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WATANABE

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(54) **LOAD DISTRIBUTION SERVER SYSTEM FOR PROVIDING SERVICES ON DEMAND FROM CLIENT APPARATUS CONNECTED TO SERVERS VIA NETWORK**

(76) Inventor: **Akira WATANABE**, Osaka (JP)

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(57) **ABSTRACT**

A load distribution server system is provided for providing a plurality of services on demand from a client apparatus, to which a plurality of servers are connected via a network for the client apparatus. Servers operate as virtual servers for the client apparatus, and take charge of services to share respective service functions and mutually transceive keep alive messages. When the keep alive message of at least one server is not received or when reception of the keep alive message is restarted in at least one server, the service function of the server of which the keep alive message is not received is allocated to at least one other server on the basis of a predetermined priority of the service function, and a virtual server corresponding to the allocated service function is activated to provide the service of the service function.

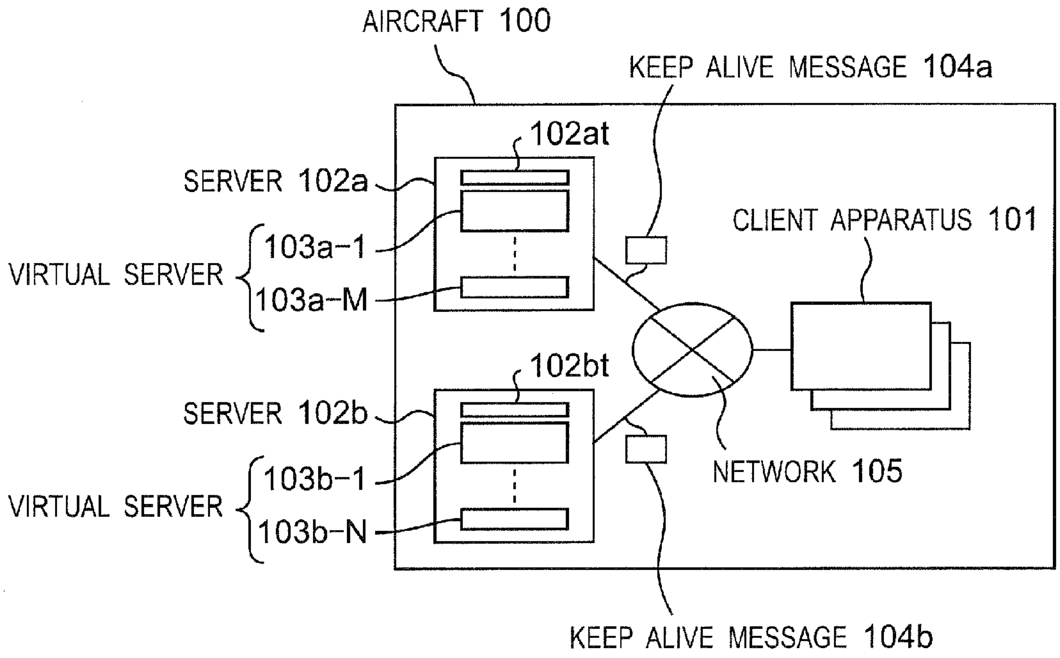


Fig. 1

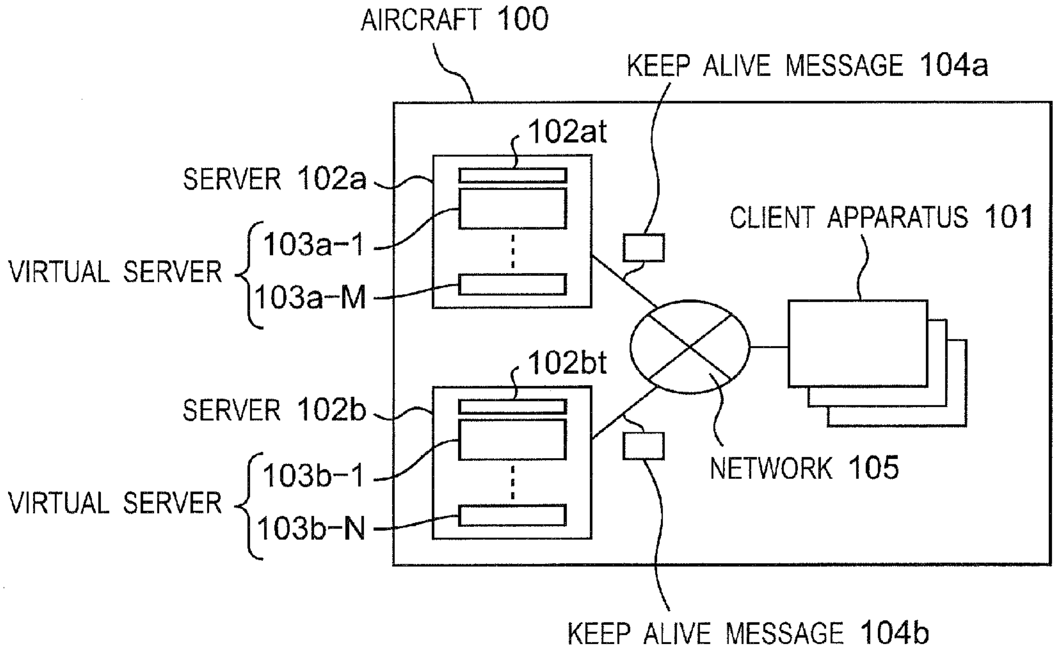

AIRCRAFT 100
KEEP ALIVE MESSAGE 104a
102at
SERVER 102a
CLIENT APPARATUS 101
VIRTUAL SERVER
103a-1
103a-M
102bt
SERVER 102b
103b-1
NETWORK 105
VIRTUAL SERVER
103b-N
KEEP ALIVE MESSAGE 104b

