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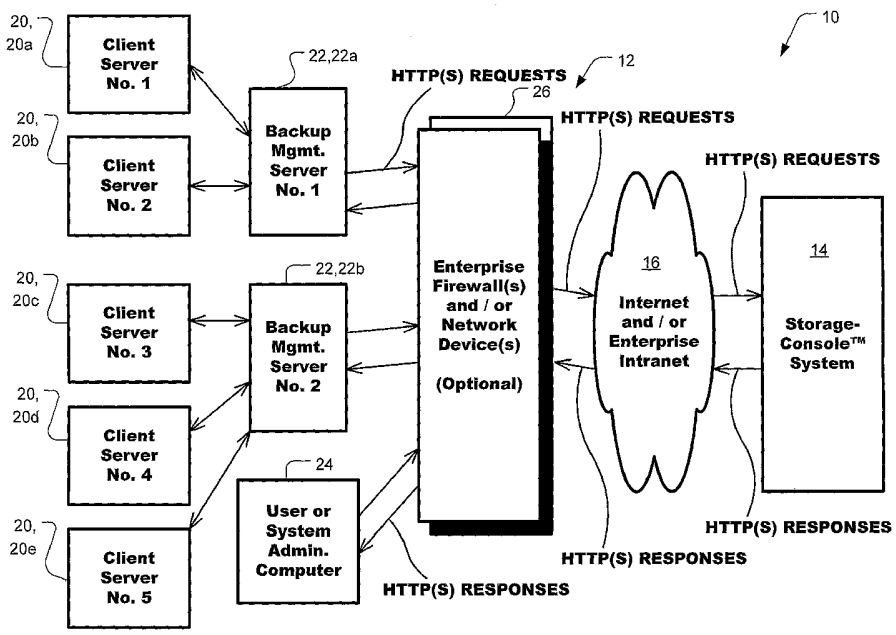
(54) Title: SYSTEM TO CAPTURE, TRANSMIT AND PERSIST BACKUP AND RECOVERY META DATA



(57) Abstract: A system to capture, transmit and persist backup and recovery meta data over a network (16). An agent (48) captures the meta data at a computerized backup management system (22). The agent transmits the meta data from the backup management system to a storage console portal system (30). And the computerized console portal system includes a database (54) to store the meta data, thereby capturing, transmitting and persisting the meta data.

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For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

SYSTEM TO CAPTURE, TRANSMIT AND PERSIST BACKUP AND RECOVERY META DATA

TECHNICAL FIELD

The invention relates generally to systems and methods for maintaining enterprise data object integrity across distributed storage networks by the use of backup and restoration process, and more particularly to managing such processes and providing meta data about such data objects and processes.

BACKGROUND ART

Modern enterprises, including corporations, public agencies, and other entities, use sophisticated networks of computers and other digital devices. Some of these function as servers to other devices on the network. Such servers typically store data, programs, documents, media content, and other information, which are collectively termed herein "data".

Data stored on servers is at risk of being damaged or destroyed by a wide range of hardware problems, software problems, user errors, or malicious activities. Thus, most enterprises make frequent backup copies of the data stored on servers.

When managing a backup system that maintains backup copies of the data stored within an enterprise, there is a need to present the current status of the backup system in a clear and concise manner to those individuals, such as system administrators, who are responsible for the system. Such presentation of status information is often complicated by the fact that medium or large enterprises often have multiple backup servers, also known as backup management servers (BMSs). Each BMS backs up the data on the servers within the enterprise that are client servers of that backup server.

Another need when managing a backup system is to store information about the data that is backed up, that is, to store meta data, in a manner that does not consume excessive storage space. The meta data typically includes data about backup operations or events that have occurred. The meta data stored may include individual file by file meta data or file details, including the meta data for each backup copy of each file that is stored in each backup management system.

There is also a need to store the meta data in a manner that allows efficient retrieval of

every backup and restore event for a particular file, or set of files, that occurred during a particular time period.

Yet another need when managing a backup system is to transfer the meta data across a network to a meta-data server. This transfer should be done in a manner that does not consume excessive network bandwidth. Further, this transfer should be done in a manner that does not compromise the security of the backup servers, which are extremely sensitive because they store all or most of the data that the enterprise stores electronically. Further, this transfer should be done in a manner that does not compromise the security of the meta data that is being transferred, which is also extremely sensitive because it describes the data that the enterprise stores electronically.

There is also a need to reduce the footprint that the process of gathering and storing the meta data has on the resources of the backup management servers, that is, to reduce the impact on the resources of the backup management servers that are consumed in the process of gathering and storing the meta data. These resources include, among others, processor bandwidth, memory allocation, memory bandwidth, storage allocation and storage bandwidth.

Another need when managing a backup system is to recover automatically from problems or exceptions. Exceptions occur when the process of gathering and storing the meta data does not function in a normal or expected manner. Typical causes of exceptions in backup management systems include, but are not limited to: an unstable or unreliable network connection between components of a BMS; a network proxy server that is down or not functioning properly; a network that is saturated by excessive traffic, such as may be caused by malicious activity or viruses, or by reallocating network traffic that is usually handled by a network component that is currently inoperable or down; a network portal server that is down or not functioning properly; or a meta data server that is down.

There is also a need to automatically add and set up or provision a client server after it has been newly added to the enterprise's network. A large enterprise may have 10,000 or more client servers. In such an enterprise, adding new client servers and restructuring or reallocating existing ones may occur on an almost daily basis.

DISCLOSURE OF INVENTION

Accordingly, it is an object of the present invention to provide a system to capture, transmit and persist backup and recovery meta data.

Briefly, one preferred embodiment of the present invention is a system to capture, transmit and persist backup and recovery meta data over a network. An agent captures the meta data at a computerized backup management system. The agent then transmits the meta data from the backup management system to a computerized storage console portal system. And the console portal system includes a database to store the meta data, thereby capturing, transmitting and persisting the meta data.

The other objects and advantages of the present invention will become clear to those skilled in the art in view of the description of the best presently known mode of carrying out the invention and the industrial applicability of the preferred embodiment as described herein and as illustrated in the several figures of the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

The drawings illustrate technologies related to the invention, show example embodiments of the invention, and give examples of using the invention. The objects, features and advantages of the invention will become more apparent from the following detailed description when read in conjunction with the following drawings:

FIG. 1 is a functional block diagram of an exemplary embodiment of the invention, emphasizing aspects within an enterprise network that capture and transmit meta data.

FIG. 2 is a functional block diagram of an exemplary embodiment of the invention, emphasizing aspects within a StorageConsole (TM) system that persist and manage the backup and recovery meta data of the enterprise.

FIG. 3 is a functional block diagram of another exemplary embodiment of the invention, particularly showing the communication paths used between client servers and a backup management server, as well as those used between the backup management server and a SC portal server.

FIG. 4 is a functional block diagram of yet another exemplary embodiment of the invention, particularly showing the communication paths and methods used between the StorageConsole system and the users of an enterprise's computers, servers and networks.

FIG. 5 is a data structure diagram or database schema suitable for storing meta data, including the file details, according to an embodiment of the invention.

FIG. 6 is an exemplary status summary or mission control report according to an embodiment of the invention.

FIG. 7 is a flow chart of a process to capture and transmit backup and recovery meta data according to an embodiment of the invention.

FIG. 8 is a flow chart of a process to manage and store capture and received meta data according to an embodiment of the invention.

FIG. 9 is a flow chart of a process for handling exceptions according to an embodiment of the invention.

FIG. 10 is a flow chart of a process to add a new client server according to an embodiment of the invention.

FIG. 11 is a block diagram showing an architectural overview of the infrastructure of an exemplary embodiment of the invention.

FIG. 12 is a block diagram showing another architectural overview of an exemplary embodiment of the invention.

FIG. 13A-D are a flow chart depicting an example backup process using NetBackup as exemplary backup server software.

FIG. 14A-B are a flow chart depicting an example restore process, again using NetBackup as backup server software.

FIG. 15A-C are a flow chart depicting a suitable flow process for the data receiver agent of the invention.

In the various figures of the drawings, like references are used to denote like or similar elements or steps.

BEST MODE FOR CARRYING OUT THE INVENTION

The descriptions and discussions herein illustrate technologies related to the invention, show examples of the invention and give examples of using the invention. Known methods, procedures, systems, circuits, or elements may be described without giving details so as to avoid obscuring the principles of the invention. On the other hand, details of specific embodiments of the invention are described, even though such details may not apply to other embodiments of the invention.

Some descriptions and discussions herein use abstract or general terms including but not limited to agent, demon, symbol, number, byte, communicate, object, procedure, and block. Those skilled in the art use such terms as a convenient nomenclature for components, data or operations within a computer, digital device or electromechanical system. Such components, data and operations are represented by physical properties of actual objects

including but not limited to electronic voltage, magnetic field and optical reflectivity. Similarly, perceptive or mental terms including but not limited to detect, sense, recall, present, test, compare, control, process, manipulate, analyze, and determine may also refer to such components, data or operations or to manipulations of such physical properties.

One preferred embodiment of the present invention is a system to capture, transmit and persist backup and recovery meta data. To simplify the following discussion we generally show the invention in the context of a global backup system (GBS). As illustrated in the various drawings herein, and particularly in the view of FIG. 1, the GBS **10** is depicted by the general reference character 10.

FIG. 1-2 are functional block diagrams of an exemplary GBS **10** in accord with the present invention. FIG. 1 emphasizes aspects within an enterprise network **12** that are of particular importance to the ability of the GBS **10** to capture and transmit meta data for a typical enterprise. FIG. 2 emphasizes aspects within a StorageConsole™ system (SCS **14**) that are of particular importance to the ability of the GBS **10** to persist and manage the backup and recovery meta data of the enterprise. The an enterprise network **12** and the SCS **14** communicate via the Internet and/or an enterprise intranet (generically, an I-net **16**).

Turning now to FIG. 1, it shows how client servers **20**, backup management servers (BMS **22**), an administrator system **24**, and optional additional network devices **26** communicate via the I-net **16**. For reference, the respective client servers **20** are client servers **20a-e** and the BMS **22** are BMS **22a-b**. Some examples of common additional network devices **26** include routers, bridges, and firewalls.

