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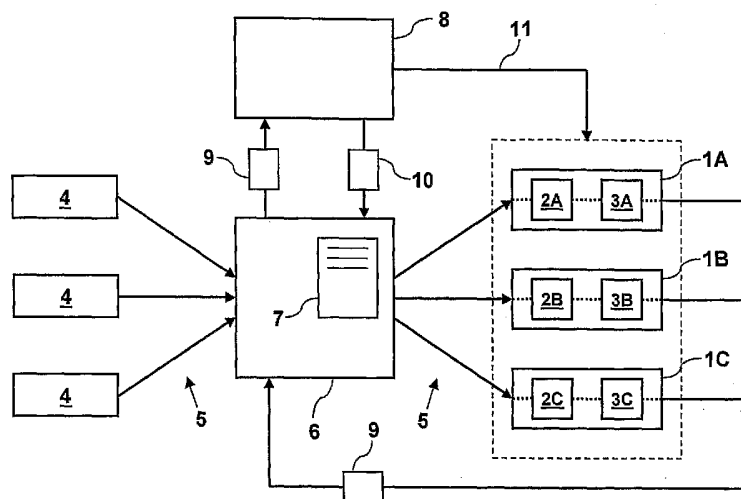
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[Continued on next page]

(54) Title: COMPUTER ARRANGEMENT AND METHOD FOR PROVIDING SERVICES FOR CLIENTS OVER A NETWORK



(57) Abstract: The computer arrangement for providing services for clients (4) over a network (5) comprises of at least two servers (1), each hosting at least one application (2), an administration means (8), set up to automatically provision the servers (1) to provide the services, and at least one network load balancer (6) connected to the clients (4) and the servers (1), responsible for at least one of the services, set up to gather information on the state of the servers (1) and/or the state of applications (2) on the servers (1) and set up to route incoming requests of clients (4) to one of the servers (1). The computer arrangement and method for providing services are characterized in that the network load balancer (6) provides the administration means (8) with information (9) on the state of the servers (1) and/or the applications (2) on the servers (1), and the administration means (8) provides the network load balancer (6) with information (10) about which servers (1) are provisioned to provide the at least one service the network load balancer (6) is responsible for.

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Description of the InventionCOMPUTER ARRANGEMENT AND METHOD FOR PROVIDING SERVICES FOR
CLIENTS OVER A NETWORK

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The invention relates to a computer arrangement that comprises at least two servers for providing services for clients over a network, and more particularly to the use of an automated administration means and a network load balancer
10 within the computer arrangement.

Computer arrangements of that type typically include several computers, called servers, providing particular services that clients can make use of by sending appropriate requests over
15 a network. There is a huge variety of different types of services that can be offered by servers. Examples are file-, web- or database-services.

Usually each individual service is provided by an application
20 program running on a server. Often many instances of an application are executed in parallel in order to be able to handle all incoming requests. Depending on its capacity and performance, a single server can host just one but also several instances of one or different application programs.
25 For the following, by way of example a situation is assumed where each server only runs one instance of an application to provide a particular service.

It is desirable that clients do not have to care about the
30 actual configuration of an computer arrangement that provides a service, i.e. clients do not have to know (and also they can not know) which one of the servers are available to process their tasks. This can be achieved by providing a

central authority, called router, that receives incoming requests of clients and distributes (routes) them to one of the servers. Clients only have to know one address, often called a virtual address, to which they send their request.

5 This virtual address is assigned to the router, which redirects the request to one of the servers by replacing the destination address (i.e. the virtual address) with the address of one of the servers. The servers usually just have addresses that are visible within the computer arrangement
10 only. The router is supplied a list of these addresses. If the routing process is set up to equalize the work-load of the servers, this central authority is referred to as a network load balancer. Different types of network load balancers are known, some of which actually measure the load
15 that applications impose on the servers, some keep track of distributed tasks and either calculate load values or just distribute the requests for all servers having to handle a comparable number of requests at the same time. Furthermore, network load balancers exist that determine and use
20 additional information, for example the state of the servers, i.e. whether each server operates correctly or not.