Fig.2

102at, 102bt

SERVICE FUNCTION	REQUIRED RESOURCE NR(Fy)	PRIORITY P(Fy)
Fy1	NR(Fy1)	P(Fy1)
Fy2	NR(Fy2)	P(Fy2)
Fy3	NR(Fy3)	P(Fy3)
⋮	⋮	⋮

Fig.3

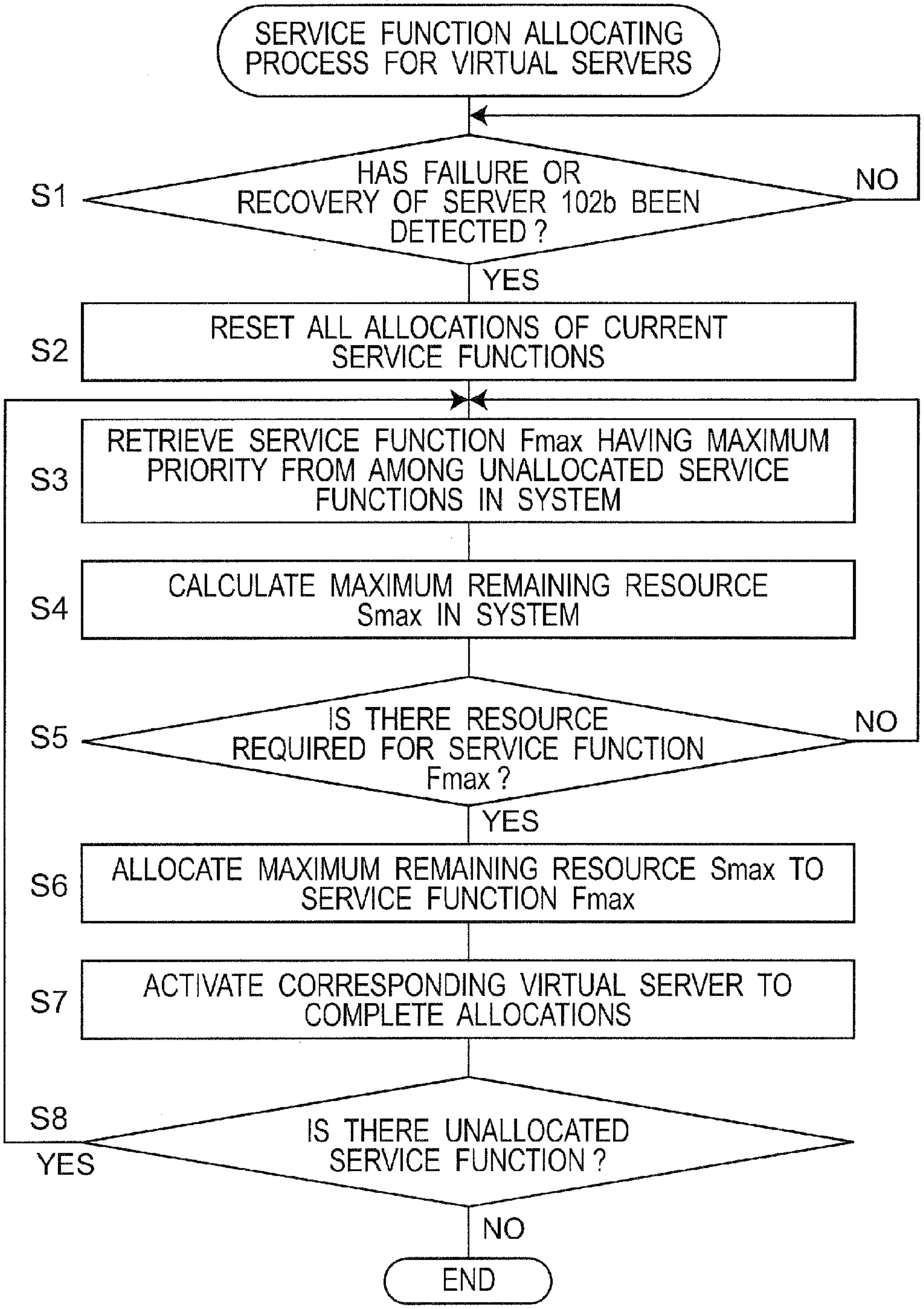
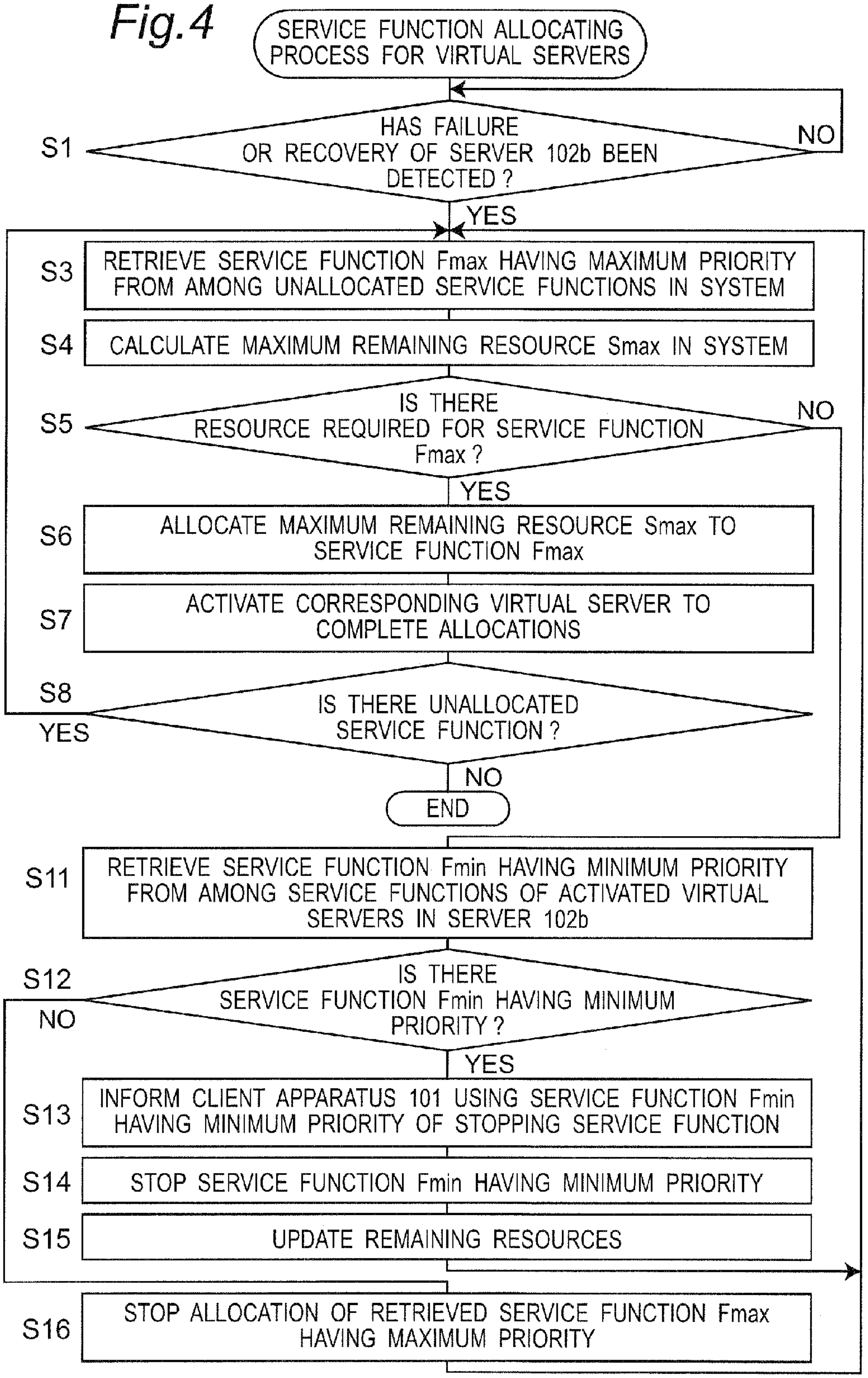