There may by thousands of client servers **20** and BMSs **22** present in a typical enterprise using the GBS **10**, and the necessarily simplified embodiments shown in the figures herein should not be interpreted restrictively. For example, two enterprises that use present commercial embodiments of the GBS **10** for their complex network-backup needs are the United States Patent and Trademark Office (USPTO) and Bank of America Corporation (BOA). The USPTO is relatively concentrated geographically, whereas, BOA offices are widely distributed all over the world.

Backup copies of data at the client servers **20a-b** is backed up by BMS **22a** and backup copies of data at the client servers **20c-e** are backed up by BMS **22b**. Typically, such backups are done on a regular schedule, such as a full copy of all files being made starting at midnight of each working day. Another common schedule is for a full copy of all files to be made weekly or monthly, with incremental daily backups. In an incremental backup, copies are made of only those files that have changed since the last backup – sometimes since the

last full backup, sometimes since the last incremental backup.

The BMSs **22** communicate meta data and other backup information to the SCS **14**, or to other servers that store this information, in sessions conducted according to the well-known hyper-text transport protocol (HTTP) or the much more secure HTTPS protocol. Generally, all such sessions will be initiated by the respective BMSs **22**. This is not a necessary requirement of the GBS **10**, however, but rather a matter of prudent network management for security purposes.

Some form of a network connection is typically used to convey information between the BMSs **22** and the SCS **14**. In some cases, the SCS **14** is located within an enterprise itself and this communication can occur exclusively over the enterprise's intranet. In other cases, the SCS **14** is located elsewhere and communication occurs over the public Internet. The I-net **16** generically represents these network connections.

Turning now to FIG. 2, the SCS **14** includes more optional network devices **26**, StorageConsole web servers (SC portal servers **30**), optional internal firewalls **32**, and StorageConsole database servers (SC database servers **34**). For reference, the respective SC portal servers **30** are SC portal servers **30a-b** and the SC database servers **34** are SC database servers **34a-c**.

In some embodiments of the invention, any BMS **22** may access any of the SC portal servers **30**; any SC portal server **30** may access any of the SC database servers **34**; and the meta data and other backup information associated with a particular BMS **22** may be stored on any one of the SC database servers **34** or such information may be replicated on more than one of the SC database servers **34a-c** so that there is a fallback to help ensure reliability of the GBS **10**.

Typically the SC portal servers **30** are coupled to the I-net **16** via one or more instances of the optional network devices **26** (e.g., routers, switches, or firewalls), however, this is optional. The SC portal servers **30** may be coupled via conventional network equipment to the SC database servers **34**, or via the optional internal firewalls **32** for added security. Here as well, multiple instances of similar or identical equipment may be used to have a fallback device available in case of problems, or may be used for balancing network traffic. The optional network devices **26** and internal firewalls **32** and the use of the HTTPS protocol may be less important for communication over a small, private and trusted intranet than for communication that uses the vast, public and interception-prone Internet.

A SC portal server **30** may run on a machine that is separate from the SC database server **34** or both may run on the same machine. If two different machines are used, then one

or more of the optional internal firewalls **32** may be used between the machines to increase security. Firewalls are known in the art that can be configured to allow proper database access commands and responses to pass through, but block other messages.

In some embodiments, all communication between the software used and the SC portal server **30** occur via the Java data base connectivity protocol (JDBC). In such embodiments, the internal firewalls **32** can monitor this traffic to ensure that all messages are legal JDBC commands and responses.

With reference briefly also to FIG. 1, users access the GBS **10** via a user or system administrator computer (an administrator system **24**) that is coupled to the I-net **16**. In FIG. 1-2 the administrator system **24** shown is within the enterprise network **12**, but this is not a requirement, and one or more administrator systems **24** can be within the enterprise network **12**, within the SCS **14**, or otherwise coupled to the I-net **16**. A user may be an ordinary or individual user, who accesses the GBS **10** to request that one of his or her files be restored from backup storage. Such a user may also be a system administrator who is responsible for managing backup system in one or more enterprise networks **12** or for managing all or part of the GBS **10**.

FIG. 3 is a functional block diagram of another exemplary embodiment of a GBS **10**, particularly showing the communication paths used between two client servers **20a-b** and a BMS **22**, as well as those used between the BMS **22** and a SC portal server **30**.

Backup events occur periodically. In a backup event, client backup software **40** running on a particular client server **20a-b** sends data and meta data to backup server software **42** that runs on an associated BMS **22**. Restore events occur on an occasional or as needed basis. In a restore event, data is sent from the backup server software **42** of a BMS **22** back to the client backup software **40** of one of the client servers 20a-**b** served by that BMS **22**. As cannot be overstressed, in a typical large enterprise there may be thousands of client servers **20** and BMSs **22** present. The backup scenario just described can take place thousands of times per day and the restore scenario just described can take place tens or hundreds of times per day.

Various embodiments of the invention may be used in conjunction with various client backup software **40** and backup server software **42**. Such software includes but is not limited to: the NetBackup products from VERITAS Software Corporation of Mountain View, California; the LEGATO NetWorker products from LEGATO Systems, Inc. of Mountain View, California; and the Tivoli Storage Manager products from IBM Corporation.

Typically the data transfer between the client backup software **40** and backup server

software **42** occurs via an enterprise intranet such as a local area network (LAN), but wide area networks (WANs), storage area networks (SANs), or other communication channels may also be used.

The backup server software **42** on each BMS **22** receives the backup data and the backup meta data and sends the restore data. Typically, the meta data for each backup and restore event is stored in a catalog that is held on a disk drive 44 within the BMS **22**. Typically, the backup data is stored on one or more storage units **46**, which may include but are not limited to disk drives, tape drives, or "juke boxes". A juke box holds a library of tapes or other digital media and allows each to be individually selected, automatically positioned to be active, and then read, written or both.

The backup server software **42** interacts with the GBS **10** by providing backup statistics and meta data to a StorageConsole agent (SC agent **48**) and by receiving restore requests from the SC agent **48**. The SC agent **48** is the software component of the GBS **10** that runs on the BMS. As discussed in detail presently, the SC agent 48 in the inventors' presently preferred embodiment is implemented as three software components that run largely independently.

The backup statistics that are communicated to and stored by the SC database server **34** may include, but are not limited to one or more of: the current inventory of media (tapes or other) held within a BMS **22**; the current inventory of storage units **46** (tape drives, disk drives, jukeboxes, or other) that are part of a BMS **22** ; the current utilization of the media held within a BMS **22**; or current utilization of the storage units **46** within a BMS **22**.

The SC agents **48** communicate with the SC portal server **30** via initiating HTTP or HTTPS sessions with a StorageConsole web portal (SC web portal **50**). These sessions occur over the I-net **16**.

Because the communications occur via sessions that use the well-known and commonly used HTTP or HTTPS protocols, no changes are required in routers, bridges, firewalls, etc. (e.g., the optional network devices **26** shown in FIG. 1-2) or in other security policies when the SC agents **48** are installed on BMSs **22**. This substantially simplifies installation, both the technical process of installing the SC agents **48** and the managerial or information technology department of obtaining approval for installation of the GBS **10**.

Further because communications occur via sessions that use the stateless HTTP or HTTPS protocols, embodiments of the invention employing these protocols can have no communication socket or channel open during or after communication. An open socket that has already been authenticated, verified and allowed access is a major point of vulnerability

in the security of a network.

In the inter-process communication scheme depicted in FIG. 3, the BMS **22** becomes a client of the SC portal server **30** by initiating a communication session. But preferably never visa versa. That is, as a strong security practice, the SC portal server **30** need never initiate any communication with a BMS **22**. Because the BMS **22** need never responds to a communication session that an external device is attempting to initiate, there is no way that a curious person, a deliberate hacker or any kind of impostor can use such a communication path to compromise the security of the BMS **22**. This security feature is very advantageous for enterprises that use the public Internet to communicate their meta data to SC portal server **30**.

Nevertheless, this security feature is also advantageous for enterprises that use a private intranet for such communication, in that the feature prevents a user with authorized access to a portion of the enterprise's servers or networks from using the meta-data communication path to illegitimately access other portions of the enterprise's data. Few users, if any, have access to all of the data on all servers of an enterprise.

The SC agents **48** send meta data for each backup event, meta data for each restore event, and backup statistics to the SC web portal **50**. Also, the SC agents **48** periodically poll the SC web portal **50** to see if any restore operations have been requested for the BMS **22**. If so, they receive the details of what file or files are to be restored from what backup event.

The SC agents **48** may be software that is written in the Java (TM) programming language. Such SC agents **48** are then more easily ported to BMSs **22** using different operating systems and different processors than SC agents **48** that are written in the C or the C++ programming languages.

In some embodiments of the invention, the Java cryptography extension (JCE), the Java authentication and authorization service (JAAS) or both may be used to implement some of the security, authentication and encryption features of the GBS **10**.

In some embodiments of the GBS **10**, the Java code that is used in the SC agents **48** is transformed by a process that obfuscates the code, that optimizes the code, or both. Such processes include, but are not limited to those of: the DashO products from Preemptive Solutions, Inc. of Cleveland, Ohio; or the Jshrink product from Eastridge Technology of Princeton, New Jersey.

The SC web portal **50** is the access point by means of which the SC agents **48** that run on a BMS **22** access the SCS **14**. The SC web portal **50** is also an access point by means of which system administrators, ordinary users, or both may access the SC portal server **30**.

In embodiments of the invention in which the HTTPS protocol is used, unauthorized access to the SC web portal **50** is prevented, or at least made very improbable, by the security of HTTPS. HTTPS is based on the use of a secure sockets layer (SSL) and on public-key encryption. Some embodiments of this protocol use 128-bit encryption, which makes decrypting of an intercepted message unlikely using any presently known technique.

Some embodiments of the GBS **10** obtain the public key used for this encryption from a digital certificate that authenticates the recipient of a message. A digital certificate is issued, encrypted and signed by a trusted third party. Digital certificates make it highly unlikely that an unauthorized imposture can appear either to the SCS **14** or to one of the BMSs **22** to be the other party in their communication channel.

In addition to or instead of using the HTTPS protocol or server certificates, some embodiments of the GBS 10 use a "magic key" to authenticate the identity of each BMS **22** prior to granting any access to the SCS **14**. The magic key is an encoded form of one or more information tokens. At least one of the information tokens used has a unique value for each BMS **22**.