Often a network service provider runs a plurality of servers, called a server farm. Considering the growing size of modern
25 server farms, which can consist of hundreds of servers, there is an increasing demand to automate administrative tasks, for example allocating the available resources to different types of services. The approach to automate administrative tasks is known as autonomous computing (AC). A central element in an
30 AC-environment is an automated administration means to perform administrative tasks which is sometimes also referred to as a decision engine. The administration means is capable of dynamically allocating or freeing servers and of starting

new or stopping running instances of different applications on these servers, thereby conditioning the server to provide a particular service. In the following, "provisioning" a server is meant to comprise all necessary administrative steps to prepare or condition a server to be ready to provide a particular service. Usually the administration means is hosted on a computer within the arrangement that is specifically designated for administrative tasks. The decision whether to start or stop instances of applications and whether it is necessary to allocate new servers or give away control over servers depends on a number of criteria and basic conditions. Important factors are for example how much load running instances of an application carry and the state of the servers. But also other, non-technical but economical considerations, for example different priorities of customers, might be taken into account.

In an autonomous computer arrangement that uses one or more network load balancers, the administration means as well as the load balancers might need information on the servers and on applications in order to fulfill their duties. Both authorities determine this information, thereby causing extra workload and network traffic.

It is therefore an object of the invention to present a computer arrangement for providing services for clients over a network where the workload and the network traffic caused by the determination of information needed by the network load balancers and the administration means is minimized.

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The above object is accomplished by a computer arrangement according to claim 1 and a method according to claim 8.

The computer arrangement according to the invention comprises at least two servers, each hosting at least one application and designated to provide the services to clients over the network, an administration means, set up to provision the
5 servers to provide the services by allocating the servers and/or by starting or stopping instances of the applications on the servers and at least one network load balancer connected to the clients and the servers, responsible for at least one of the services, set up to gather information on
10 the state of the servers and/or the applications on the servers and set up to route incoming requests of clients to one of the servers. The computer arrangement and the method according to the invention are characterized in that the network load balancer provides the administration means with
15 information on the state of the servers and/or the applications on the servers, and the administration means provides the network load balancer with information about which servers are provisioned to provide the at least one service the network load balancer is responsible for.

20 According to the invention information that is needed by both, network load balancer and administration means, is shared. This prevents from obtaining relevant information twice and thus decreases workload and network traffic.

25 In a preferred embodiment of the invention each server hosts a network load balancer agent, the network load balancer agent being set up to determine information on the state of the servers and/or the applications on the servers and set up
30 to report the information to the network load balancer. In a further preferred embodiment the servers are provided with an operating system having a kernel, and the network load balancer agents are integrated into the kernel.

Other features which are considered as characteristic for the invention or which describe advantageous embodiments of the present invention are set forth in the appendend claims.

5

The above and other objects, features and advantages of the present invention will become apparent from the following description in conjunction with the accompanying drawings.

10 In the drawings:

Fig. 1 is a conceptual diagram of an embodiment of a computer arrangement according to the present invention;

15 Fig. 2 is a flowchart representation of an embodiment of a method for providing services according to the present invention.

Fig. 1 shows several servers 1 (1A, 1B, 1C), each hosting an application 2 (2A, 2B, 2C) and a network load balancer agent 3 (3A, 3B, 3C). The servers 1 are set up to provide services to clients 4 using a network 5. The computer arrangement further comprises a network load balancer 6 with a list of addresses 7 and an administration means 8. The network load balancer 6 is connected to the clients 4 and the servers 1 by the network 5. Furthermore, network load balancer 6 is connected to the network load balancer agents 3 to receive state information 9 and to the administration means 8 to transmit the state information 9 to and receive provisioning information 10 from the administration means 8. The administration means 8 is set up to control the servers 1 using a control connection 11.

Figure 1 shows a computer arrangement where three servers 1 are currently set up to provide a particular service made available by instances of the application 2 to the clients 4. In the embodiment shown, each server 1 hosts just one application 2. However, the invention is not restricted to such a situation. Servers 1 could also host several applications 2, possibly in conjunction with different network load balancers 6 for different types of applications 2. Also, the numbers of servers 1 shown in the diagram is just exemplary. Computer arrangements for providing services to clients over a network often comprise several tens or even hundreds of servers. The arrangement might comprise further servers 1 which might be used to provide further services. The invention can be easily applied to computer arrangements (server farms) of any size. The servers 1 can either be independent physical units, for example blade servers, or can be virtual servers. Virtual servers share a common hardware which runs a software that emulates several hardware units.

Each service provided by the computer arrangement is related to a particular network address. In order to select a particular service, clients 4 use this particular network address as the destination address in a request to be sent to the computer arrangement. Within the computer arrangement, each network addresses for a particular service is assigned to a central instance, which receives the request and routes it to one of the servers 1. In the embodiment shown, the network load balancer 6 is the central instance that receives all requests of clients 4 concerning the particular service made available by the application 2. By way of example, the network load balancer 6 is responsible for one particular service only.