SERVICE FUNCTION ALLOCATING PROCESS FOR VIRTUAL SERVERS
S1
HAS FAILURE OR RECOVERY OF SERVER 102b BEEN DETECTED ?
NO
YES
S2
RESET ALL ALLOCATIONS OF CURRENT SERVICE FUNCTIONS
S3
RETRIEVE SERVICE FUNCTION Fmax HAVING MAXIMUM PRIORITY FROM AMONG UNALLOCATED SERVICE FUNCTIONS IN SYSTEM
S4
CALCULATE MAXIMUM REMAINING RESOURCE Smax IN SYSTEM
S5
IS THERE RESOURCE REQUIRED FOR SERVICE FUNCTION Fmax ?
NO
YES
S6
ALLOCATE MAXIMUM REMAINING RESOURCE Smax TO SERVICE FUNCTION Fmax
S7
ACTIVATE CORRESPONDING VIRTUAL SERVER TO COMPLETE ALLOCATIONS
S8
IS THERE UNALLOCATED SERVICE FUNCTION ?
YES
NO
END

Fig.4


SERVICE FUNCTION ALLOCATING PROCESS FOR VIRTUAL SERVERS
S1
HAS FAILURE OR RECOVERY OF SERVER 102b BEEN DETECTED ?
NO
YES
S3
RETRIEVE SERVICE FUNCTION Fmax HAVING MAXIMUM PRIORITY FROM AMONG UNALLOCATED SERVICE FUNCTIONS IN SYSTEM
S4
CALCULATE MAXIMUM REMAINING RESOURCE Smax IN SYSTEM
S5
IS THERE RESOURCE REQUIRED FOR SERVICE FUNCTION Fmax ?
NO
YES
S6
ALLOCATE MAXIMUM REMAINING RESOURCE Smax TO SERVICE FUNCTION Fmax
S7
ACTIVATE CORRESPONDING VIRTUAL SERVER TO COMPLETE ALLOCATIONS
S8
IS THERE UNALLOCATED SERVICE FUNCTION ?
YES
NO
END
S11
RETRIEVE SERVICE FUNCTION Fmin HAVING MINIMUM PRIORITY FROM AMONG SERVICE FUNCTIONS OF ACTIVATED VIRTUAL SERVERS IN SERVER 102b
S12
IS THERE SERVICE FUNCTION Fmin HAVING MINIMUM PRIORITY ?
NO
YES
S13
INFORM CLIENT APPARATUS 101 USING SERVICE FUNCTION Fmin HAVING MINIMUM PRIORITY OF STOPPING SERVICE FUNCTION
S14
STOP SERVICE FUNCTION Fmin HAVING MINIMUM PRIORITY
S15
UPDATE REMAINING RESOURCES
S16
STOP ALLOCATION OF RETRIEVED SERVICE FUNCTION Fmax HAVING MAXIMUM PRIORITY

LOAD DISTRIBUTION SERVER SYSTEM FOR PROVIDING SERVICES ON DEMAND FROM CLIENT APPARATUS CONNECTED TO SERVERS VIA NETWORK

BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

[0002] The present invention relates to a server system having a redundancy and a load distribution function for use in a mobile service system for providing television broadcasting, radio broadcasting and announcement services for individual passengers in a mobile object such as an aircraft.

[0003] 2. Description of the Related Art

[0004] In recent years, television broadcasting, radio broadcasting and announcement services by the crew have been provided by using client apparatuses such as monitors and loudspeakers installed at passenger's seats and a server for controlling these apparatuses in a mobile object such as an aircraft.

[0005] On the other hand, there have been the practices of constituting the server system of a plurality of servers for improvements in the reliability and the performance of the server system and making the server redundant and load-distributed. Making the server redundant as mentioned above has been known, where a redundant architecture can be actualized by a system in which the clients and the servers are connected via a network. In the server system used in this case, servers classified into an operation system and a standby system are installed to monitor each other. When the server of the operation system enters an abnormal state, the server of the standby system takes over the control to execute control of the connected client apparatuses, and this leads to allowing the function of the whole system to be maintained, and therefore, the reliability of the server system is secured.

[0006] On the other hand, the load distribution of the server has been known, where the clients and the plurality of servers are connected together via a network, and the servers share the roles. When a malfunction or a trouble occurs in any of the servers, the plurality of other servers act to share the functions of the server.

[0007] According to the technology of another prior art technology, when making the server system redundant, one server is operated as an exercising system or an executing system, and switchover to the standby system server takes effect when the normality of the operation system server cannot be confirmed. That is, only the operation system server is normally operated, and the standby system server is not operating, and then, this leads to such a problem that the resources of the other servers cannot be effectively utilized.