Information tokens used to form the magic key may include, but are not limited to: the name of the BMS **22**; the network or internet protocol (IP) address of the BMS **22**; the name of a server group that includes the BMS **22**; a password that is manually entered into both the SC agent **48** and the SC portal server **30** when a BMS **22** is first provisioned; or system identification codes such as serial numbers or device identifiers that are embedded in the hardware or the low-level software of the BMS **22** (e.g., a MAC address).

Various other embodiments of the GBS **10** use other security precautions and procedures. These may include not allowing a user to access the SC web portal **50** until after successful completion of a password protected login procedure. As another example, the SC portal server **30** may include software "trip wires" to detect attempts at unauthorized access.

In the SC database server **34**, StorageConsole software (SC software **52**) maintains a SC database **54** of the backup and restore meta data, the backup statistics and other relevant backup information. In various embodiments of the GBS **10**, this SC database **54** may be: Java data structures; a relational database; a database implemented using the DB2 Universal Database from IBM Corporation; a database implemented using the Oracle9i Database from Oracle Corporation of Redwood City, California; or a database implemented using the SQL Server from Microsoft Corporation.

FIG. 4 is a functional block diagram of yet another exemplary embodiment of a GBS **10**, this figure particularly showing the communication paths and methods used between the

SCS **14** and the users of an enterprise's computers, servers and networks. The user **60**, who may be a system administrator or who may simply be interested in requesting the restoration of some of his or her own files, uses a computerized device **62** including a web browser **64** to interact with the SC software **52** via the SC web portal **50**. No special software is required on the computerized device **62** employed by the user **60**.

When the HTTPS protocol is used, the web browser **64** initiates or handles the authentication, digital certificate and public key encryption involved, typically with little or no involvement of the user **60**.

The user **60** may initiate a status request and in response receive the appropriate backup meta data from the SCS **14**. The request may be for backup events that include a specific file, files included in a specific backup event, or summary status information including but not limited to a report such as is described with respect to FIG. 6, presently. The user **60** may also initiate a restore request that a specific file or files be restored to a client server **20** from a copy made during a specific backup event.

FIG. 5 is a data structure diagram or database schema (schema **70**) suitable for storing meta data, including the file details, according to an embodiment of the GBS **10**. The schema **70** includes a file array or table (file table **72**), a backup array or table (backup table **74**), and a link array or table (link table **76**).

The file table **72** contains one row for each file that is backed up within an enterprise. The information or data fields within each row may differ in various embodiments of the GBS **10**. However, a typical set of fields for the file table **72** includes:

(1) A file ID of the file that is represented by this row, which is the key of the file table **72**. That is, this is the means by which a particular row can be uniquely identified within and retrieved from the file table **72**.

(2) A file type, which is one of "File", "Directory", or "Link to file or directory".

(3) An owner of the file, which is information that can be used to provide accounting information as to which owners are consuming how much of the resources of a client server **20** or of a BMS **22**.

(4) A server ID of the client server **20** on which the file is stored.

And (5), A file ID of the file table row for the parent directory that contains this file.

The backup table **74** contains one row for each backup event that is stored within the enterprise's BMSs **22**. The information or data fields within each row may differ in various embodiments of the GBS **10**. However, a typical set of fields for the backup table **74**

includes:

(1) A backup ID of the backup event represented by this row, which is the key of the backup table **74**.

(2) A date and time at which the backup event started.

(3) A date and time at which the backup event ended.

(4) A count of the number of files that were backed up in this backup event.

(5) The number of bytes that were backed up in this backup event.

(6) A status for this backup event, including but not limited to "Successful," "Warning", or "Failed"

And (7), A server ID of the client server **20** on which the files backed up are stored.

The link table **76** contains one row for each time that a particular file has been backed up. The information or data fields within each row may differ in various embodiments of the GBS **10**. However, a typical set of fields for the link table includes:

(1) A file ID of the file that was backed up.

(2) a backup ID of the backup event during which this file was backed up. Taken together, the file ID and the backup ID constitute the key of the link table **76**.

(3) A size of the version of this file backed up in this backup event.

And (4), A data and time at which the version of this file backed up in this backup event was last modified.

The ability to use the schema **70**, or a suitable equivalent, is a particularly advantageous feature of the present invention. In a typical enterprise the amount of meta data may be simply staggering. Consider Bank of America Corporation, for instance. It has currently has, roughly, fifteen thousand (15,000) BMSs **22** that perform backup jobs at least monthly or weekly, and more typically daily and even more frequently. The quantity of meta data produced each day alone easily amounts to terabytes, and it needs to be persisted day after day, for months and possibly longer. Providing a database able to store such voluminous data is not a trivial task, and getting any practical utility out of it would be near impossible. Even backing up the backup/restore meta data in such a hypothetical case would be difficult.

What the inventors have appreciated, however, is that vast amounts of the meta not change frequently, if ever. First, files are rarely added or deleted (even considering renaming and deleting files as forms of this). Their "owners" (in operating system access control lists) and identifying characteristics for their client servers **20** and responsible BMSs **22** also rarely

change. As one simple other example of redundancy, consider at a listing of names with paths for files in a deeply nested folder structure. All the path information is redundant, yet has to be persisted in some manner. Accordingly, selectively collecting the meta data at the file details level, vetting it, and then storing it in the tables in the schema **70** can facilitate matters considerably.

The GBS **10** permits selectively collecting file details by setting a flag, described in detail elsewhere herein. In many cases administrators and other users will not want file details, as contrasted with success/fail information, backup infrastructure change information (e.g., additions and deletion of client server **20** or storage device **46** changes), and backup policy changes.

It might on initial consideration seem that stripping our redundancy and otherwise manipulating the meta data can be performed at the enterprise network **12**, but that often merits deeper consideration. Burdening the SMSs **22** is usually undesirable, and might even interfere with backup and restore operations. And while conserving communication bandwidth is usually a good practice, many enterprises have excess high-speed bandwidth available, particularly at off hours. The GBS **10** can therefore be implemented to stream minimally manipulated meta data to the SCS **14**, thus off loading much of the meta data burden from the enterprise network **12**. The SCS **14** can manipulated meta data as desired, and can particularly be optimized for this.

The schema **70** then reduces the overall storage burden at the SCS **14**. The file table **72** has entries for each file; the backup table **74** has entries for each backup, and the link table **76** has linking these. Thus, as a very simple and simplified example, a file table **72** might have entries for 100 files with the backup table **74** having entries for 90 daily backups of these files. The link table **76** would then have 9,000 entries. The inventors have found that the schema **70** often permits storing the meta data in 10% or less storage that would otherwise be required.

FIG. 6 is an exemplary status summary or mission control report (MCR **80**) according to an embodiment of the GBS **10**. The first row of the MCR **80** shows the aggregate backup status of a server 1 (i.e., a BMS **22**). The second row shows the aggregate backup status of servers 2-5 within a domain A, which in this example happens to be a hierarchical domain. Domain A directly includes servers 2 and 5. Domain A also includes domain B, which includes servers 3 and 4. Thus via the domain hierarchy, domain A also includes servers number 3 and 4.

The next to last row of the MCR **80** here shows the aggregate backup status of a

server number N. And the last row shows an aggregate backup status of all the servers and domains included in this MCR **80**.

The first column of the MCR **80** shows the aggregate backup status during a custom time interval. The custom time interval may be configured to be, as one example among many, the time interval that started four weeks ago and ended two weeks ago. The second column shows the aggregate backup status during the time interval from two weeks ago to one week ago. The next seven columns show the aggregate backup status during the time intervals that correspond to the last seven days. And the last column shows the aggregate backup status of all time intervals included in this MCR **80**.

Within each row and column the appropriate aggregate backup status is shown. The status categories used, as well as the icons used to represent the status categories differ among various embodiments of the invention. However, a typical set of aggregate status icons includes:

(1) A smiley face – representing that all backup and restore events for the corresponding server (or the corresponding domain) scheduled during the corresponding time period were successful.

(2) A neutral face – representing that at least one backup or restore event for the corresponding server (or domain) scheduled during the corresponding time period generated at least one warning.

(3) A frowning face – representing that at least one backup or restore event for the corresponding server (or domain) scheduled during the corresponding time period failed.

(4) A running man – representing that the server currently has a backup or restore event that is currently in process or running .

And (5), An empty circle – representing that no backup or restore events for the corresponding server (or domain) occurred during the corresponding time period.

FIG. 7 is a flow chart of a process **100** to capture and transmit backup and recovery meta data according to an embodiment of the GBS **10**. In this process **100**, summary meta data describing a backup or restore event, or backup statistics, are transferred from the backup server software **42** on the BMS **22** to the SC software **52** at the SCS **14**. This transfer occurs via a SC agent **48** that runs on the BMS **22** and an HTTP or HTTPS session over a network such as the I-net **16**.

In a step **102**, the process **100** starts.

In a step **104**, the SC agent **48** obtains, from the data stream generated by the backup server software **42**, the summary meta data for backup or restore event, or the backup statistics that are to be sent to and held in the SC database **54**.

In a step **106**, this data stream is then parsed into fields of meta data or backup statistics.

In a step **108**, the fields that are relevant to the GBS **10** are entered into one or more data structures, which may be but are not limited to Java objects.

In a step **110**, authentication information, such as a magic key and the objects or data structures representing the relevant fields are serialized and compressed. This compressed serial stream is then sent over the I-net **16** using the HTTP or HTTPS protocol to the SC web portal **50** that is running at the SCS **14**. This transfer process is complete as soon as a message from the SC software **52** is received by the SC agent **48** that the information was successfully received.

And in a step **112** the process **100** is done.

FIG. 8 is a flow chart of a process **200** to manage and store capture and received according to an embodiment of the GBS **10**. In this process **200**, file details of backup or restore meta data is transferred from the backup server software **42** on the BMS **22** to the SC software **52** at the SCS **14**. This transfer occurs via a SC agent **48** that runs on the BMS **22** and an HTTP or HTTPS session over a network such as the I-net **16**.

In a step **202**, the process **200** starts.

In a step **204**, the SC agent **48** obtains from a data stream generated by the backup server software **42** the meta data for a batch of files that were involved in the backup or restore event. The number of files processed in a batch, that is the number processed at one time, is configurable, but several thousand files per batch may be a typical value. Upon successful receipt of each batch of meta data, the SC software **52** sends back to the SC agent **48** an acknowledgement message. Thus, the size selected for the batches of files may impact the process of automatically recovering from an exception.

In a step **206**, this data stream is then parsed into fields of meta data.