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The network load balancer 4 redirects an incoming request to one of the servers 1 and thus to an instance of application 2 that actually processes the request. This can for example be achieved by overwriting the destination address of the

5 request with the address of the server 1 to which the request is redirected. After having processed the request, the server 1 then sends its reply directly back to the client 4, the address of which is contained in the request and thus known to the server 1. The server 1 adds the address of the network
10 load balancer 6 as the sender's address to the reply. In that case, a direct network connection between the servers 1 and the client 4 is needed.

In the figure, network 5 is depicted by point-to-point
15 connections between clients 4 and network load balancer 6, and network load balancer 6 and servers 1, respectively, to symbolize the data flow of requests. But it is to be understood that the underlying network 5 is usually a network that allows data to be exchanged between all participants.

20 Other known techniques for routing or redirecting requests could as well be used. The reply could e.g. be sent back via the network load balancer 4 who would add its sender's address to the reply itself.

25 For the network load balancer 6 to be able to distribute the requests to the servers 1 it has to be provided with information about which servers 1 are available for the requested service. This information is kept in the list of addresses 7 of available servers 1.

30

The decision to which server 1 a new request of one of the clients 4 is directed is based on the operating state of servers 1 and applications 2. An important factor in the

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decision making process is the load that the applications 2 impose on the servers 1.

Several different techniques how to determine, calculate or estimate load values are known. In the embodiment shown network load balancer agents 3 are used. Each server 1 hosts one network load balancer agent 3 which is set up to determine information 9 on the state of the server 1 and the application 2, which is called state information 9 for short. State information 9 that is relevant for the routing decisions of the network load balancer comprises for example information whether the server 1 operates correctly or not, whether the application 2 works correctly or not, how busy the application is or how much load it imposes on the server.

A preferred configuration is to implement the network load balancer agents 3 close to the operating systems of the servers 1 or even integrate them into the kernel of the operating system. Network load balancer agents 3 can then be equipped with wide access privileges which would not be possible if they are implemented in a user accessible operating space where they would only with little access privileges. Kernel based network load balancer agent 3 have several advantages. A kernel based network load balancer agent 3 will be able to send state information under many circumstances where a user space network load balancer agent 3 could not. For example, if the user space allowed processor load is so high that processes cannot run, a kernel based network load balancer agent 3 will still be able to operate. Likewise, a kernel based network load balancer agent 3 can observe function- and/or subroutine-calls from application 2 to the operating system. It can for example observe if the application is still listening to a network interface (e.g. a

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port monitored by the application 2) by detecting the
"listen()" call to the operating system's kernel, thereby
judging whether the application is still operating or not.
This is faster and generates less additional workload than
5 repeatedly sending check requests to the monitored port.
Finally, the kernel based network load balancer agent 3
detects and responds to events faster than a user space
network load balancer agent 3.

10 The state information 9 determined by the network load
balancer agent 3 is then sent to the network load balancer 6
and is used in the decision making process to which server 1
requests are routed. For the transmission of the state
information 9 a separate network could be used for security
15 and/or performance reasons, or the same network 5 that
connects the servers 1, the clients 4 and the network load
balancer 6 could be used. Preferably, the information 9 is
encapsulated in a mark-up language, for example XML
(eXtensible Markup Language), for transmission.

20

Providing services that have a fast response time on the one
hand, and that do not waste any server capacity on the other
hand, requires that an appropriate number of instances of an
application 2 is running and, therefore, that an appropriate
25 number of servers 1 is dedicated to host these instances.

Provisioning the servers 1 by allocating them and/or by
starting instances of a particular application 2 is performed
by the administration means 8. The administration means 8 may
30 be software-implemented and hosted on a separate computer.
For reasons of high availability and redundancy there may
also be second administration means that could take over in
case of a failure of the first administration means 8.

Different methods to provision servers 1 by the administration means 8 are known. One way is to remotely start or stop instances of an application depending on requirements. This bears the danger of collecting remains of all applications that were once started and stopped again (like temporary files) which might lead to an unstable and slow system. Therefore, often another approach, sometimes called "bare-metal provisioning", is chosen, where for each new task (different customer, different applications) a whole boot image is transferred to a server and the server is re-booted with the new boot image. In the following "provisioning" a server 1 for a particular service is meant to comprise all methods that prepare or condition a server 1 to be available for providing a particular service.

