment, the sessions in a virtual machine with low activity are migrated to a virtual machine with higher session rates to allow for the shutdown of the low usage virtual machines. In another embodiment, new user sessions are assigned according to a minimum performance standard.

BRIEF DESCRIPTION OF THE DRAWINGS

[0003] The systems, methods, and computer readable media for managing a virtualized computing infrastructure in accordance with this specification are further described with reference to the accompanying drawings in which:

[0004] FIG. **1** depicts an example computing environment wherein aspects of the present disclosure can be implemented.

[0005] FIG. **2** depicts an example computing environment wherein aspects of the present disclosure can be implemented.

[0006] FIG. **3** depicts an example computing environment including data centers.

[0007] FIG. **4** depicts an operational environment of a data center.

[0008] FIG. **5** depicts an operational environment for practicing aspects of the present disclosure.

[0009] FIG. **6** illustrates an example architecture for practicing some of the methods disclosed herein.

[0010] FIG. **7** illustrates an example block diagram depicting some of the methods disclosed herein.

[0011] FIG. **8** illustrates an example block diagram depicting the compute component of a cloud data service.

[0012] FIG. **9** illustrates an example block diagram depicting the storage component of a cloud data service.

[0013] FIG. **10** illustrates an example block diagram depicting the fabric controller component of a cloud data service.

[0014] FIG. **11** illustrates an example block diagram depicting the CDN component of a cloud data service.

[0015] FIG. **12** illustrates an example block diagram depicting the connect component of a cloud data service.

[0016] FIG. **13** illustrates an example embodiment of the methods disclosed herein.

[0017] FIG. **14** illustrates an example embodiment of the methods disclosed herein.

[0018] FIG. **15** illustrates an example of an operational procedure for practicing aspects of the present disclosure.

[0019] FIG. **16** illustrates an example system for practicing aspects of the present disclosure.

[0020] FIG. **17** illustrates an example embodiment of a user data mounting scenario.

[0021] FIG. **18** illustrates an example embodiment of a load balancing scenario.

DETAILED DESCRIPTION

[0022] Certain specific details are set forth in the following description and figures to provide a thorough understanding of various embodiments of the disclosure. Certain well-known details often associated with computing and software technology are not set forth in the following disclosure to avoid unnecessarily obscuring the various embodiments of the disclosure. Further, those of ordinary skill in the relevant art will understand that they can practice other embodiments of the disclosure without one or more of the details described below. Finally, while various methods are described with reference to steps and sequences in the following disclosure, the description as such is for providing a clear implementation of embodiments of the disclosure, and the steps and sequences of steps should not be taken as required to practice this disclosure.

[0023] It should be understood that the various techniques described herein may be implemented in connection with hardware or software or, where appropriate, with a combination of both. Thus, the methods and apparatus of the disclosure, or certain aspects or portions thereof, may take the form of program code (i.e., instructions) embodied in tangible media, such as floppy diskettes, CD-ROMs, hard drives, or any other machine-readable storage medium wherein, when the program code is loaded into and executed by a machine, such as a computer, the machine becomes an apparatus for practicing the disclosure. In the case of program code execution on programmable computers, the computing device generally includes a processor, a storage medium readable by the processor (including volatile and non-volatile memory and/or storage elements), at least one input device, and at least one output device. One or more programs that may implement or utilize the processes described in connection with the disclosure, e.g., through the use of an application programming interface (API), reusable controls, or the like. Such programs are preferably implemented in a high level procedural or object oriented programming language to communicate with a computer system. However, the program(s) can be implemented in assembly or machine language, if desired. In any case, the language may be a compiled or interpreted language, and combined with hardware implementations.

[0024] A remote desktop system is a computer system that maintains applications that can be remotely executed by client computer systems. Input is entered at a client computer system and transferred over a network (e.g., using protocols based on the International Telecommunications Union (ITU) T.120 family of protocols such as Remote Desktop Protocol (RDP)) to an application on a terminal server. The application processes the input as if the input were entered at the terminal

server. The application generates output in response to the received input and the output is transferred over the network to the client

[0025] Embodiments may execute on one or more computers. FIG. **1** and the following discussion are intended to provide a brief general description of a suitable computing environment in which the disclosure may be implemented. One skilled in the art can appreciate that computer systems **200**, **300** can have some or all of the components described with respect to computer **100** of FIG. **1**.

[0026] The term circuitry used throughout the disclosure can include hardware components such as hardware interrupt controllers, hard drives, network adaptors, graphics processors, hardware based video/audio codecs, and the firmware/software used to operate such hardware. The term circuitry can also include microprocessors configured to perform function(s) by firmware or by switches set in a certain way or one or more logical processors, e.g., one or more cores of a multi-core general processing unit. The logical processor(s) in this example can be configured by software instructions embodying logic operable to perform function(s) that are loaded from memory, e.g., RAM, ROM, firmware, and/or virtual memory. In example embodiments where circuitry includes a combination of hardware and software an implementer may write source code embodying logic that is subsequently compiled into machine readable code that can be executed by a logical processor. Since one skilled in the art can appreciate that the state of the art has evolved to a point where there is little difference between hardware, software, or a combination of hardware/software, the selection of hardware versus software to effectuate functions is merely a design choice. Thus, since one of skill in the art can appreciate that a software process can be transformed into an equivalent hardware structure, and a hardware structure can itself be transformed into an equivalent software process, the selection of a hardware implementation versus a software implementation is trivial and left to an implementer.