In a step **208**, the fields that are relevant to the GBS **10** are entered into one or more data structures, including but not limited to Java objects. Each file may be represented as one instance of the Java object or data structure.

In a step **210**, the magic key and the objects or data structures representing the relevant meta data for the batch of files are then serialized and compressed. The compressed,

serial stream is sent via the HTTP or HTTPS protocol to the SC web portal **50** that at the SCS **14**.

In a step **212**, a determination is made if there are more files in the backup or restore event. This process **200** is complete as soon as a message from the SC software **52** is received by the SC agent **48** that the information was successfully received, and in a step **214** the process **200** is done. Otherwise, the process **200** continues at step 204 by looping back to get the meta data for another batch of files as soon as such an acknowledgement is received.

The SC agents **48** may be implemented to be "light weight" or to have a small "footprint" so that they do not consume much of the resources of the BMS **22** on which they run.

The portion of the SC agents **48** handling file details can consume substantial resources of the BMS **22** on which it runs, depending on the number of files for which details must be gathered and transferred to the SCS **14**. However, the impact of this is substantially reduced in the GBS **10** by having this portion of the SC agent **48** only execute when a backup or restore event terminates, and not when a polling or request message is received from the SC portal server **30**. Such a SC portal server **30** initiated or server pull communication scheme could interrupt the BMS **22** while a backup or restore event is running, at which time the resources of the BMS **22** are heavily utilized and the backup or restore meta data of interest may be incomplete or unavailable.

Preferably, none of the SC agents **48** store data on the BMS **22** on which they run. Of course, the SC agent **48** must itself be stored and information must be maintained while an invocation of it is active, up until an acknowledgement is received of successful communication with the SCS **14**. Having the SC agent **48** store any data on the BMS **22** could result in the BMS **22** running out of storage capacity, which could cause performance problems or even cause the BMS **22** to malfunction or crash.

There is a substantial contrast between the footprint of the SC agents **48** on the BMSs **22** on which they run and the footprint of the client backup software **40** on the client server **20** on which it runs. Backup events are typically scheduled when users are at home or not working because much of the disk access bandwidth available on a client server **20** is consumed by a backup event.

FIG. 9 is a flow chart of a process **300** for handling exceptions according to an embodiment of the GBS **10**. This process **300** occurs when a SC agent **48** running on a BMS **22** encounters exception conditions when sending data to the SC software **52** running at the SCS **14**.

As discussed above, the normal communication channel between the SC agent **48** and the SCS **14** is for the SC agent **48** to initiate an HTTP or HTTPS session with the SC portal server **30**. The SC agent **48** sends to the SC portal server **30** the appropriate meta data or other information, or sends the file details meta data for a batch of the files that are involved in a backup or restore event. Then, the communication stays active within the SC agent **48** until it receives back from the SC portal server **30** a normal acknowledgement message, or an ACK. Typically, the acknowledgement message received is an ACK, indicating that the data has been successfully received and interpreted.

However, various other acknowledgement messages may also be sent from the SCS **14**, depending on the information that was sent and on whether it was completely and correctly received. An acknowledgement message may request that the information be resent because it was only partly received or contained errors. An acknowledgement message may request that additional information be sent, as is the case when a newly installed client server 20 is backed up for the first time. It is also possible that no acknowledgement message is received, perhaps because the information sent was not received or was received sufficiently garbled form that the SCS **14** could not correctly identify the sender of the information.

When an ACK is not received or when a resend acknowledgement message is received, the operation of sending the information is then repeated, according to a retry interval and maximum count or according to a schedule of when the communication is to be retried. For example, a retry schedule may call for the first retry to be immediate, and then each subsequent retry to occur after a time interval has elapsed that is longer than the previous time interval. If an ACK is received in response to a retry, then the communication is successful and the process **300** terminates.

When an ACK is not received within the retry limit or maximum retry count, then the SC agent **48** escalates the exception and attempts to send the information via a secondary fallback communication channel. If an ACK is received in response, then the communication is successful and the process **300** terminates.

When an ACK is not received within the retry limit set for this channel, then the GBS **10** may escalate the situation to using a third-level, or even higher-level, communication channel. If an ACK is received in response, then the communication is successful and the process **300** terminates.

Various fallback communication channels are used in various embodiments of the GBS **10**, including but not limited to: using an alternative uniform resource locator (URL) or IP address for the SC portal server **30**; addressing a fallback SC portal server **30**; or sending

the information using a protocol that is not HTTP or HTTPS but is equally secure, non-intrusive and light weight, such as the simple mail transfer protocol (SMTP).

When an ACK is not received within the retry limit or maximum count of the highest-level communication channel, the SC agent **48** then again escalates the exception. The SC agent **48** sends an e-mail message describing the exception to one or more designated individual or generic e-mail addresses, such as "sys-admin," "customer-exception-report@StorageConsole.com," or "backup-system-sustainment@my-enterprise.com."

FIG. 10 is a flow chart of a process **400** to add a new client server **20** according to an embodiment of the GBS **10**. This process occurs when the SC software **52** running at the SCS **14** automatically provisions a client server **20** that has been newly added.

The SC software **52** detects that a client server **20** has been newly added when a SC agent **48** sends backup or restore meta data pertaining to files stored on that BMS **22**. When meta data is received, the client server **20** involved is used as a lookup key in the meta data database. Typically, the client server **20** is found in the database, in which case the newly received meta data is added to the SC database **54**.

When the client server **20** is not found in the database, then the SC software **52** sends back to the SC agent **48** a request for basic information about the client server **20**. This request is sent along with, and is part of, the acknowledgement message sent in response to receiving the meta data.

In various embodiments of the GBS **10**, the basic information may include, but is not limited to, one or more of the following: the name of the new client server **20**; the IP address of the new client server **20**; the make of the new client server **20**, e.g. Sun Microsystems, Dell Computer Corporation, or the like; and the model of the new client server **20**, e.g. Sun Fire V1280, PowerVault 725N, or the like. None of this information need be manually entered into the GBS **10**.

When the basic information about the newly added client server **20** is received by the SC software **52** from the SC agent **48**, then the client server **20** is added to the SC database **54**.

The GBS **10** uses a number of configuration settings that can be altered on a system by system basis at the client server **20**. These include, but are not limited to: whether or not file details are entered into the SC database **54** for each backup and restore event; what individuals can log into the SC web portal **50** and access the meta data or other information about the new client server **20**; and whether or not accounting of backup resource consumption is performed by file ownership. The initial values used for the new client server

20 for these configuration settings are taken from the settings that are established for a default server group within the enterprise.

After the basic information and initial setting values are stored into the SC database **54**, the meta data received about the backup or restore event that occurred on the newly added client server **20** is then entered into the meta data database. The SC agent **48** normally does not need to resend this meta data, but the SC agent **48** may not receive an ACK for the meta data transmission until the GBS **10** has provisioned the newly added client server **20** and successfully stored the meta data received.

FIG. 11 is a block diagram showing an architectural overview of the infrastructure of an exemplary GBS **10**. There are two main infrastructure components: the backup infrastructure **500** and the StorageConsole infrastructure (SC infrastructure **502**). These two components can reside within a single enterprise or they can be decoupled, with the SC infrastructure **502** residing within one server enterprise and the backup infrastructure **500** residing in one or more number of client enterprises.

As noted above, in the inventors' presently preferred embodiment the enterprise networks **12** (i.e., in the backup infrastructure **500**) each include a SC agent **48** that is actually three major agents: an event agent **504**, a restore event trigger **506**, and a cron agent **508**. A data receiver agent **520** is used within the SCS **14** (i.e., in the SC infrastructure **502**). Collectively, these agents aid in the data collection, data consolidation and data mining of information from BMSs **22** running various backup server software **42**, which includes but is not limited to Veritas NetBackup which is used for the sake of example here. The SC agent 48 interfaces and with the backup server software **42**, to obtain the data utilized by the SC web portal **50** (see e.g., FIG. 3).

In the backup infrastructure **500** of the GBS **10** the event agent **504**, the restore event trigger **506**, and the cron agent **508** (comprising the SC agent **48**) reside on the BMS **22** to gather data based on activities performed by the backup server software **42**.

The event agent **504** is implemented as a standalone Java daemon process which waits for backups to be completed by the backup server software **42**. As needed, the backup server software **42** is configured to write backup event parameters to a log file at the end of a backup event completion. This log file is monitored by the event agent **504**. As soon as a new entry is made in the log file the event agent **504** starts to collect all of the information pertaining to the backup job by calling the relevant NetBackup command line interfaces. For access authentication purposes, a magic key is added to the information collected. The information and key are then packaged into Java Objects, serialized, compressed and transported to the

data receiver agent **520** over HTTP/HTTPS. The data receiver agent **520** thus receives the information pertaining to the backup job just performed by the backup server software **42**.

When a restore job being is undertaken, the backup server software **42** is configured to call the restore event trigger **506**, which collects information pertaining to the restore job and sends it to the data receiver agent **520**.

The restore event trigger **506** as a process is event driven, in the sense that instances of it are transient processes. They startup, perform the required operation, and terminate, thus imposing minimum load on the BMS **22**.

The cron agent **508** is implemented as a standalone Java daemon process that spawns threads based on the jobs declared in a crontab file the GBS **10** maintains. The cron agent **508** currently spawns five threads, one each for five jobs or child agents (child agents **510**), discussed presently.

The SC software **52** includes Java servlets residing on the SC Portal server **30**. These respond to requests from event triggers from the event agent **504** and the restore event trigger **506** and the child agents **510** of the cron agent **508** that reside on the BMS **22** as parts of the SC agent **48**.

The data receiver agent **520** is one such Java servlet. It is configured to listen for requests from the event triggers 504, **506** and child agents **510** on the BMSs **22**. On receiving a request, the data receiver agent **520** decodes the information and determines what type of request it has. Once the type of the message has been deciphered, the data in it is authenticated, decompressed, de-serialized and persisted into the SC database **54**.

A job queue agent **522** is the other major Java servlet residing on the SC Portal server **30**. The job queue agent **522** gets polled by other agents, such as the restore scheduler child agent **510** to initiate new restore jobs, which the initiating agents then process and perform. The job queue agent **522** is configured to return restore jobs that are pending for execution on the BMS **22**. The restore jobs are packaged into an XML document, and transferred to the restore scheduler child agent **510** in the cron agent **508**. The restore scheduler child agent **510** in turn processes the restore jobs one at a time, and sends back the job status to the job queue agent **522**, which then are persisted into the SC database **54**.