[0008] Moreover, according to this technology, when achieving the load distribution of the server system, it is only possible to evenly distribute the function of the server in which the malfunction has occurred to the plurality of other servers. Accordingly, there is such a problem that the loads of the plurality of other servers become heavy since the servers take charge of another function in addition to their own functions, and processing consequently becomes slow.

[0009] However, in the server system in an aircraft or the like, it is necessary to fulfill a plurality of service functions of different levels of importance. In concrete, the announcement service in the aircraft is ranked as the most important service to continue flight, and the slow processing of the server that performs the service leads to impairing the safety of the flight of the aircraft.

SUMMARY OF THE INVENTION

[0010] An object of the present invention is to provide a load distribution server system capable of effectively utilizing the server resources and improving the system reliability by simultaneously making the server system redundant and load-distributed.

[0011] In order to achieve the aforementioned objective, according to one aspect of the present invention, there is provided a load distribution server system for providing a plurality of services on demand from a client apparatus, to which a plurality of servers are connected via a network for the client apparatus. The plurality of servers operate as virtual servers for the client apparatus, and the plurality of servers take charge of the plurality of services to share respective service functions and mutually transceive keep alive messages. When the keep alive message of at least one server is not received or when reception of the keep alive message is restarted in at least one server, the service function of the server of which the keep alive message is not received is allocated to at least one other server on the basis of a predetermined priority of the service function, and a virtual server corresponding to the allocated service function is activated to provide the service of the service function.

[0012] In the above-mentioned load distribution server system, when the keep alive message of at least one server is not received or when reception of the keep alive message is restarted in at least one server, at least one other server retrieves a service function having a maximum priority among the service functions that have not been allocated in the load distribution server system, and in a case where there is a resource required for the service function, the retrieved service function is allocated to the resource, and a virtual server corresponding to the allocated service function is activated to provide the service of the service function.

[0013] Alternatively, in the above-mentioned load distribution server system, when the keep alive message of at least one server is not received or when reception of the keep alive message is restarted in at least one server, at least one other server retrieves a service function having a maximum priority among the service functions that have not been allocated in the load distribution server system, and in a case where there is a service function having a minimum priority when there is no resource required for the service function, the service function is stopped and the remaining resources are updated, and thereafter, the service function having the maximum priority is retrieved from among the service functions that have not been allocated in the load distribution server system.

[0014] In addition, in the above-mentioned load distribution server system, when the keep alive message of at least one server is not received or when reception of the keep alive message is restarted in at least one server, at least one other server retrieves the service function having the maximum priority from among the service functions that have not been allocated in the load distribution server system, and in a case where there is no service function having the minimum priority when there is no resource required for the service function, allocation of the service function having the maximum priority is stopped.

[0015] Further, in the above-mentioned load distribution server system, the load distribution server system is a service system provided in an aircraft.

[0016] Therefore, according to the load distribution server system of the present invention, the effective utilization of the server resources and the improvement in the system reliability can be improved by allowing the server system to be load-distributed and redundant concerning the service functions according to a priority.

BRIEF DESCRIPTION OF THE DRAWINGS

[0017] These and other objects and features of the present invention will become clear from the following description taken in conjunction with the preferred embodiments thereof with reference to the accompanying drawings throughout which like parts are designated by like reference numerals, and in which:

[0018] FIG. **1** is a block diagram showing a configuration of a load distribution server system according to a first preferred embodiment of the present invention;

[0019] FIG. **2** is a tabulation showing service function management tables **102** at and **102***bt* stored in the storage apparatuses of servers **102***a* and **102***b*, respectively, of the load distribution server system of FIG. **1**;

[0020] FIG. **3** is a flow chart showing a service function allocating process for virtual servers executed by the server **102***a* of the load distribution server system of the first preferred embodiment of the present invention; and

[0021] FIG. **4** is a flow chart showing a service function allocating process for virtual servers executed by the server **102***a* of a load distribution server system according to a second preferred embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0022] Preferred embodiments of the present invention will be described below with reference to the drawings.

First Preferred Embodiment

[0023] FIG. **1** is a block diagram showing a configuration of a load distribution server system according to a first preferred embodiment of the present invention.

[0024] As shown in FIG. **1**, a plurality of client apparatuses **101** such as monitors and loudspeakers installed at passenger's seats exist in an aircraft **100**, and the apparatuses are connected to a plurality of servers (physical servers) **102***a* and **102***b* via a local area network (hereinafter, referred to as a network) **105** of, for example, wireless LAN or wired Ethernet (registered trademark). Although the servers **102***a* and **102***b* are described as two in number in the present preferred embodiment, the number is not limited because the servers **102***a* and **102***b* are provided according to service functions.