[0027] FIG. **1** depicts an example of a computing system which is configured with aspects of the disclosure. The computing system can include a computer **20** or the like, including a processing unit **21**, a system memory **22**, and a system bus **23** that couples various system components including the system memory to the processing unit **21**. The system bus **23** may be any of several types of bus structures including a memory bus or memory controller, a peripheral bus, and a local bus using any of a variety of bus architectures. The system memory includes read only memory (ROM) **24** and random access memory (RAM) **25**. A basic input/output system **26** (BIOS), containing the basic routines that help to transfer information between elements within the computer **20**, such as during start up, is stored in ROM **24**. The computer **20** may further include a hard disk drive **27** for reading from and writing to a hard disk, not shown, a magnetic disk drive **28** for reading from or writing to a removable magnetic disk **29**, and an optical disk drive **30** for reading from or writing to a removable optical disk **31** such as a CD ROM or other optical media. In some example embodiments, computer executable instructions embodying aspects of the disclosure may be stored in ROM **24**, hard disk (not shown), RAM **25**, removable magnetic disk **29**, optical disk **31**, and/or a cache of processing unit **21**. The hard disk drive **27**, magnetic disk drive **28**, and optical disk drive **30** are connected to the system bus **23** by a hard disk drive interface **32**, a magnetic disk drive interface **33**, and an optical drive interface **34**, respectively. The drives and their associated computer readable media provide nonvolatile storage of computer readable instructions, data structures, program modules and other data for the computer **20**. Although the environment described herein employs a hard disk, a removable magnetic disk **29** and a removable optical disk **31**, it should be appreciated by those skilled in the art that other types of computer readable media which can store data that is accessible by a computer, such as magnetic cassettes, flash memory cards, digital video disks, Bernoulli cartridges, random access memories (RAMs), read only memories (ROMs) and the like may also be used in the operating environment.

[0028] A number of program modules may be stored on the hard disk, magnetic disk **29**, optical disk **31**, ROM **24** or RAM **25**, including an operating system **35**, one or more application programs **36**, other program modules **37** and program data **38**. A user may enter commands and information into the computer **20** through input devices such as a keyboard **40** and pointing device **42**. Other input devices (not shown) may include a microphone, joystick, game pad, satellite disk, scanner or the like. These and other input devices are often connected to the processing unit **21** through a serial port interface **46** that is coupled to the system bus, but may be connected by other interfaces, such as a parallel port, game port or universal serial bus (USB). A display **47** or other type of display device can also be connected to the system bus **23** via an interface, such as a video adapter **48**. In addition to the display **47**, computers typically include other peripheral output devices (not shown), such as speakers and printers. The system of FIG. **1** also includes a host adapter **55**, Small Computer System Interface (SCSI) bus **56**, and an external storage device **62** connected to the SCSI bus **56**.

[0029] The computer **20** may operate in a networked environment using logical connections to one or more remote computers, such as a remote computer **49**. The remote computer **49** may be another computer, a server, a router, a network PC, a peer device or other common network node, a virtual machine, and typically can include many or all of the elements described above relative to the computer **20**, although only a memory storage device **50** has been illustrated in FIG. **1**. The logical connections depicted in FIG. **1** can include a local area network (LAN) **51** and a wide area network (WAN) **52**. Such networking environments are commonplace in offices, enterprise wide computer networks, intranets and the Internet.

[0030] When used in a LAN networking environment, the computer **20** can be connected to the LAN **51** through a network interface or adapter **53**. When used in a WAN networking environment, the computer **20** can typically include a modem **54** or other means for establishing communications over the wide area network **52**, such as the Internet. The modem **54**, which may be internal or external, can be connected to the system bus **23** via the serial port interface **46**. In a networked environment, program modules depicted relative to the computer **20**, or portions thereof, may be stored in the remote memory storage device. It will be appreciated that the network connections shown are examples and other means of establishing a communications link between the computers may be used. Moreover, while it is envisioned that numerous embodiments of the disclosure are particularly well-suited for computer systems, nothing in this document is intended to limit the disclosure to such embodiments.

[0031] Referring now to FIG. **2**, depicted is a high level block diagram of a computer system configured to effectuate

virtual machines. As shown in the figures, computer system **100** can include elements described in FIGS. **1** and **2** and components operable to effectuate virtual machines. One such component is a hypervisor **202** that may also be referred to in the art as a virtual machine monitor. The hypervisor **202** in the depicted embodiment can be configured to control and arbitrate access to the hardware of computer system **100**. Broadly stated, the hypervisor **202** can generate execution environments called partitions such as child partition **1** through child partition N (where N is an integer greater than or equal to 1). In embodiments a child partition can be considered the basic unit of isolation supported by the hypervisor **202**, that is, each child partition can be mapped to a set of hardware resources, e.g., memory, devices, logical processor cycles, etc., that is under control of the hypervisor **202** and/or the parent partition and hypervisor **202** can isolate one partition from accessing another partition's resources. In embodiments the hypervisor **202** can be a stand-alone software product, a part of an operating system, embedded within firmware of the motherboard, specialized integrated circuits, or a combination thereof

[0032] In the above example, computer system **100** includes a parent partition **204** that can also be thought of as domain **0** in the open source community. Parent partition **204** can be configured to provide resources to guest operating systems executing in child partitions **1**-N by using virtualization service. Each child partition can include one or more virtual processors such as virtual processors **230** through **232** that guest operating systems **220** through **222** can manage and schedule threads to execute thereon. Generally, the virtual processors **230** through **232** are executable instructions and associated state information that provide a representation of a physical processor with a specific architecture. For example, one virtual machine may have a virtual processor having characteristics of an Intel x86 processor, whereas another virtual processor may have the characteristics of a PowerPC processor. The virtual processors in this example can be mapped to logical processors of the computer system such that the instructions that effectuate the virtual processors will be backed by logical processors. Thus, in these example embodiments, multiple virtual processors can be simultaneously executing while, for example, another logical processor is executing hypervisor instructions. Generally speaking, and as illustrated by the figures, the combination of virtual processors and memory in a partition can be considered a virtual machine such as virtual machine **240** or **242**.

[0033] Generally, guest operating systems **220** through **222** can include any operating system such as, for example, operating systems from Microsoft®, Apple®, the open source community, etc. The guest operating systems can include user/kernel modes of operation and can have kernels that can include schedulers, memory managers, etc. A kernel mode can include an execution mode in a logical processor that grants access to at least privileged processor instructions. Each guest operating system **220** through **222** can have associated file systems that can have applications stored thereon such as terminal servers, e-commerce servers, email servers, etc., and the guest operating systems themselves. The guest operating systems **220**-**222** can schedule threads to execute on the virtual processors **230**-**232** and instances of such applications can be effectuated.