The GBS **10** employs an architecture that provides a unique way of handling backup server software **42** from different backup software vendors. Each major backup software vendor today uses a non-standard interface to its application. Further, even these applications are not entirely consistent from version to version. These factors pose a huge obstacle for enterprises that have different backup software to contend with. And they pose an even

greater problem to a system like the GBS **10**, since it has to contend with this variety of backup server software **42** and do so seamlessly from a user's perspective.

One approach would be to write code to make the SCS **14** interact independently with each type of backup server software **42**. However, this would increase development cycle time, and also propagate increase in design, testing, and maintenance cycles. Instead, the inventors have crafted an adaptor architecture to reside in the enterprise network **12** and provide the SCS **14** with a single interface to the various backup server software **42**.

FIG. 12 is a block diagram showing another architectural overview of an exemplary GBS **10**. A single interface show here as a backup adaptor interface **530** exposes methods to a wide range of objects and operations, which are standard components of the backup server software **42**, such as standard Backup Event, Restore Event, Backup Policy, Drives, Tapes, etc. components.

Because the backup adaptor interface **530** is well defined, sub-adaptors **532** for each of the various backup software applications can easily be developed. These sub-adaptor **532** objects implement methods defined by the backup adaptor interface **530**, and interact with a respective backup product (backup server software **42** instance) by calling the product's command line interface (CLI). A sub-adaptor **532** object decodes the data returned by calls to the CLI and populates this data into fields defined by the backup adaptor interface **530**.

This architecture minimizes changes to the SCS **14**, in the event that an underlying backup product changes. Additional backup products can also easily be supported by developing new sub-adaptors **532** as new backup products emerge.

Turning now to the event agent **504**, the backup server software **42** is configured so that a backup event trigger is called in the event of a backup job being completed. This backup event trigger in turn collects all the information pertaining to the backup job by calling relevant command line interfaces to the backup server software **42**. The information collected is next packaged into Java Objects, serialized, magic keyed, compressed and transported to the data receiver agent **520**, thus providing the data receiver agent 520 with the information pertaining to the backup job.

FIG. 13A-D are a flow chart depicting an example backup process **600** using NetBackup as exemplary backup server software **42**. In a step **602**, a backup job is performed on a BMS **22** using NetBackup. In a step **604**, NetBackup completes the backup job and calls a script (e.g., "$NETBACKUP_HOME/backup_exit_notify") that writes the client name, class label, schedule label, schedule type, status and stream number to a log (e.g., $APTARE_HOME/mbs/logs/backups.lst"). In step **606**, the event agent **504** monitors the log.

If the event agent **504** observes an addition to the log, it reads the backup parameters, initializes a backup driver, and starts a new thread to process this backup event.

In a step **608**, the backup driver initializes a BackupEvent object and in a step **610** the BackupEvent object makes a determination if the backup job was successful.

If the job is determined to be successful, in a step **612** the BackupEvent object calls the NetBackup command line interface (CLI) to query data about the backup job and sets its status to "Success". In a step **614** the BackupEvent object populates itself with the backup job data. Alternately, if the job is determined to be unsuccessful, in a step **616** the BackupEvent object sets its status to "Failed".

Then, in a step **618**, a BackupDetailsGenerator initializes connection to the data receiver agent **520** running on the SC portal server **30** and in a step **620** data transfer commences in an iterative manner as long as the transfer is successful or a loop count is less than a pre-set max error count (a "while condition").

In a step **622**, the BackupEvent object is transferred to the data receiver agent **520** and the data receiver agent **520** processes the data and sends back an acknowledgement (ACK).

In a step **626**, a determination is made if the ACK indicates the status of the BackupEvent object is "Success". If so, in a step **628** a branch (1a) is followed, described presently. Otherwise, in a step **630** a determination is made if the ACK indicates an invalid server exception or an invalid IP address exception. If so, in a step **632** a branch (2) is followed, described presently. Otherwise, in a step **634** a determination is made if the ACK indicates an invalid policy name exception or an invalid schedule name exception. If so, a sub-process **636** is called to collect backup policy data, also described presently. And otherwise, step **620** is returned to for another iteration (L loop).

Picking up now with the branch (1a) in step **628**, this leads to a step **640** where a determination is made if file level details are to be collected from the BMS **22**. One way to do this is to store flags in the SC database **54**. Flags can indicate whether as little as one particular file or as much as all of the files and folders under a BMS **22** are of interest. Of course, many millions of files and folders will usually be under a single BMS **22** and billions may be present in even a medium sized enterprise, so setting the flags permits administrators to configure the GBS **10** as they feel efficient and necessary.

If the ACK contains a flag indicating the BMS **22** has file level details, a sub-process **642** is called to collect the file level details, discussed presently. Otherwise, in this implementation, the sub-process **636** is here also called to collect backup policy data and, after that, in a step **644** the process **600** terminates.

Picking up again in step **620**, only now considering the case that the "while condition" is not met, in a step **650** a determination is made if transfer has not been successful and the loop count is equal or greater than the pre-set max error count (i.e., that here has been a serious failure). If so, in a step **652** an e-mail advisement is sent to an appropriate party, and step **644** is proceed to, where the process **600** terminates.

Picking up finally with the branch (2) in step **632**, this also leads to step **652**, from there to step **644** and termination of the process **600**.

FIG. 13C particularly shows the sub-process **636** that collects backup policy data. In a step **660**, the backup driver (at the BMS **22**) initializes a BackupPolicy object. In a step **662**, the BackupPolicy object calls NetBackup CLIs to populate itself with policy data. And in a step **664**, the BackupDetailsGenerator initializes connection to the data receiver agent **520** running on the SC portal server **30**.

In a step **666**, data transfer commences in an iterative manner as long as the transfer is successful or a loop count is less than the pre-set max error count (a "while condition").

In a step **668**, the BackupPolicy object is transferred to the data receiver agent **520**, which processes the data and sends back an acknowledgement (ACK).

In a step **670**, a determination is made if the ACK indicates success in persisting the policy data into the SC database **54**. If so, the sub-process **636** is finished. Otherwise, step **666** is returned to for another iteration (H loop).

Picking up again in step **666**, only now considering the case that the "while condition" is not met, in a step **672** a determination is made if transfer has not been successful and the loop count is equal or greater than the pre-set max error count (i.e., that here has been a serious failure). If so, the branch (2) to step **652** (FIG. 13B) is followed. Otherwise, in a step **674** a branch (4) is followed that leads out of the sub-process **636** to step **618** (FIG. 13B) in the main part of process **600**.

FIG. 13D particularly shows the sub-process **642** is called that collects the file level details. In a step **680**, the backup driver (at the BMS **22**) initializes a FileDetails object. In a step **682**, the FileDetails object calls NetBackup CLIs and initializes a FileDetailsStream. And in a step **684**, the BackupDetailsGenerator initializes connection to the data receiver agent **520** running on the SC portal server **30**.

In a step **686**, data transfer commences in an iterative manner as long as the transfer is successful or a loop count is less than the pre-set max error count (a "while condition").

In a step **688**, data transfer continues in an iterative manner as long as the FileDetailsStream has data (also a "while condition"). In a step **690**, the FileDetailsStream

initializes a FileAttributes object for each line from the NetBackup Image catalog for the given backup event, and in a step **692** the FileAttributes object is transferred to the data receiver agent **520**, which processes the data and sends back an acknowledgement (ACK). And then step **688** is returned to for another iteration (J loop).

Next considering the case of data no longer being present in the FileDetailsStream, in a step **694** a determination is made if the ACK indicates success in persisting the data into the SC database **54**. If so, the sub-process **642** is finished. Otherwise, step **686** is returned to for another iteration (K loop).

Picking up again in step **686**, only now considering the case that the "while condition" there is not met, in a step **696** a determination is made if transfer has not been successful and the loop count is equal or greater than the pre-set max error count (i.e., that here has been a serious failure). If so, the branch (2) to step **652** (FIG. 13B) is followed. Otherwise, in step **674** the branch (4) to step **644** is followed that leads out of the sub-process **642** to step **618** (FIG. 13B) in the main part of process **600**.

Turning now to the restore event trigger **506**, the backup server software **42** is configured to call the restore event trigger **506** in the event of a restore job being completed. The restore event trigger **506** in turn collects all the information pertaining to the Restore Job by calling relevant command line interfaces (CLIs) to the backup server software **42**. The information collected is then packaged into Java Objects, serialized, magic keyed, compressed and transported to the data receiver agent **520**, thus providing the data receiver agent **520** with the information pertaining to the backup job.

FIG. 14A-B are a flow chart depicting an example restore process **700**, again using NetBackup as backup server software **42**. In large part, process **700** resembles process **600** described above. In a step **702**, a restore job is performed on a BMS **22**. In a step **704**, NetBackup completes this job and calls a standard script (e.g., $NETBACKUP_HOME/restore_notify) once the restore is completed. This starts a special script (e.g., $APTARE_HOME/mbs/bin/restoretrigger.sh), passing it the client name and the event time stamp (so the GBS **10** can identify the particular backup event). In a step **706**, the special script then initializes a RestoreDetailsGenerator class that loads a backup driver specific to the type of backup server software **42** that performed the backup.

In a step **708**, the backup driver initializes a RestoreEvent object and in a step **710** the RestoreEvent object makes a determination if the backup job was successful. If the job is determined to be successful, in a step **712** the RestoreEvent object calls the NetBackup command line interface (CLI) to query data about the restore job and sets its status to

"Success". In a step **714** the RestoreEvent object populates itself with the restore job data. Alternately, if the job is determined to be unsuccessful, in a step **716** the RestoreEvent object sets its status to "Failed".

Then, in a step **718**, the BackupDetailsGenerator initializes connection to the data receiver agent **520** running on the SC portal server **30** and in a step **720** data transfer commences in an iterative manner as long as the transfer is successful or a loop count is less than the pre-set max error count (a "while condition").

In a step **722**, the RestoreEvent object is transferred to the data receiver agent **520** and the data receiver agent **520** processes the data and sends back an acknowledgement (ACK).

In a step **724**, determination is made if the ACK indicates success in persisting the restore data into the SC database **54**. If so, process **700** is finished. Otherwise, in a step **726** a determination is made if the ACK indicates an event does not exist exception. If so, a sub-process **728** processes the RestoreEvent object for the given event ID. And otherwise, step **720** is returned to for another iteration (K loop).