The control connection 11 between the administration means 8 and the servers 1 which is used to provision the servers 1, could be established through the network 5. In an other embodiment, a separate network could be used for security and/or performance reasons.

The basic idea behind the invention is that in an autonomous computing environment the performance of the system can be enhanced when administration means 8 and network load balancer 6 share their information on the servers 1. The resulting exchange of information is now described in conjunction with Fig. 2.

Fig. 2 shows a flowchart representation of an embodiment of a method according to the present invention.

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In step A of Fig. 2, a provisioning decision concerning a particular service is translated into action by the administration means 8 using the control line 11 as described above in connection with Fig. 1. If the particular service is to be started for the first time, the provisioning decision is based on predetermined initialization values or might be initialized by a human administrator.

Information 10 on the provisioning process, called provisioning information 10 for short) is then transmitted from the administration means 8 to the network load balancer 6 in step B. Provisioning information 10 comprises at least the network addresses of the servers 1 that provisioned to provide the particular service the network load balancer is responsible for or that are deprovisioned, i.e. that are either added to or removed from the pool of servers 1 conditioned to provide that particular service. Additional data that might be relevant for the routing process and could be used by the network load balancer 6 could also be contained in provisioning information 10. Such additional data could for example be data on the performance of provisioned servers 1. Provisioning information 10 could be in form a mark-up language based transaction, in particular in form of an XML-based transaction.

In step C, the provisioning information 10 is received by the network load balancer 6 and used to update the list 7 in step D. Instead of a list, any appropriate data structure could be used.

In step E, state information 9 on the servers 1 and the application 2 on these servers 1 are gathered from the network load balancer agent 3. State information 9 is then

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used to decide to which server 1 contained in the list 7 a request of a client is routed to as shown in step F.

5 State information 9 is transmitted to and received by the administration means 8 in steps G and H, respectively. The state information 9 transmitted to the administration means 8 might not be in exactly the same form and format as it was originally received by the network load balancer 6. Instead, it could be a selected subset of the originally received
10 state information 9 or the originally received state information 9 could be processed by the network load balancer 6 before transmission. Processing could for example involve time averaging, especially in case of fluctuating load data.

15 In step I, the state information 9 is used by the administration means to make further provisioning decisions, if appropriate. The method then restarts with step A to translate any further provisioning decisions into action.

20 The method leads to an iterative and interactive decision making process based on the state information 9 and the provisioning information 10 exchanged between administration means 8 and network load balancer 6.

25 Although the invention herein has been described with reference to particular embodiments, it is to be understood that these embodiments are merely illustrative of the principles and applications of the present invention. It is therefore to be understood that numerous modifications may be
30 made to the illustrative embodiments and that other arrangements may be devised without departing from the spirit and scope of the present invention as defined by the appended claims.

Reference List

- 1 Server
- 2 Application
- 5 3 Network load balancer agent
- 4 Client
- 5 Network
- 6 Network load balancer
- 7 List of provisioned servers
- 10 8 Administration means
- 9 State information
- 10 Provisioning information
- 11 Control connection

Claims:

1. A computer arrangement for providing services for clients (4) over a network (5), comprising

- 5 - at least two servers (1), each hosting at least one application (2) and designated to provide the services to clients (4) over the network (5);
- an administration means (8), set up to provision the servers (1) to provide the services by allocating the servers (1) and/or by starting or stopping instances of the applications (2) on the servers (1);
- 10 - at least one network load balancer (6) connected to the clients (2) and the servers (1), responsible for at least one of the services, set up to gather information (9) on the state of the servers (1) and/or the applications (2) on the servers (1) and set up to route incoming requests of clients (4) to one of the servers (1);
- 15

where

the network load balancer provides the administration means with information (9) on the state of the servers (1) and/or the applications (2) on the servers (1), and the administration means provides the network load balancer (6) with information (10) about which servers are provisioned to provide the at least one service the network load balancer is responsible for.

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2. The computer arrangement of claim 1, where

the information (10) about which servers (1) are provisioned to provide the at least one service the network load balancer (6) is responsible for comprise a list (7) of the respective servers (1).

30

15

3. The computer arrangement of one of the claims 1 or 2,
where

each server (1) hosts a network load balancer agent (3), the
network load balancer agent (3) being set up to determine the
5 information (9) on the state of the server (1) and/or the
application (2) on the server (1) and set up to report the
information (9) to the network load balancer (6).