[0034] FIG. **3** and the following description are intended to provide a brief, general description of an example computing environment in which the embodiments described herein may be implemented. In particular, FIG. **3** depicts an illustrative operating environment **300** that includes data centers **308** for providing computing resources. Data centers **308** can provide computing resources for executing applications and providing data services on a continuous or an as-needed basis. The computing resources provided by the data centers **308** may include various types of resources, such as data processing resources, data storage resources, data communication resources, and the like. Each type of computing resource may be general-purpose or may be available in a number of specific configurations. For example, data processing resources may be available as virtual machine instances. The virtual machine instances may be configured to execute applications, including Web servers, application servers, media servers, database servers, and the like. Data storage resources may include file storage devices, block storage devices, and the like. The data center includes more than virtual machine computing resources, including a number of physical computing devices that can be configured to run one or more virtual machines that can be migrated across the physical resources to load balance.

[0035] The computing resources provided by the data centers **308** may be enabled by one or more individual data centers. The data centers **308** are facilities utilized to house and operate computer systems and associated components. The data centers **308** typically include redundant and backup power, communications, cooling, and security systems. The data centers **302** might also be located in geographically disparate locations. One illustrative configuration for a data center **308** that implements the concepts and technologies disclosed herein for scalably deploying a virtualized computing infrastructure will be described below with regard to FIG. **3**.

[0036] The customers and other consumers of the data centers **308** may access the computing resources provided by the data centers **302** over a network **306**. It should be appreciated that a local-area network ("LAN"), the Internet, or any other networking topology known in the art that connects the data centers **308** to remote consumers may be utilized. It should also be appreciated that combinations of such networks might also be utilized.

[0037] The user computer **304** may be a computer utilized by a customer or other consumer of the data centers **308**. For instance, the user computer **304** may be a server computer, a desktop or laptop personal computer, a thin client, a tablet computer, a wireless telephone, a personal digital assistant ("PDA"), an e-reader, a game console, a set-top box, or any other computing device capable of accessing the data centers **308**.

[0038] The user computer **304** may be utilized to configure aspects of the computing resources provided by the data centers **308**. In this regard, the data centers **308** may provide a Web interface through which aspects of its operation may be configured through the use of a Web browser application program executing on the customer computing system **304**. Alternatively, a stand-alone application program executing on the customer computing system **304** might access an application programming interface ("API") exposed by the data centers **308** for performing the configuration operations. Other mechanisms for configuring the operation of the data centers **308**, including deploying updates to an application, might also be utilized.

[0039] FIG. **4** depicts a computing system diagram that illustrates one configuration for a data center **308**, including

the concepts and technologies disclosed herein for scalably deploying a virtualized computing infrastructure. FIG. **2** includes server computers **402** for providing computing resources for executing an application. The server computers **402** may be standard server computers configured appropriately for providing the computing resources described above. For instance, in one implementation the server computers **402** are configured to provide the processes **406**.

[0040] In one embodiment, the processes **406** may be virtual machine instances. A virtual machine instance may be an instance of a software implementation of a machine (i.e., a computer) that executes programs much like a physical machine executes programs. In the example of virtual machine instances, each of the servers **402** may be configured to execute an instance manager capable of executing the instances. The instance manager might be a hypervisor or another type of program configured to enable the execution of multiple processes **406** on a single server **402**, for example.

[0041] It should be appreciated that although some of the embodiments disclosed herein are discussed in the context of virtual machine instances, other types of instances can be utilized with the concepts and technologies disclosed herein. For example, the technologies disclosed herein might be utilized with instances of storage resources, processing resources, data communications resources, and with other types of resources. The embodiments disclosed herein might also be utilized with computing systems that do not utilize virtual machine instances, i.e. that use a combination of physical machines and virtual machines.

[0042] In the example data center shown in FIG. **4**, a LAN **401** is utilized to interconnect the server computers **402**. The LAN **401** may also connected to the WAN **306** illustrated in FIG. **3**. It should be appreciated that the network topology illustrated in FIGS. **3** and **4** has been greatly simplified and that many more networks and networking devices may be utilized to interconnect the various computing systems disclosed herein. Appropriate load balancing devices or software modules might also be utilized for balancing a load between data centers, between each of the server computers **402** in each data center, and between instances **406** purchased by each customer of the data centers. These network topologies and devices should be apparent to those skilled in the art.

[0043] Cloud computing generally refers to a computing environment for enabling on-demand network access to a shared pool of computing resources (e.g., applications, servers, and storage) such as those described above. Such a computing environment may be rapidly provisioned and released with minimal management effort or service provider interaction. Cloud computing services typically do not require end-user knowledge of the physical location and configuration of the system that delivers the services. The services may be consumption-based and delivered via the Internet. Many cloud computing services involve virtualized resources such as those described above and may take the form of web-based tools or applications that users can access and use through a web browser as if they were programs installed locally on their own computers.

[0044] Cloud computing services are typically built on some type of platform. For some applications, such as those running inside an organization's data center, this platform may include an operating system and a data storage service configured to store data. Applications running in the cloud may utilize a similar foundation.

[0045] FIG. **5** provides further detail to the example environment shown in FIG. **3**. An administrator at user computer **304** can set up desktop configuration **501** including identifying an operating system, applications, policies and storage settings. Such preferences can be changed by the administrator and the provider of the services can charge a fee to the administrator for providing the requested configuration.

[0046] In one embodiment and as further described in FIG. **6**, a cloud service can implement an architecture comprising a stack of four layers as follows:

- **[0047]** a cloud computing platform **601** configured to provide the resources to support the cloud services
- **[0048]** a desktop provisioning and management layer **602** for creating and managing the cloud computing assets that enable application providers to provide applications, enterprise desktop providers and desktop resellers to create and manage desktops, users to connect to their desktops, etc. This layer can translate the logical view of applications and desktops to the physical assets of the cloud computing platform.
- **[0049]** an application provider/enterprise desktop provider/desktop reseller/user experiences layer **603** that provides distinct end-to-end experiences for each of the four types of entities described above.
- **[0050]** a vertical layer **604** that provides a set of customized experiences for particular groups of users and provided by desktop resellers.

[0051] In one embodiment of a cloud computing platform, a stamp may be implemented and used to define a unit of isolation and may be configured to define a traditional remote desktop deployment. A remote desktop controller component can be provided that maintains customer artifacts and credentials, manages loads across stamps, and provisions and resizes stamps. A remote desktop controller can also create and manage applications and desktops. Whereas a particular end point provides the virtual equivalent of a user's desktop, the stamp (or multiple stamps) provides the virtual equivalent of an companies computing infrastructure.