Picking up again in step **720**, only now considering the case that the "while condition" is not met, in a step **730** a determination is made if transfer has not been successful and the loop count is equal or greater than the pre-set max error count (i.e., that here has been a serious failure). If so, in a step **732** an e-mail advisement is sent to an appropriate party, and in a step **734** the process **700** is exited.

With reference again to FIG. 11, the cron agent **508** is implemented a standalone Java demon process, which spawns threads for its child agents **510** based on the jobs declared in a Crontab file. Currently, the inventors have the cron agent **508** spawn multiple threads (e.g., 5 or more, one each for various jobs (child agents **510**), namely the Restore Scheduler, Tape Inventory, Tape Details, Tape Status, and other. Each of these child agents **510** is configured to run at particular time intervals.

The restore scheduler child agent **510** is initiated to poll the job queue agent **522** to determine if a restore job is pending for its BMS **22**. If so, the restore scheduler calls the backup server software **42**, via its CLI, to initiate that restore job.

The tape inventory child agent **510** is initiated to call the backup server software **42** to gather a list of the robots and tape drives present on its BMS **22**. The tape details child agent **510** is initiated to call the backup server software **42** to gather a list of the tapes in a tape library on its BMS **22**. The tape status child agent **510** is initiated to call the backup server software **42** to gather the status of the tapes within the tape library. The policy details child agent **510** captures all of the backup policies that are maintained by the backup server

software **42**. The backup polices define rules that the backup server software follows when backing up the client servers **20**. The storage unit details child agent **510** captures all of the storage unit details from the backup server software **42**. In backup server software **42**, such as NetBackup, a storage unit is a group of one or more storage devices **46** of a specific type and storage density in a BMS **22**. The information from these child agents **510** is collected, packaged into Java Objects, serialized, magic keyed, compressed and transported to the data receiver agent **520**.

The smart updater child agent **510** pools the data receiver agent **520** in the SCS **14** for updates to the core libraries in the SC database **54**. In the case it finds newer version of the core library, the smart updater automatically downloads it and re-starts the cron agent **508** and the event agent **504**.

As mentioned previously, the data receiver agent **520** is implemented as a Java servlet that is configured to listen for requests from the event triggers 504, **506** and the child agents **510** of the cron agent **508** on the BMSs **22**. On receiving a request, the data receiver agent **520** decodes the information and determines what type of request it has just received. Once the type of the message has been deciphered, the data is authenticated, decompressed, de-serialized and persisted into the SC database **54**.

FIG. 15A-C are a flow chart depicting a suitable flow process **800** for the data receiver agent **520**. In a step **802**, the data receiver agent **520** receives a request from the event triggers (the event agent **504** or the restore event trigger **506**) or a child agent **510** of the cron agent **508**. In a step **804**, the request type, compression and source are determined, and un-compression is performed as needed. In a step **806**, whether the source of the request is authorized and authenticated is determined, and appropriate action is taken. In a steps **808-822**, determinations are made about the request type and appropriate branches are followed for further process. If none of the types are proper, however, in a step **824** a message that an illegal request has been made can be sent back, and in a step **826** the process **800** returns control to the SC portal server **30** for other tasks.

If the request type was "EVENT", in a step **830** the BackupEvent object in the request is de-serialized. Then, in a step **832** a DbBackupEvent object is initialized to persist the BackupEvent object into the SC database **54**. Next, in a sub-process **834**, any error codes are processed. If there were no error codes, in a step **836** the data receiver agent **520** sends a message that persisting the BackupEvent object was successful, and in a step **838** the process **800** returns control to the SC portal server **30** for other tasks.

If the request type was "POLICY", "FAILURE", "RESTORE", "TAPE DETAILS",

"INVENTORY DETAILS", or "TAPE STATUS" (branches "3" through "8" in FIG. 15A) the steps are effectively the same. The object is de-serialized; a Db-type object is initialized to persist the received object into the SC database **54**; the sub-process **834** looks for and processes any error codes (these can vary as needed, say, if processing "TAPE DETAILS" could result in particular error codes); if there were no error codes, the data receiver agent **520** sends an appropriate message that persisting the object was successful; and the process **800** returns control to the SC portal server **30** for other tasks.

If the request type was "FILE", however, a slightly different approach is used. In a step **840** the FileDetailsLine object in the request is de-serialized. Then, in a step **842** a DbFileDetails object is initialized to persist the FileDetailsLine object into the SC database **54**. Next, in steps **844-846**, any error codes are processed, and in a step **848** the process **800** returns control to the SC portal server **30**. If there were no error codes, in a step **850** the data receiver agent **520** sends a message that persisting the FileDetailsLine object was successful, and in step **848** the process **800** returns control to the SC portal server **30**.

With reference again to FIG. 11, every child agent **510** of the cron agent **508** may be implemented with an automatic recovery feature, to execute in the event of an exception condition occurring during the transmission of meta data from its BMS **22** to the data receiver agent **520**. The child agent **510** tries to transmit the meta-data to the data receiver agent **520** a configurable number of times, or until the child agent **510** receives an acknowledgement from the data receiver agent **520**. The interval between the retries is also a configurable parameter. The default data transmission mechanism is Java object serialized over HTTP(s). The re-try logic uses this data transmission mechanism to transfer the data, but in the event of a communication failure, the child agent **510** tries to use an alternate transmission mechanism. The alternate mechanism used may be transmitting data over SMTP (Simple Mail Transfer Protocol). An email message containing the textual representation of the meta data can be sent over SMTP to the data receiver agent **520**. This alternate transmission mechanism is used to transmit the data a configurable number of times, or until the child agent **510** receives an acknowledgement. If the child agent **510** is still unsuccessful in transmitting the data, an email message containing a suitable error message, e.g., the possible cause and source of the message, is sent to an appropriate party.

As was discussed previously, the backup event agent **504** transmits backup event related meta data to the data receiver agent **520**, where the backup event is related to the client server **20** that was backed up by the backup management server. The data receiver agent **520** validates the information about the client server **20** that is part of the backup meta-

data. In the case the client server **20** does not exist in the SC database **54**, however, information for the client server **20** can be automatically added into the SC database **54**. These is straightforward, since the client server **20** is also associated to the default server group that its BMS **22** belongs to. The same can happen when a new client server **20** is encountered as the data receiver agent **520** processes restore event meta-data.

The foregoing drawing figures and descriptions are not intended to be exhaustive or to limit the invention to the forms and embodiments disclosed. Rather, specific details are presented to illustrate the invention. In light of the teachings herein, the techniques known to those skilled in the art, and advances in the art yet to be made, numerous modifications, variations, selections among alternatives, changes in form, and improvements can be made to the invention. Thus, the breadth and scope of the invention should not be interpreted in a limited manner, and should be defined only in accordance with the following claims and their equivalents.

INDUSTRIAL APPLICABILITY

The present invention is well suited for application to capture, transmit and persist backup and recovery meta data. As has been described herein in the context of the global backup system (GBS **10**), various embodiments of the invention, provide methods and apparatuses for one or more of the following: for providing a centralized repository for meta data and related communication and control mechanisms; for efficiently storing and retrieving the meta data at the StorageConsole server (SCS **14**); for securely and efficiently transferring meta data and other backup information over a network (I-net **16**); for reducing the footprint on the backup management servers (BNSs **22**) of a StorageConsole agent (SC agent **48**) that directs the process of gathering the meta data and sending it to the SCS **14**; for automatically recovering from exceptions, or for automatically provisioning a client server **20** that is newly added to the enterprise; and for meaningfully representing and presenting the status of the GBS **10**.

On request, some embodiments of the invention display an array of aggregated status indicators. The aggregated status indicators are displayed in what is termed herein a mission control report (MCR **80**).

Rows of the array of aggregated status indicators correspond with servers within the enterprise. or correspond with domains where each domain contains multiple servers. Columns of the array correspond with time intervals, including but not limited to a particular

day or week. Aggregated status indicators within cells of the array display the aggregated status of every backup or restore event that occurred for the server(s) or domain(s) that correspond to the cell during the time interval that corresponds to the cell.

Aggregated status indicators may have various iconic shapes and colors; for example, a green smiley face may indicate that all scheduled backup and restore events were completely successful, a yellow neutral face may indicate that at least one backup or restore event generated a warning, and a red frowning face may indicate that at least one of the events failed. By looking at the array of aggregated status indicators, the system administrator can see at a glance a meaningful representation of the current status of the backup system for which he is responsible.

Some embodiments of the invention meet the need for efficient storage and retrieval of meta data by appropriately structuring the meta data in a relational database or in a similar data structure (the SC database **54**). This employs a schema **70** that includes a file table **72**, a backup table **74**, and a link table **76**.

The file table **72** contains one entry or row for each separate file, folder or link (also known as a shortcut) on a server that is backed up. The backup table **74** contains one row for each backup event. The link table **76** contains one row for every occasion on which any file was backed up, where each row in the link table **76** contains a pointer to the file-table row for that the file that was backed up and also contains a pointer to the backup-table row for the backup event in which the file was backed up.

The link table **76** may grow to be very large. For example, if an enterprise has 50,000 files that are fully backed up once a day and the backup copies of the files are kept for 180 days, then the link table **76** will contain 9 million entries. Such a large number of potential entries makes it particularly advantageous that each row in the link table **76** is small. Each link-table row is small because it points to, but does not duplicate, the meta data about the file involved and the meta data about the backup event involved.

Further, finding all backup events that include a particular file can be efficiently performed. Such a find operation consists of selecting those entries in a link table **76** that contain a pointer to the corresponding file-table row.

Some embodiments of the invention meet the need for efficient and secure transfer of meta data and other backup information by using the secure hyper-text transfer protocol (S-HTTP or HTTPS), by using public keys in the HTTPS communication that come from digital server certificates that are signed and verified by a trusted third party, by initiating communication only from the BMSs **22** to the SC portal server **30** and never the other way

around, or by including in each message that initiates a communication session an identity verification tag or magic key that is unique to the BMS **22** initiating the session.

Because a BMS **22** never responds to a communication session that an external device is attempting to initiate, there is no way that a curious person, a deliberate hacker or any kind of impostor can use this communication path to compromise the security of any BMS **22**.

The magic key used some embodiments of in the GBS **10** is an encoded form of information tokens. At least some of the information tokens have unique values for each BMS **22**, making it unlikely that a communication session can be accidentally or maliciously initiated from any device other than the BMS **22** that purports to initiate the session.