4. The computer arrangement of claim 3, where
10 the servers (1) are provided with an operating system having
a kernel, and where the network load balancer agents (3) are
integrated into the kernel.

5. The computer arrangement of claim 4, where
15 the network load balancer agents (3) determine information on
the state of applications (2) on the servers (1) by observing
function and/or subroutine calls of the applications (2) to
the operating system.

20 6. The computer arrangement of one of the claims 3 to 5,
where
the information (9) sent from the network load balancer
agents (3) to the network load balancer (6) is encapsulated
in a mark-up language, e.g. XML, for transmission.

25

7. The computer arrangement of one of the claims 1 to 6,
where

the information (9, 10) exchanged between the network load
balancer (6) and the administration means (8) is encapsulated
30 in a mark-up language, e.g. XML, for transmission.

8. A method for providing services for clients (4) over a
network (5) with the following steps

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- providing a computer arrangement, the computer arrangement comprising:
 - at least two servers (1), each hosting at least one application (2) and designated to provide the services to clients (4) over the network (5);
 - an administration means (8), set up to provision the servers (1) to provide the services by allocating the servers (1) and/or by starting or stopping instances of the applications (2) on the servers (1);
 - at least one network load balancer (6), responsible for at least one of the services, set up to gather information (9) on the state of the servers (1) and/or the applications (2) on the servers (1) and set up to route incoming requests of clients (4) to one of the servers (1) based on the determined information (9);
 - transmitting information (9) on the state of the servers (1) and/or the applications (2) on the servers (1) from the network load balancer (6) to the administration means (8);
 - basing the decisions, on which of the servers (1) to provision by the administration means (8), on the information (9) transmitted from the network load balancer (6) to the administration means (8); and
 - transmitting information (10) about which servers (1) are provisioned to provide the at least one service the network load balancer (6) is responsible for, from the administration means (8) to the network load balancer (6).

Fig. 1:

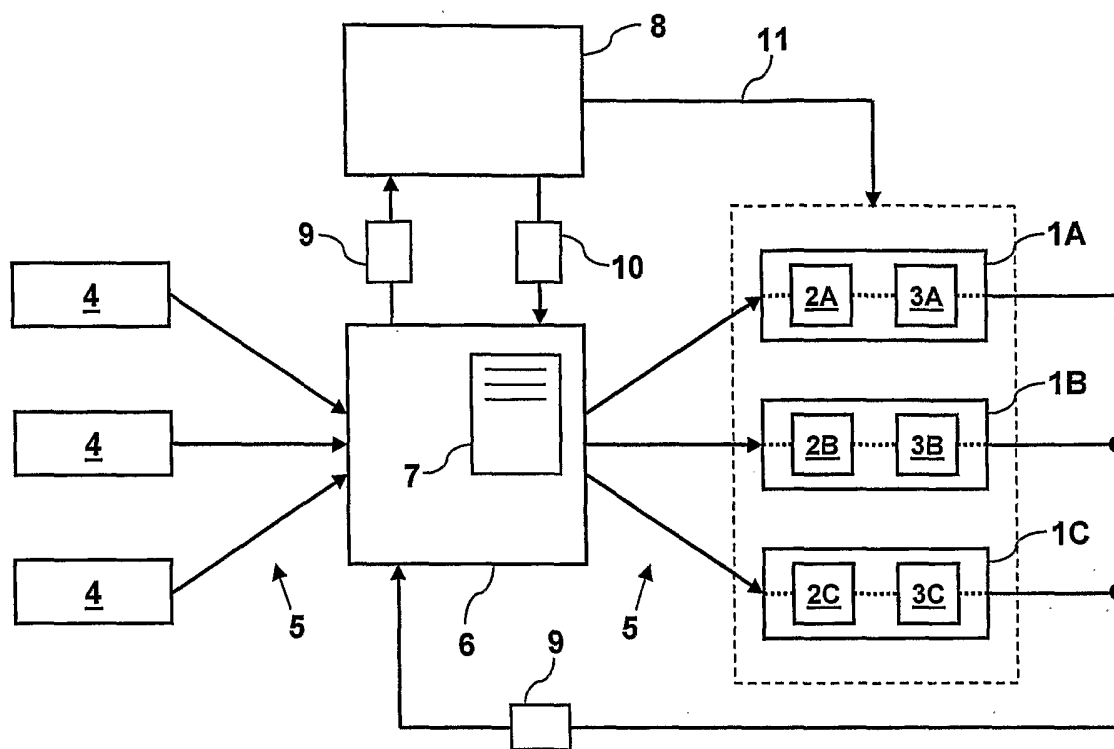
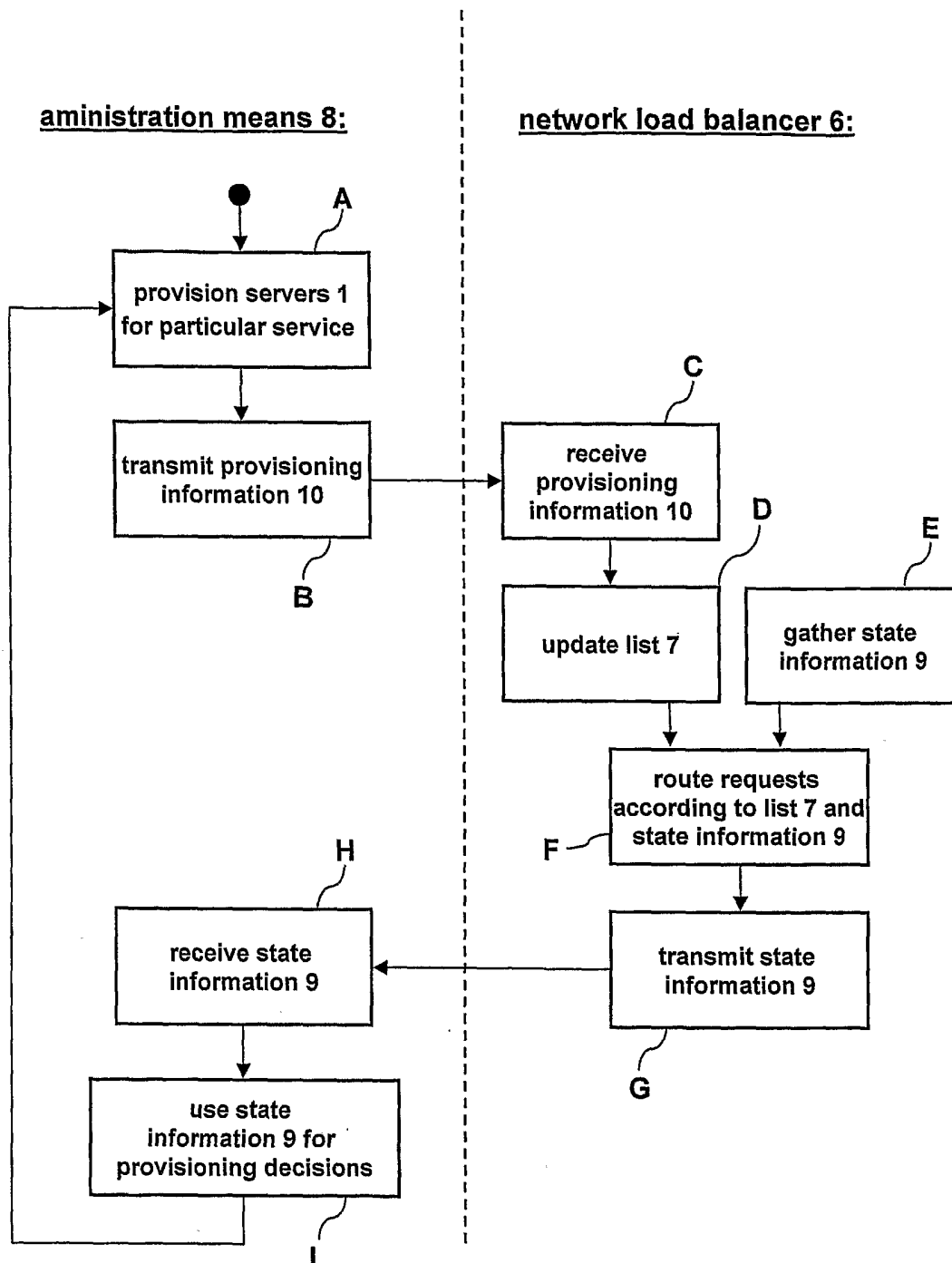


Fig. 2:



INTERNATIONAL SEARCH REPORT

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A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H04L29/06 G06F9/46

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H04L G06F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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

☒ Patent family members are listed in annex.

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- *P* document published prior to the international filing date but later than the priority date claimed

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- *X* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
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Manea, A

INTERNATIONAL SEARCH REPORT

Information on patent family members

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