[0025] A plurality of service functions provided by the system exist separately in the servers **102***a* and **102***b*, and one or a plurality of M virtual servers **103***a*-**1** to **103***a*-M and one or a plurality of N virtual servers **103***b*-**1** to **103***b*-N operate to fulfill the service functions in the respective servers **102***a* and **102***b*. The virtual servers **103***a*-**1** to **103***a*-M and **103***b*-**1** to **103***b*-N are servers that operate virtually to perform communications with a client apparatus **101** by using a virtual IP address set for each service function in the servers **102***a* and **102***b*. The virtual servers **103***a*-**1** to **103***a*-M and **103***b*-**1** to **103***b*-N are managed by a method as described later by using the service function management tables **102** at and **102***bt* of FIG. **2** so that one service function is operated only in one server **102***a* or **102***b*.

[0026] Each client apparatus **101** communicates with a virtual server (one of **103***a*-**1** to **103***a*-M and **103***b*-**1** to **103***b*-N) having a virtual IP address allocated for each service function. In this case, by using the virtual IP address, the client apparatus **101** can operate without considering which of the servers **102***a* and **102***b* the virtual server corresponding to each service function is operating in. That is, even if the server **102***a* or **102***b* in which the virtual server is actually operating is changed, switchover of the virtual server can be not considered since each client apparatus **101** communicates with the other party's virtual server by using the virtual IP address.

[0027] The servers **102***a* and **102***b* transmit keep alive messages **104***a* and **104***b* for vital surveillance by using a multicast IP. For example, the server **102***a* judges that the server **102***b* is normally operating when receiving the keep alive message **104***b* of the other server **102***b*. Moreover, the keep alive messages **104***a* and **104***b* are transmitted periodically at definite periodic intervals. For example, when reception from the other server **102***b* cannot be achieved after a lapse of a definite period, it is determined that the server **102***b* has failed in an abnormal state. By thus making a judgment by transceiving the keep alive messages **104***a* and **104***b* by the server **102***a*, the state of the server **102***b* can be judged.

[0028] In this case, the server IDs of the servers **102***a* and **102***b* are defined as Sx (x=a, b), and the service function IDs are defined as Fyi (i=1, 2, . . .) (generically referred to as a service function Fy). The resource of the server ID(Sx) is expressed as R(Sx) since the servers **102***a* and **102***b* have respective varied resources, and the required resource is defined as NR(Fyi) (i=1, 2, . . .) (generically referred to as a required resource NR(Fy)) since each service function ID(Fyi) has a varied server resource amount used for each service function. Moreover, the priority of each service function ID(Fyi), which is also varied every service function, is therefore defined as P(Fyi) (i=1, 2, . . .) (generically referred to as a priority P(Fy)).

[0029] FIG. **2** is a tabulation showing service function management tables **102** at and **102***bt* stored in the storage apparatuses of the servers **102***a* and **102***b*, respectively, of the load distribution server system of FIG. **1**. As apparent from FIG. **2**, the required resource NR(Fyi) and the priority P(Fyi) are preparatorily set for respective service functions Fyi (i=1, 2, . . .) by the administrator. The priority P(Fyi) is set as 10, 9, . . . , 1, for example, in the order of higher priorities. For example, when the number and the resource amounts of the servers are changed or the operating service functions are increased or decreased in number, the changes can be reflected by setting the same changes.

[0030] With the above definitions, the remaining resource RR(Sx) of the server ID(Sx) is expressed by the following equation:

$$RR(Sx) = R(Sx) - \sum_i NR(Fyi). \tag{1}$$

[0031] where Fyi denotes a service function ID operating with the server ID(Sx).

[0032] FIG. **3** is a flow chart showing a service function allocating process for virtual servers executed by the server **102***a* of the load distribution server system of the first preferred embodiment of the present invention. The servers **102***a* and **102***b* perform control of allocating each service function Fyi to the servers **102***a* and **102***b* by executing the service function allocating process of FIG. **2**. The allocated service function Fyi is operated by activating the virtual servers **103***a*-**1** to **103***a*-M and **103***b*-**1** to **103***b*-N, and a service corresponding to the service function Fyi is provided for the client apparatus **101**.

[0033] FIG. **3** shows a case where the processes in step S**2** and the subsequent steps are executed when the server **102***b* detects a failure or recovery (S**1**). When the server **102***a* cannot receive the aforementioned keep alive message **104***b* in a definite interval and determines that the server **102***b* has failed or recovered (YES in S**1**), the server **102***a* totally resets allocation of the current service functions (S**2**), and thereafter, starts a recalculating process of the allocation of the virtual server.