Some embodiments of the invention meet the need for reducing the footprint on the BMSs **22** of the process of gathering the meta data and sending it to the SC portal server **30** by running only light-weight software on the BMSs **22** as the SC agents **48**.

The footprint of the SC agents **48** is reduced by using one or more of the following techniques: by executing only when a backup or restore event terminates, and not when a polling or request message is received from the server; by communicating with the SC portal server **30** only via HTTP or HTTPS sessions initiated by the SC agent **48**, and not allowing the SC portal server **30** to initiate communications; and by storing data only at the SCS **14** and not storing any data on any BMS **22**.

Some embodiments of the invention meet the need for automatically recovering from exceptions by expecting an acknowledgement message in response to every communication that occurs over the I-net **16** (Internet and / or intranet), and then retrying the communication until such an acknowledgement is received.

The interval between retries, or the schedule of time intervals to be used between the retries, can be configured. A maximum number of retries can be set. If this number is exceeded without a successful acknowledgement, then the GBS **10** initiates communication via a secondary channel. In some embodiments, this escalation process can be repeated as needed, that is, if the secondary-channel communication is not acknowledged then it is tried again and if necessary third-level fallback channels, and so on, are used.

Such fallback communication channels may include, but are not limited to: accessing servers via alternate communication links; accessing alternate servers; or sending e-mail messages describing the failure to one or more designated e-mail address. The use of these escalating or fallback communication channels allows the GBS **10** to recover from many exceptions without loosing the integrity of the meta data, without loosing the ability to communicate, and with a minimal amount of intervention from system administrators.

Some embodiments of the invention also meet the need for automatically provisioning a client server **20** that is newly added to an enterprise. If in the course of a processing a backup or restore event, it is determined that a client server **20** has no entry in the SC database **54**, an acknowledgement message can be sent back to the SC agent **48** that both confirms correct receipt of the meta data for the event and that further requests that the SC agent **48** gather the basic information necessary to enter the new client server **20** into the SC database **54**.

These embodiments can further be implemented to automatically add basic information to the SC database **54** and to assign new client servers **20** to the default group of BMSs **22** that were established when an enterprise was initially set up to use the SCS **14**. Initial values used for a new client server **20** for configuration settings that can be altered on a system by system basis can be taken from established client servers **20** for a default BMS **22** within the enterprise network **12**.

For the above, and other, reasons, it is expected that the global backup system (GBS **10**) of the present invention will have widespread industrial applicability. Therefore, it is expected that the commercial utility of the present invention will be extensive and long lasting.

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CLAIMS

What is claimed is:

1. A system to capture, transmit and persist backup and recovery meta data over a network, comprising:

an agent to capture the meta data at a computerized backup management system;

said agent to transmit the meta data from said backup management system to a storage console portal system; and

said computerized console portal system including a database to store the meta data, thereby capturing, transmitting and persisting the meta data.

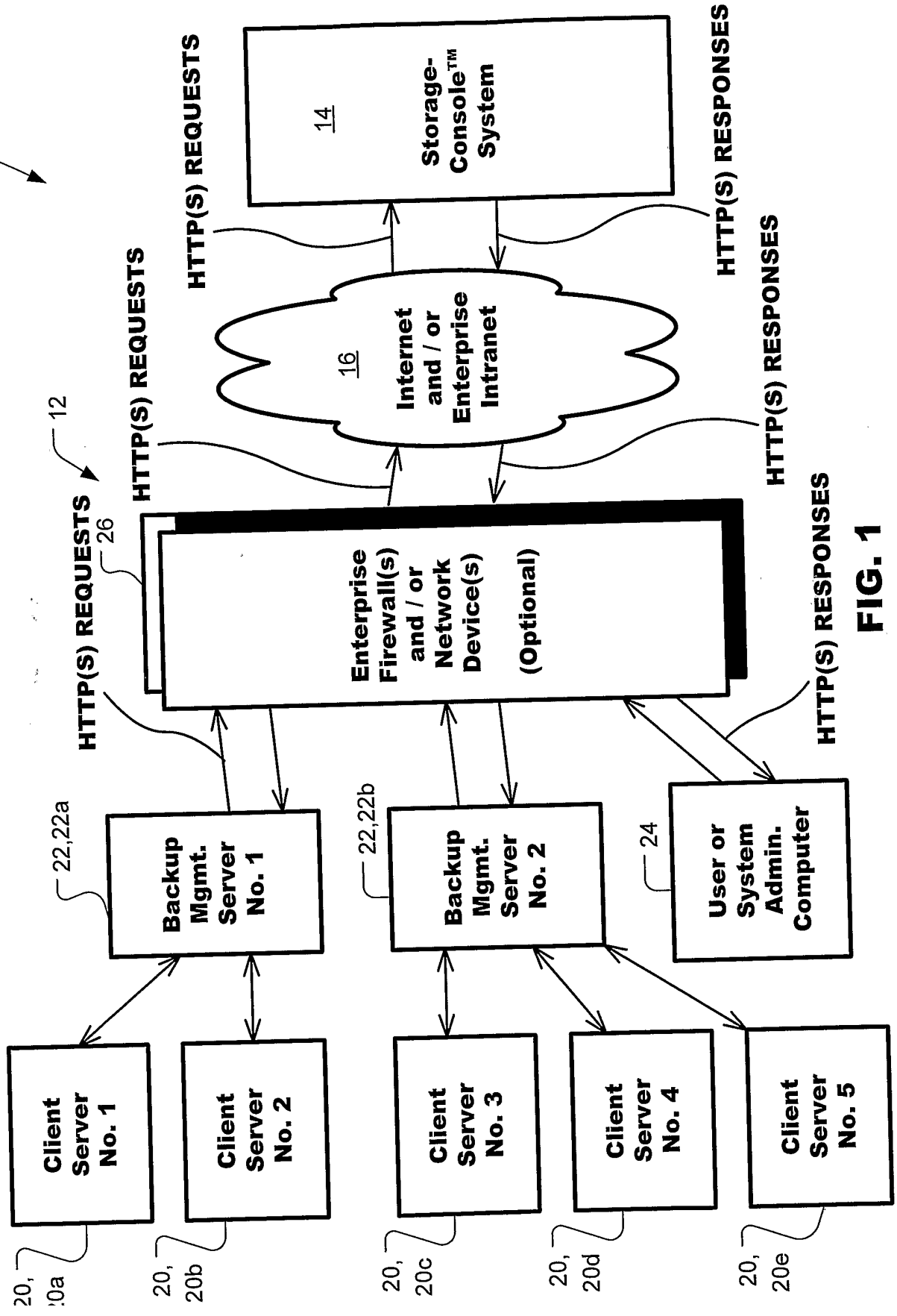
10
14
Storage-Console™ System
HTTP(S) REQUESTS
HTTP(S) RESPONSES
16
Internet and / or Enterprise Intranet
12
26
Enterprise Firewall(s) and / or Network Device(s) (Optional)
22,22a
Backup Mgmt. Server No. 1
22,22b
Backup Mgmt. Server No. 2
24
User or System Admin. Computer
Client Server No. 1
Client Server No. 2
Client Server No. 3
Client Server No. 4
Client Server No. 5
20, 20a
20, 20b
20, 20c
20, 20d
20, 20e

FIG. 1

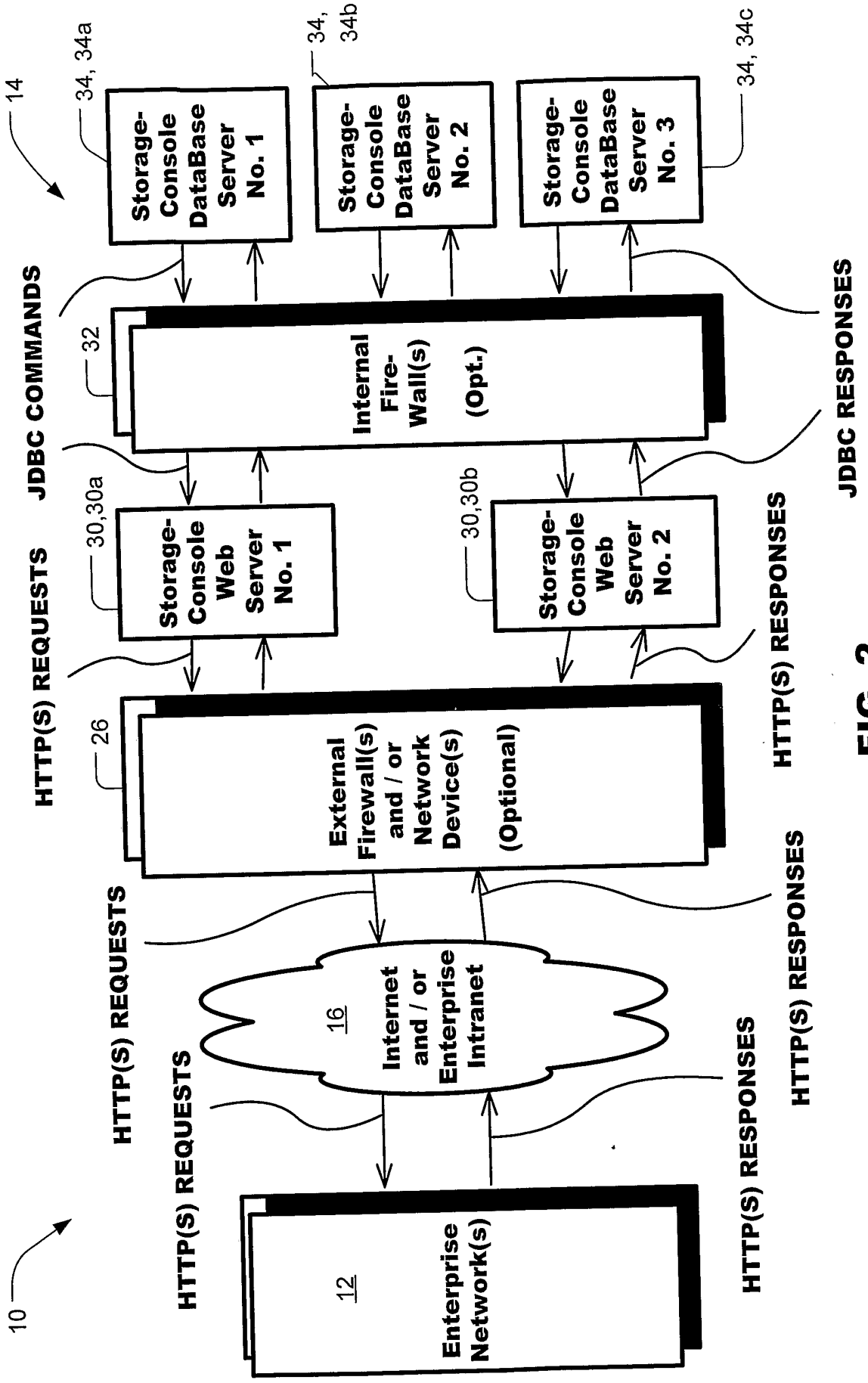
10
12
Enterprise Network(s)
16
Internet and / or Enterprise Intranet
26
External Firewall(s) and / or Network Device(s) (Optional)
32
Internal Fire-Wall(s) (Opt.)
14
34, 34a
Storage-Console DataBase Server No. 1
34, 34b
Storage-Console DataBase Server No. 2
34, 34c
Storage-Console DataBase Server No. 3
30,30a
Storage-Console Web Server No. 1
30,30b
Storage-Console Web Server No. 2
HTTP(S) REQUESTS
HTTP(S) REQUESTS
HTTP(S) REQUESTS
JDBC COMMANDS
HTTP(S) RESPONSES
HTTP(S) RESPONSES
HTTP(S) RESPONSES
JDBC RESPONSES