[0052] The layers described above may involve a number of components. Such components may include the following which are further described below.

- **[0053]** a compute component (e.g., FIG. **8**) that runs applications in the cloud.
- **[0054]** a storage component (e.g., FIG. **9**) that stores binary and structured data in the cloud
- **[0055]** a fabric controller component (e.g., FIG. **10**) that deploys, manages, and monitors applications. The fabric controller may also handle updates to system software throughout the platform
- **[0056]** a content delivery network component (e.g., FIG. **11**) that increases the speed for global access to data in the cloud storage by maintaining cached copies of that data around the world
- **[0057]** a connect component (e.g., FIG. **12**) that allows creating IP-level connections between on-premises computers and cloud applications.

[0058] Referring to FIG. **8** depicting a compute component **810**, an application may be implemented as one or more roles **800 801 802** as described above. The cloud service may run multiple instances of each role, using load balancing to spread requests across the roles.

[0059] A portal may be provided to allow a developer to submit an application to the cloud service. The portal may be configured to receive configuration information that informs

the cloud platform of how many instances of each role to run. The fabric controller component may create a virtual machine (VM) for each instance and run the code for the appropriate role in that VM. Requests from the application's users can be made using protocols such as HTTP, HTTPS, and TCP. The requests can be load balanced across all instances of a role.

[0060] Referring to FIG. **9** depicting a storage component **910**, the cloud platform may provide data storage using a number of data structures and formats. For example, data storage can be provided as an unstructured blob of binary data **900**. Metadata can be used to provide information as to content. In order to allow applications to work with data in a more structured fashion, cloud storage services may provide storage as groups of entities that are associated with properties. Applications may also be provided a means to query data such, as, for example, an API that includes search parameters. Additionally, cloud storage can provide a way for web role instances to communicate asynchronously with worker role instances. For example, a user might submit a request to perform some compute-intensive task via a web interface implemented by a web role. The web role instance that receives this request can write a message into a queue **902** describing the work to be done. A worker role instance that is waiting on this queue can then read the message and carry out the specified task. Results can be returned via another queue.

[0061] The cloud storage service may replicate data in order to provide fault tolerance. Furthermore, data can be backed up copy in another data center in a different physical location for redundancy and enhanced availability.

[0062] Referring to FIG. **10**, a fabric controller component **1000** may be a distributed application replicated across a group of machines. The fabric controller component can be configured to own all of the resources in its environment such as computers, switches, and load balancers. The fabric controller component **1000** can also monitor running applications, determine where new applications should run, and select physical servers to optimize hardware utilization. The fabric controller component can also be configured to start, monitor, and terminate virtual machines.

[0063] In an embodiment and referring to FIG. **11**, the cloud service can store copies of data at sites closer to the clients **1100** that use the data. For example, the first time a particular piece of data is accessed by a user, the content delivery network component can store a copy of that data (i.e., cache) at a location that is geographically close to that user. The next time the data is accessed, the contents can be delivered from the cache rather than from the more remote original.

[0064] In an embodiment and referring to FIG. **11**, in order to support the applications and data used within an organization, on-premises environments may be connected with the cloud service. In an embodiment, this type of combination can be effectuated by providing IP-level connectivity between a cloud application and machines running outside of the cloud. An endpoint agent **1201** can be installed on each on-premises computer **1202** that connects to a cloud application. The cloud application may also be configured to work with the cloud connect component **1200**. The agent can use protocols such as IPsec to interact with a particular role in that application. By using such an agent, the potential complexity of configuring protocols such as IPsec **1203** can be transparent to the user, while providing a much simpler connection than methods such as virtual private networks (VPNs). Once the connection is established, roles in a cloud application can appear to be on the same IP network as the on-premises machine.

[0065] By establishing such connections, a cloud application can access an on-premises database directly. A cloud application can also be domain-joined to the on-premises environment, allowing a single sign-on to the cloud application by on-premises users, and the use of existing active directory accounts and groups for access control.

[0066] In various embodiments, a remote desktop computing experience can be provided in which a desktop provider can provide an elastic pool of desktops from which an administrator can easily provision and manage numerous user desktops, much in the same manner as provisioning and managing a single user desktop. The remote desktop user can thus be provided with a desktop experience that is always available, free of administrative procedures, and billed based on consumption. For application providers, such a service can enable the application providers, with minimal effort, to provide traditional desktop applications to users in the form of web applications.

[0067] As businesses move to adopt remote or virtual desktops as a means to centralize the administration of secure and compliant employee desktops, it would be advantageous for IT administrators to be able to provide a homogenous desktop environment in order to control and minimize costs. Thus a platform that can provide a plurality of remote or virtual desktops can provide scalable and homogenous computing environments at low cost. By architecting a hosted desktop solution on a cloud platform in a manner similar to that of a homogenous computing model, IT administrators can be provided an environment that can significantly lower cost as compared to traditional "Desktop as a Service" alternatives.

[0068] A cloud computing platform can be configured to operate with and provide benefits to multiple users and providers. For example, for an application provider that provides applications to an enterprise desktop provider or a desktop reseller, a cloud computing platform may be configured to provision and sell traditional desktop applications in a scalable cloud model. The application provider may be enabled to create an application provider account with payout account information, upload application packages, test uploaded applications on a selected operation system, publish the application on an application marketplace on the cloud, monitor application usage and set user charges per user.

[0069] For an enterprise desktop provider who creates and/or manages desktops, a cloud platform may be configured to provision desktops which may include bundles of applications to groups of users with similar requirements. For example, a group of users may all be employees of the same enterprise customer. The desktop provider may be enabled to be able to create an enterprise desktop provider account and provide credit information, e.g., by way of a credit card or other credit facility. The desktop provider may further be enabled to a create desktops by selecting, for example, an OS version and compatible applications from the cloud marketplace, upload additional applications as needed, and choose a delivery mode, i.e., a full desktop experience or remote application delivery. The desktop provider may also be enabled to provide credentials to enable access from desktops to the customers' on-premise active directory, add users to enable access to desktops, set policies to control user access to appli-

cations on the desktop, set up a URL for a web page for desktop users, and access connection activity and disable/enable access for users.