[0034] First of all, a service function ID(Fmax) of the maximum priority P(Fyi) in the function ID(Fyi) scheduled to operate in the whole system is retrieved (S**3**). For example, assuming that the service functions scheduled to operate in the whole system are two service functions owned by the virtual servers **103***a* and **103***b*, when the virtual server **103***b* has a higher priority than the virtual server **103***a*, the virtual server **103***b* is required to preferentially operate. Next, Smax that is the maximum remaining resource RR(Sx) in the servers operable in the system is calculated (S**4**). In this case, the server resource R(Sx) of the server ID(Sx) of the server **102***b* becomes zero due to the failure of the server **102***b*, and therefore, the server **102***a* is consistently selected in the configuration of the two servers **102***a* and **102***b*. That is, a relation of server **102***a*=server ID(Smax) holds. In a configuration of three or more servers, the server having the maximum remaining resource amount is selected from among the operable servers.

[0035] Regarding the retrieved service function ID(Fmax) and server ID(Smax), the server ID(Smax) judges whether the service function ID(Fmax) has a required resource (S**5**). If there is a sufficient required resource (YES in S**5**), the service function ID(Fmax) is assigned to operate as the server ID(Smax) (S**6**). At this time, when the server ID(Smax) is the self-server ID, which is set to the server **102***a*, a virtual IP address corresponding to the service function ID(Fmax) is made effective to operate a virtual server **103***b*-*n* corresponding to the service function ID(Fmax) for update into an allocation completion state (S**7**). When there is an insufficient required resource (No in S**5**), the program flow returns to step S**3**, and processing from step S**3** is repeated except for the retrieved service function.

[0036] If allocations of all the service function IDs are completed (No in S**8**), the service function allocating process is ended. If allocations of all the service functions are not completed (YES in S**8**), the processing from step S**3** is repetitively executed again. That is, since the allocation of the virtual server **103***a* is not yet completed, the processing is repetitively executed. In order to operate a service function ID(Smax) of a higher priority, it is possible to search another operable server by the repetitive processing. If there is such a server, optimal relocation of the service functions can be achieved by performing reboot.

[0037] By the above allocation control, distributed allocation can be executed in a state in which the required resource of each service function ID(Fyi) is operable within the server resource R(Sx) owned by each server ID(Sx) according to the priority of the service functions.

[0038] Next, in a case where the server **102***b* that has been failed is recovered and transmission of the keep alive message **104***b* is restarted, the server **102***a* receives the keep alive message **104***b* and judges that the server **102***b* has been recovered, and sets the resource amount R(Sx) of the server ID(Sx) back to the initial setting value from zero to execute again the service function allocating process of FIG. **3**. Moreover, the recovered server **102***b* executes allocation likewise as an initialization process. As a result, the service function is allocated to the recovered server **102***b*, and then a load distribution can be achieved. Moreover, by adding the server resource, it is possible to recover the low-priority service functions of the server **102***a* that has been stopped.

Second Preferred Embodiment

[0039] FIG. **4** is a flow chart showing a service function allocating process for virtual servers executed by the server **102***a* of a load distribution server system according to a second preferred embodiment of the present invention. The load distribution server system of the second preferred embodiment of the present invention has a configuration similar to that of FIG. **1**, and the servers **102***a* and **102***b* have service function management tables **102** at and **102***bt* similar to those of FIG. **2**. The present system is characterized in that the service function allocating process of FIG. **3** is replaced by the service function allocating process of FIG. **4**. In comparison with the service function allocating process of FIG. **3**, the service function allocating process of the second preferred embodiment is characterized in that:

[0040] (1) the process in step S**2** is eliminated; and

[0041] (2) execution of "processes, when a service function Fmin having the minimum priority is retrieved and existing, for stopping the service function Fmin and so on in steps S**11** to S**16** when the answer is NO in step S**5**.

[0042] The processes in step S**1** to step S**8** of FIG. **4** are similar to those of FIG. **3** except for not executing the process in step S**2**. When the server resource amount of the server **102***a* is insufficient for a service function Fmax in step S**5** (No in S**5**), a low-priority service function ID (Fmin) is retrieved (S**11**), and it is judged whether there is the required resource of the service function ID (Fmax) together with the remaining resource RR(Sx) (S**12**). In a case where the resource is insufficient, when there is a low-priority service function (YES in S**12**), the client apparatus **101** that is using the service function Fmin of the minimum priority is informed of stopping the service function Fmin (S**13**), and the service function Fmin of the minimum priority is stopped (S**14**). By stopping the function, the remaining resources are updated to increase the remaining resource amount of the server (S**15**), and it is judged again whether there is the required resource of the service function (S**3**).