[0070] A desktop reseller may be an entity who creates and/or manages desktops for sale as a service to users. A desktop reseller may be enabled to perform capabilities similar to an enterprise desktop provider, such as creating a desktop reseller account, creating signup and connection scenarios for remote users, creating one or more desktops by selecting an OS version and compatible applications from the cloud marketplace, and uploading additional applications and choosing a delivery mode. A desktop reseller may also be enabled to set policies to manage user access to applications on the desktop, and provide OS and application updates either automatically or manually. A desktop reseller may also be enabled to view connection activity and disable/enable access, monitor desktop usage, and receive payments from users.

[0071] A user may be an identifiable entity who accesses a desktop provisioned by an enterprise desktop provider or a desktop reseller. The user may, via the cloud platform, access desktops from any location, browse to a URL for desktop service, and sign in and access the provisioned services. In some embodiments, the user may be provided a list of desktop environments that the user can log into.

[0072] Referring to FIG. **13**, illustrated is an example block diagram depicting a process for providing remote desktop services in a cloud computing framework. A user may access via a browser a web page that provides an entry point to the remote desktop services accessible to the user and configured in accordance with the user's IT departments requirements. The user may log onto the system using credentials provided to the user. The credentials may be a persistent ID such as a Windows Live ID or OpenID. A user will then be redirected to an authentication server which may require entry of a username and password over a secured connection. Once authenticated, the user may be issued a password that is persisted for that user, the password being provided to other services so that additional authorization is not required. In an embodiment, the password may be persisted for that user even if the desktop session ends, unless the user explicitly logs off from the session.

[0073] A mechanism may be provided for automatically logging into a cloud based system in which a single user authentication and authorization process permits a user to access the resources in the cloud based system where the user has access permission, without the need to enter multiple passwords. Providing single sign-on allows users to log in once and access multiple applications without the need to enter more passwords. Single sign on is desirable for enterprises by increasing security and efficiency by reducing the number of passwords that must be maintained. For cloud service providers, single sign on provide a better user experience by allowing users greater access without additional authentication effort.

[0074] A cloud based service may not accept token log-on credentials generated by a single sign-on service. For example, a web-ID provider or single sign on service may prompt a user for sign on credentials, and the service may generate a ticket or tokens that can be used for connecting to other services. Examples of such systems may include Windows, Linux, and iOS. It is desirable to give users in an on-premises enterprise domain, for example, single sign-on access to applications running in the cloud service.

[0075] In an embodiment, when a user logs into a cloud based desktop and provides authentication credentials, a one-time password may be automatically generated and persisted. The generated one-time password may be used to log in automatically to additional processes in the cloud based system. In one embodiment, the generated one-time password can be persisted until the user explicitly logs off. Thus, even when the desktop session is unexpectedly terminated, the password can be persisted.

[0076] In another embodiment, a user may have an account with a service that provides integrated on line services such as Windows Live or Yahoo. Such a service may provide a set of services and software products such as email and multimedia services that are accessible using a single user ID and password. In an embodiment a user of such an integrated service may also be provided an option to access cloud based computing services as described above. Thus when a user has opted for cloud based computing services as part of such an integrated service, once the user has logged on to the service the user may be presented an option to accessed the cloud based computing service and request a remote desktop session. Because the cloud based service, e.g., the remote desktop, may not accept the credentials from the integrated service, the cloud based service may generate an account with a one time password that allows the user to access the desktop session. The details of the one time password need not be provided to the user since the password only exists for the duration of the session or until the user logs off. In an embodiment the one time password may be persisted so that the user may return to the desktop if the desktop is inadvertently disconnected without having to restart the logon process.

[0077] In an embodiment illustrated in FIG. **14**, client **1404** may enter a URL for his company's cloud based service home page **1400**. Alternatively, the user may enter a URL for an integrated online service. The user may be directed to an online authentication service **1401** which prompts the user for authentication credentials. The online authentication service **1401** may be a service used by the administrator for the user and the user's credential information may be provided by the administrator to the cloud service, authorizing the service to create a user profile and allowing the user to launch and access desktops. Alternatively, the online authentication service **1401** may be provided by the integrated online service. Once the user is authenticated, the user is directed to a homepage **1402**, the user can access the cloud service **1410** with the credentials provided by the online authentication service. The cloud service **1410** generates a one time password **1405** and/or a temporary user account, and the user's one time password is sent **140** to an endpoint **1407**. As described above, the endpoint **1407** can be a user desktop session.

[0078] The one-time password may be generated based on the credentials received by the online authentication service. In an embodiment, the password can be stored in a local credentials store in the virtual machine hosting the user session. Thus the password is not persisted with the user in the user's profile, thus allowing for enhanced security and avoiding the need for the cloud service to maintain permanent passwords for each user.

[0079] The user can be presented with a number of desktops, e.g., an engineering desktop, a finance desktop, etc. that can be selected and logged into. For example, each desktop can be tailored to a specific functionality. The user may be presented with the specific desktops based on predefined authorization. Once the users selects a desktop, a new desktop

instance may be instantiated for that user. If a previous desktop instance is selected the session associated with the previous desktop instance may be resumed. The session for this user and session for other users can be launched as endpoints within a virtual machine that hosts a number of such sessions. A saved profile may be associated with each endpoint that is created or resumed that includes the user's preference and state information from a previous session and other information needed to maintain the user's state so the user's session can be persisted, paused, and resumed. Generally a desktop may consist of an operating system, applications, and settings. A desktop instance generally refers to a desktop plus a specific user profile. In some cases a desktop instance and a desktop session may be used interchangeably.

[0080] In an embodiment, multiple sessions can be launched for additional users. Referring to the example embodiment illustrated in FIG. **14**, multiple sessions corresponding to multiple endpoints may be instantiated as additional users log into the system. Furthermore, the users may comprise multiple user types as defined by the administrator for the group of users. For example, as shown in the figure, multiples users of both Type **1** and Type **2** may log into the system and begin sessions. For example, Type **1** may be a finance type desktop and Type **2** may be an engineering type desktop. Of course, other examples are also possible. A virtual machine may be configured to host a number of sessions of one or more types. In one embodiment, the numbers of sessions may be independent of the underlying virtual machine configuration that is hosting the various user sessions. As additional user sessions are instantiated on the virtual machine, additional virtual machines may be launched. In one embodiment, a set number of remote desktop sessions can be configured to execute on a virtual machine. As more remote desktop sessions are needed, another virtual machine can be launched. An elastic pool of virtual machines may be provided so that sessions can be dynamically added at any time without the need for an end user or administrator to understand the underlying details for the structures providing the services.

[0081] Since the user may be assigned a virtual machine (VM) endpoint from a pool of available VM endpoints, the next time that a user logs in, the user may be connected to any one of the VM endpoints in the pool. In order to create a custom desktop experience for the user, the user's preferences and state data may be saved. In one embodiment, the user's preference and state data may be saved to a set of data that may be associated with the user so that any time that the user logs on and is assigned a desktop, the user preference and state data may be obtained so that the user's previous desktop state can be resumed. So for example, if the users is associated with a session (i.e. end point) on a first virtual machine and later is assigned to a different session on a different virtual machine, the user's desktop state from the first virtual machine would generally not be available to the session on the second virtual machine. However, according to an aspect of the disclosure, the user's state is saved independently of the session and the particular VM endpoint. As described in the present disclosure, such a set of user data may be referred to as a virtual profile. In various embodiments the virtual profile may be implemented and referred to as a virtual hard drive or virtual hard disk (VHD). As such, when the user is connected with a session on a different virtual machine, the previous user's state can be migrated to the new session. This feature allows a single master desktop that is designed to serve a particular Type to have a custom feel for each particular user. The result is that a user of an otherwise generic session environment is perceived by the user as having a personal desktop look and feel.

[0082] As discussed above, during the course of a user session, a client may open and close remote access connections to the cloud service, and during any given connection, the client may change settings and preferences in the session. A mechanism is described herein for provisioning remote desktops in a cloud based infrastructure while maintaining user personalization. In cloud based systems, a user may not always reconnect to the same virtual desktop. In one embodiment, the virtual profile assigned to a user may be mounted to the endpoint assigned to the user. The virtual profile may include information such as the user's personal data and personalization information (e.g., settings, profiles, files, application data, etc.).

[0083] When the user disconnects or logs off from the remote desktop, the virtual profile is demounted from the endpoint and saved for subsequent user sessions. The virtual profile thus saves information regarding the user's state when the user is disconnected and provides the information as needed for launching the next user session.

[0084] Since a user may be assigned a VM endpoint from a pool of available VM endpoints, the next time that a user logs in, the user may be connected to any one of the VM endpoints in the pool. In order to create a custom desktop experience for the user, the user's saved preference and state data may be used to provide the customized desktop experience regardless of the particular VM endpoint to which the user is connected.

[0085] While the terms virtual profile and VHD are used to describe a data structure for saving a user's preference and state information, it should be understood that the present disclosure is not intended to be limited to any particular file or data format. In one embodiment a virtual profile or a VHD may be a virtual hard disk file format that is configured as data that is typically found on a physical data disk drive.

[0086] Initially, a virtual profile or a VHD may be populated with data operable to configure a user's desktop in accordance with the standard desktop configuration as defined by, for example, a company IT administrator. Thus a virtual profile or a VHD may include data defining the "gold image" of the desktop (i.e., the standard desktop configuration for a user role). Nevertheless, as a user uses a particular remote desktop and begins to customize the desktop by for example, changing the wallpaper, adding music, saving local documents, etc., that information is stored to the virtual profile or a VHD and an each time thereafter that a user is connected to a standard remote desktop, it is populated with the data from the virtual profile or a VHD to provide the look and feel of a custom user experience.

[0087] Any combination of user types (i.e., desktop types) may be defined within the boundaries of a single cloud service boundary. For example cloud service boundary **1410** may define a single service boundary as defined and configured for a set of services provided to a particular company and accessible using a predetermined URL which, when entered via a browser, may provide a web interface for logging on to the service and accessing the desktops configured for service.

[0088] In an embodiment, when a user session is requested, a connection to a connection broker may initially be requested. The connection broker may determine the stamp associated with the requested user session and select a virtual machine that is hosting user sessions within the identified

stamp. For example, if the request indicates that a user session is desired, the connection broker may search a database that includes IP address port number combinations or network identifiers to find a suitable virtual machine being hosted on a cloud server. The connection broker can generate a redirection request that causes the user session to be associated with the identified virtual machine.

[0089] Referring to the embodiment described in FIG. **16**, an endpoint may be notified **1600** that a user has logged into the system. The system searches for a virtual profile **1601** and determines whether a virtual profile already exists for the user **1602**. If there is no virtual profile for the user, then a virtual profile is created **1603**. If a virtual profile already exists for the user or if a virtual profile was created, then the user virtual profile is moved to the endpoint **1604**. The user desktop session may be launched **1605**. When it is determined that the user has logged out **1606**, then the virtual profile is dismounted **1607** from the endpoint and saved for subsequent use.

Load Balancing By Endpoints

[0090] In an embodiment, a mechanism is provided for balancing client sessions across virtual machines such that the number of virtual machines is efficiently managed. In some embodiments, the total number of virtual machines is minimized to reduce power consumption, cooling, and other cost drivers, while assigning users across the sessions. In one embodiment, the sessions in a virtual machine with low activity are migrated to a virtual machine with higher session rates to allow for the shutdown of the low usage virtual machines. In another embodiment, new user sessions are assigned according to a minimum performance standard.

[0091] Such load balancing may be performed in accordance with a predetermined load balancing metric. A load balancing metric may be determined so that the computing resources are allocated to effectuate the hosted services are substantially optimized with respect to power, CPU usage, and other factors. Many data centers allocate computing resources so as to evenly balance out the processes that are hosted among the resources to ensure that none of the resources are overloaded. However, such allocation policies result in a larger number of resources being powered on and not being fully utilized.

[0092] In an embodiment, the load balancing metric may be determined so as to balance loads among computing resources so that new user sessions are hosted on computing resources to substantially minimize the total number of hosting computing devices. For example, if a first computing resource is moderately utilized and a second computing resource has a low utilization, then new user sessions may be loaded on the first computing resource so that as existing user sessions are terminated, the computing resource with low utilization can be shut down, resulting in greater power utilization efficiencies at the data center.