[0043] When allocation has failed even if all the low-priority service functions are stopped (No in S**12**), the allocation of the retrieved service function Fmax having the maximum priority is stopped, and an allocation completion state is established (S**16**). In this case, when the virtual server **103***a* judges that there is a required resource, and the replacement of the service function is possible, the low-priority service function of the server **102***a* is stopped according to the priority of the service functions, and replaced by a high-priority service function of the server **102***b*, so that the server **102***a* can continue processing.

[0044] By the above allocation control, distributed allocation can be executed in a state in which the required resource of each function ID-Fx is operable within the server resource R(Sx) owned by each server ID(Sx) according to the priority of the service functions.

[0045] Next, when the server **102***b* that has failed is recovered and the transmission of the keep alive message **104***b* is restarted, the server **102***a* receives the keep alive message **104***b* and judges that the server **102***b* has recovered, and the resource amount R(Sx) of the server ID(Sx) is set back to the initial setting value from zero to execute again the service function allocating process of FIG. **4**. Moreover, the recovered server **102***b* executes allocation likewise as an initialization process. As a result, the service function is allocated to the recovered server **102***b*, achieving load distribution. Moreover, by adding the server resource, it is possible to recover the low-priority service functions of the server **102***a* that has been stopped.

Modified Preferred Embodiment

[0046] Although the case where there are two servers has been described above in the present preferred embodiment of the present invention, the present invention is not limited to this. When there are more number of servers, the service function of the server **102***b* replaced by the server **102***a* can be shared by a plurality of servers. As described above, by replacing the high-priority function of the failed server among the plurality of servers with the own low-priority function of another server, the processing of the high-priority function can be continued without degrading the performance.

[0047] The above load distribution server system can also be provided for not only the airplane service system but also other server systems like a train service system, a bus service system, and a broadcasting system.

INDUSTRIAL APPLICABILITY

[0048] The load distribution server system of the present invention is able to improve the effective use of the server resources and the system reliability by allowing the servers to be distributed and redundant concerning the service functions according to the priority, and useful as mobile object service systems of aircrafts, trains and the like to provide television broadcasting and announcement services for individual passengers.

[0049] Although the present invention has been fully described in connection with the preferred embodiments thereof with reference to the accompanying drawings, it is to be noted that various changes and modifications are apparent to those skilled in the art. Such changes and modifications are to be understood as included within the scope of the present invention as defined by the appended claims unless they depart therefrom.

What is claimed is:

1. A load distribution server system for providing a plurality of services on demand from a client apparatus, to which a plurality of servers are connected via a network for the client apparatus,

wherein the plurality of servers operate as virtual servers for the client apparatus,

wherein the plurality of servers take charge of the plurality of services to share respective service functions and mutually transceive keep alive messages, and

wherein, when the keep alive message of at least one server is not received or when reception of the keep alive message is restarted in at least one server, the service function of the server of which the keep alive message is not received is allocated to at least one other server on the basis of a predetermined priority of the service function, and a virtual server corresponding to the allocated service function is activated to provide the service of the service function.

2. The load distribution server system as claimed in claim **1**,

wherein, when the keep alive message of at least one server not received or when reception of the keep alive message is restarted in at least one server, at least one other server retrieves a service function having a maximum priority among the service functions that have not been allocated in the load distribution server system, and in a case where there is a resource required for the service function, the retrieved service function is allocated to the resource, and a virtual server corresponding to the allocated service function is activated to provide the service of the service function.

3. The load distribution server system as claimed in claim **1**,

wherein, when the keep alive message of at least one server is not received or when reception of the keep alive message is restarted in at least one server, at least one other server retrieves a service function having a maximum priority among the service functions that have not been allocated in the load distribution server system, and in a case where there is a service function having a minimum priority when there is no resource required for the service function, the service function is stopped and the remaining resources are updated, and thereafter, the service function having the maximum priority is retrieved from among the service functions that have not been allocated in the load distribution server system.

4. The load distribution server system as claimed in claim **3**,

wherein, when the keep alive message of at least one server is not received or when reception of the keep alive message is restarted in at least one server, at least one other server retrieves the service function having the maximum priority from among the service functions that have not been allocated in the load distribution server system, and in a case where there is no service function having the minimum priority when there is no resource required for the service function, allocation of the service function having the maximum priority is stopped.

5. The load distribution server system as claimed in claim **1**,

wherein the load distribution server system is a service system provided in an aircraft.

6. The load distribution server system as claimed in claim **2**,

wherein the load distribution server system is a service system provided in an aircraft.

7. The load distribution server system as claimed in claim **3**,

wherein the load distribution server system is a service system provided in an aircraft.

8. The load distribution server system as claimed in claim **4**,

wherein the load distribution server system is a service system provided in an aircraft.

* * * * *