[0093] It should be noted that computing resources can refer to hardware resources such as servers and storage units as well as virtual resources such as virtual machines. For example, as discussed above, a number of cloud user sessions may be allocated to one or more virtual machines. For example, one data center may implement a policy in which each virtual machine hosts sixteen cloud user sessions. A load balancing metric may allocate user sessions to moderately and highly loaded virtual machines in order to maximally utilize the loaded virtual machines and reduce the total number of virtual machines that are executing.

[0094] Thus in one embodiment, new user sessions may be allocated to an available computing resource with the highest number of sessions being hosted. In another embodiment, each computing resource may be classified as having one of a low, medium, and high load utilization levels, and new user sessions may be assigned to the computing resources in the following order: medium, high, and low. Other classification schemes may be used, with the objective being the allocation of sessions so that the smallest number of resources are utilized at any given time.

[0095] In an embodiment, user sessions and their associated data and applications can be migrated to another computing resource in accordance with the predetermined load balancing metric. As users log off and user sessions are terminated, existing user sessions may be reallocated so as to reduce the overall number of computing resources that are in operation. For example, user sessions hosted on a computing resource classified as low utilization may be migrated to a computing resource classified as high to allow for a shutdown of the computing resource classified as low.

[0096] The load balancing metric may be determined according to factors other than power consumption. For example, the load balancing metric may be determined in accordance with a minimum performance standard. Such a standard may consider session loading schemes that provide for greater overall performance. For example, system costs such as power may be balanced against session load distributions that provide higher network performance and thus provide a better user experience.

[0097] FIG. **18** illustrates one embodiment in accordance with the present disclosure. A user may log **1800** to a cloud based service. The cloud based service may determine if a user session already exists at an endpoint **1802**. If so then the user is assigned **1804** to the endpoint that is hosting the user session. If the user does not already have a session available at an endpoint, then the cloud service may determine an endpoint in a load balanced manner in accordance with one embodiment.

[0098] The system may retrieve usage threshold information for all endpoints **1806**. In one embodiment the usage threshold information may comprise a categorization indicating the relative amount of the total session capacity for each endpoint. For example, the threshold may be one of low, medium, and high, each indicating the relative usage of the maximum session capacity for the endpoint. If there is at least one endpoint with a medium threshold **1808**, then one of the medium threshold endpoints is selected **1814**. If there are no medium threshold endpoints, then if there is at least one endpoint with a high threshold **1810**, then one of the high threshold endpoints is selected **1816**. Finally, if there are no high threshold endpoints, then if there is at least one endpoint with a low threshold **1812**, then one of the high threshold endpoints is selected **1818**.

[0099] The selection of endpoints may be performed using a variety of methods. In one embodiment, endpoints are selected using a random or pseudorandom selection process.

[0100] In another embodiment, a round robin selection method may be used. In this embodiment, endpoints are selected in round robin fashion. For example, a list of addresses of available endpoints may be stored in a sorted order according to one or more criteria such as, for example, in order of endpoints most recently updated. Upon receiving

a connection request, a global lock is acquired, the first endpoint is obtained from the sorted list and assigned to the user, and the list is then updated. The end user is then redirected to the assigned endpoint.

[0101] In another embodiment, a queuing selection method may be used. In this embodiment, whenever an endpoint is added to the stamp, the endpoint address is added to a queue as many times as the maximum number of sessions. Upon receiving a connection request, an endpoint address is selected from the queue in queued order, the endpoint address is validated to determine that the endpoint is available and accepting connections. Upon verification, the end user is redirected to the endpoint.

[0102] In another embodiment, a session caching selection method may be used. In this embodiment, when load balancing is initiated, an attempt is made to cache sessions from the endpoints that are available. The maximum number of session is twice the number of concurrent requests that an RDCM instance can process per second. Upon receiving a connection request, an endpoint address from the local cache is retrieved by acquiring a local lock. The endpoint address is assigned to the end user. An attempt is made to span a thread that performs caching when the available session in the cache falls below the minimum cache length, which is the number of concurrent requests that an RDCM instance can process per second. The end user is redirected to the endpoint.

[0103] In another embodiment, a stateless list selection method may be used. In this embodiment, when an RDCM instance starts, the RDCM chooses a prime number according to the instance ID. A list of all sessions (e.g. [1,2,3,4,5,6,7,8,9,10]) is created. A unique list based on the odd prime number assigned for the instance (e.g., 3) is created by counting with the prime (e.g., [3,6,9,2,7,1,8,5,10,4]). Upon receiving a connection request, the endpoint address is selected from the list and an attempt is made to book the endpoint by updating the table row to booked. If the booking attempt succeeds, then the endpoint is assigned to the user.

[0104] In various embodiments, a medium threshold endpoint is given priority because of tradeoffs between overall system performance and the objective of strictly minimizing the total number of endpoints. When considering an overall balance between performance and economic factors, it may be preferable to select medium threshold endpoints before selecting high threshold endpoints. High threshold endpoints may be given priority over low threshold endpoints because of the cost of running an endpoint with low utilization coupled with the likelihood that termination of user sessions in a low threshold endpoint may allow for the low threshold endpoint to be freed up and thus shut down.

[0105] FIG. **15** depicts an exemplary operational procedure for managing a virtualized computing infrastructure including operations **1500**, **1502**, **1504**, **1506**, and **1508**. Referring to FIG. **15**, operation **1500** begins the operational procedure and operation **1502** illustrates receiving a request for a remote desktop session from one of a plurality of users. Each of the remote desktop sessions may comprise an operating environment and software applications to be included in the operating environment. The remote desktop sessions can each correspond to a user role. For example, an administrator can use a user interface to define two desktop environments for a medium sized company. The administrator may define a first desktop environment for engineering staff and may select an operating system and version, an email and calendar application, a browser application, office applications, and a drawing application. The administrator may further specify that up to fifty such desktops may be used at one time. The administrator may also define a second desktop environment for finance staff and may select an operating system and version, an email and calendar application, a browser application, office applications, and a database application. The administrator may further specify that up to twenty-five such desktops may be used at one time. The remote desktop configurations can be accessible via the Internet using a URL. For example, after configuring the desktop environments, the desktop environments may be accessible by the individual users by entering, for example, www.company.com/tech and www.company.com/finance."

[0106] Operation **1504** illustrates determining the number of remote desktop sessions hosted by each of a plurality of virtual machines.

[0107] Operation **1506** illustrates selecting a virtual machine to host the requested remote desktop session in order to increase the number of remote desktop sessions hosted by the virtual machines that currently host a plurality of remote desktop sessions.

[0108] Operation **1508** illustrates instantiating the requested remote desktop session on the selected virtual machine.

[0109] FIG. **16** depicts an exemplary system for managing a virtualized computing infrastructure as described above. Referring to FIG. **16**, system **1600** comprises a processor **1610** and memory **1620**. Memory **1620** further comprises computer instructions configured for managing a virtualized computing infrastructure. Block **1622** illustrates instantiating one or more remote desktop configurations that makes available, to a plurality of users via a remote network connection, remote desktop configurations each comprising an operating environment and software applications to be included in the operating environment. Block **1624** illustrates receiving a request for a remote desktop session from one of the plurality of users, the remote desktop session conforming to one of the one or more remote desktop configurations. Block **1626** illustrates instantiating the requested remote desktop session and loading data and applications associated with the remote desktop session on a computing device selected in accordance with a predetermined load balancing metric.

[0110] Any of the above mentioned aspects can be implemented in methods, systems, computer readable media, or any type of manufacture. For example, a computer readable medium can store thereon computer executable instructions for managing a virtualized computing infrastructure. Such media can comprise a first subset of instructions for saving, at a first computing data center, a user remote desktop configuration, the user remote desktop configuration including saved state information for an operating environment and software applications executing in the operating environment, the first computing data center configured to provide at least computation and storage services; a second subset of instructions for determining a probable location from which a user will access the user remote desktop configuration; and a third set of instructions for, based on said determining, migrating the saved user remote desktop configuration to a second computing data center and making available, via a remote network connection, the saved user remote desktop configuration to the user from the second computing data center. It will be appreciated by those skilled in the art that additional sets of instructions can be used to capture the various other aspects

disclosed herein, and that the three presently disclosed subsets of instructions can vary in detail per the present disclosure.

1. A method for managing a virtualized computing infrastructure, the method comprising:

receiving a request for a remote desktop session from one of a plurality of users;

determining the number of remote desktop sessions hosted by each of a plurality of virtual machines;

selecting a virtual machine to host the requested remote desktop session in order to increase the number of remote desktop sessions hosted by the virtual machines that currently host a plurality of remote desktop sessions;

instantiating the requested remote desktop session on the selected virtual machine.

2. The method of claim **1**, wherein the selected virtual machine is determined by balancing loads among virtual machines such that new user sessions are hosted on computing devices to substantially minimize the total number of virtual machines.

3. The method of claim **2**, wherein the selected virtual machine is the virtual machine with the highest number of hosted remote desktop sessions.

4. The method of claim **2**, wherein the selected virtual machine is the virtual machine with fewer than the highest number of hosted remote desktop sessions and more than the lowest number of hosted remote desktop sessions.

5. The method of claim **4**, further comprising classifying each virtual machine as having one of a low, medium, and high load level, and assigning new user sessions to the computing devices in the order of medium, high, and low.

6. The method of claim **1**, wherein said selecting further comprises assigning the remote desktop session to an endpoint according to a random selection method.

7. The method of claim **1**, wherein said selecting further comprises assigning the remote desktop session to an endpoint according to one of a round robin, queuing, and session caching selection method.

8. The method of claim **1**, wherein the predetermined load balancing metric is determined according to a minimum performance standard.

9. A computing system comprising:

a computing device comprising at least one processor;

a memory communicatively coupled to said processor when said system is operational; said memory having stored therein computer instructions that upon execution by the at least one processor cause:

instantiating one or more remote desktop configurations that makes available, to a plurality of users via a remote network connection, remote desktop configurations each comprising an operating environment and software applications to be included in the operating environment;

receiving a request for a remote desktop session from one of the plurality of users, the remote desktop session conforming to one of the one or more remote desktop configurations; and

instantiating the requested remote desktop session and loading data and applications associated with the remote desktop session on a computing device selected in accordance with a predetermined load balancing metric.

10. The computing system of claim **9**, further comprising migrating the data and applications to another computing device in accordance with the predetermined load balancing metric.

11. The computing system of claim **9**, wherein the one or more remote desktop configurations each conform to a user configuration template for scalably propagating the one or more remote desktop configurations in a virtualized computing environment.

12. The computing system of claim **9**, wherein the metric is determined by balancing loads among computing devices such that new user sessions are hosted on computing devices to substantially minimize the total number of hosting computing devices.

13. The computing system of claim **12**, wherein the new user sessions are hosted on an available computing device with the highest number of hosted sessions.

14. The computing system of claim **12**, further comprising classifying each computing device as having one of a low, medium, and high load level, and assigning new user sessions to the computing devices in the following order: medium, high, and low.

15. The computing system of claim **14**, wherein user sessions hosted on a computing device classified as low are migrated to a computing device classified as high to allow for a shutdown of the computing device classified as low.

16. The computing system of claim **9**, wherein said selecting further comprises assigning the remote desktop session to an endpoint according to one of a random, round robin, queuing, and session caching selection method.

17. A computer readable storage medium storing thereon computer executable instructions for providing access to a remote user session in a computing environment, the computer readable storage medium comprising:

instructions for saving, at a first computing data center, a user remote desktop configuration, the user remote desktop configuration including saved state information for an operating environment and software applications executing in the operating environment, the first computing data center configured to provide at least computation and storage services;

instructions for determining a probable location from which a user will access the user remote desktop configuration; and

instructions for based on said determining, migrating the saved user remote desktop configuration to a second computing data center and making available, via a remote network connection, the saved user remote desktop configuration to the user from the second computing data center.

18. The computer readable storage medium of claim **17**, wherein the metric is determined by balancing loads among computing devices such that new user sessions are hosted on computing devices to substantially minimize the total number of hosting computing devices.

19. The computer readable storage medium of claim **18**, wherein the new user sessions are hosted on an available computing device with the highest number of hosted sessions.

20. The computer readable storage medium of claim **18**, further comprising instructions for classifying each computing device as having one of a low, medium, and high load level, and instructions for assigning new user sessions to the computing devices in the following order: medium, high, and low.

* * * * *