FIG. 2

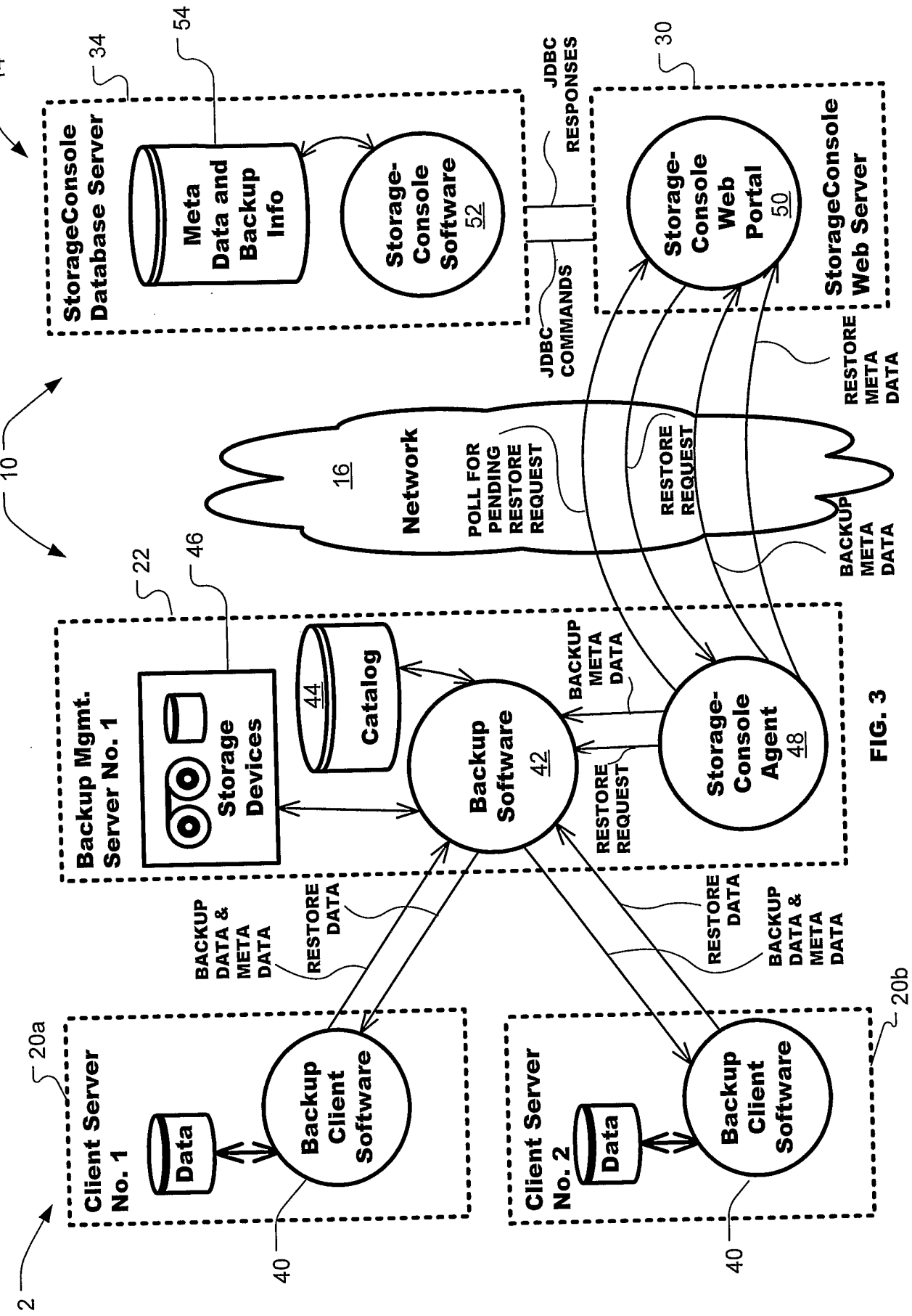
14
34
54
StorageConsole Database Server
Meta Data and Backup Info
Storage-Console Software 52
JDBC RESPONSES
JDBC COMMANDS
30
Storage-Console Web Portal 50
StorageConsole Web Server
10
16
Network
POLL FOR PENDING RESTORE REQUEST
RESTORE REQUEST
RESTORE META DATA
BACKUP META DATA
22
46
Backup Mgmt. Server No. 1
Storage Devices
44
Catalog
Backup Software 42
BACKUP META DATA
Storage-Console Agent 48
RESTORE REQUEST
BACKUP DATA & META DATA
RESTORE DATA
RESTORE DATA
BACKUP DATA & META DATA
20a
Client Server No. 1
Data
Backup Client Software
40
20b
Client Server No. 2
Data
Backup Client Software
40
2

FIG. 3

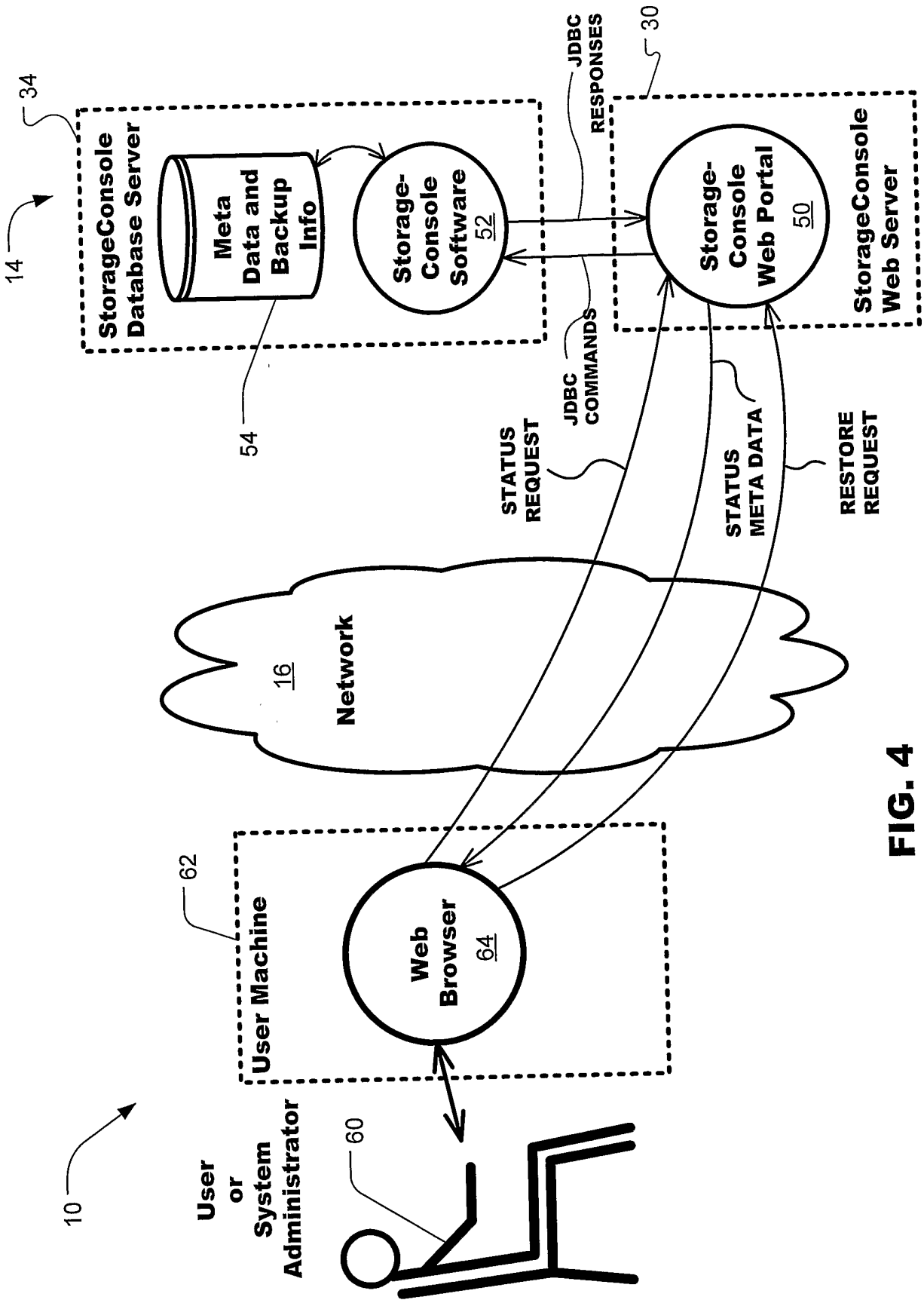
10
14
34
StorageConsole Database Server
Meta Data and Backup Info
54
Storage-Console Software 52
JDBC RESPONSES
30
JDBC COMMANDS
Storage-Console Web Portal 50
StorageConsole Web Server
STATUS REQUEST
STATUS META DATA
RESTORE REQUEST
16
Network
62
User Machine
Web Browser 64
User or System Administrator
60

FIG. 4

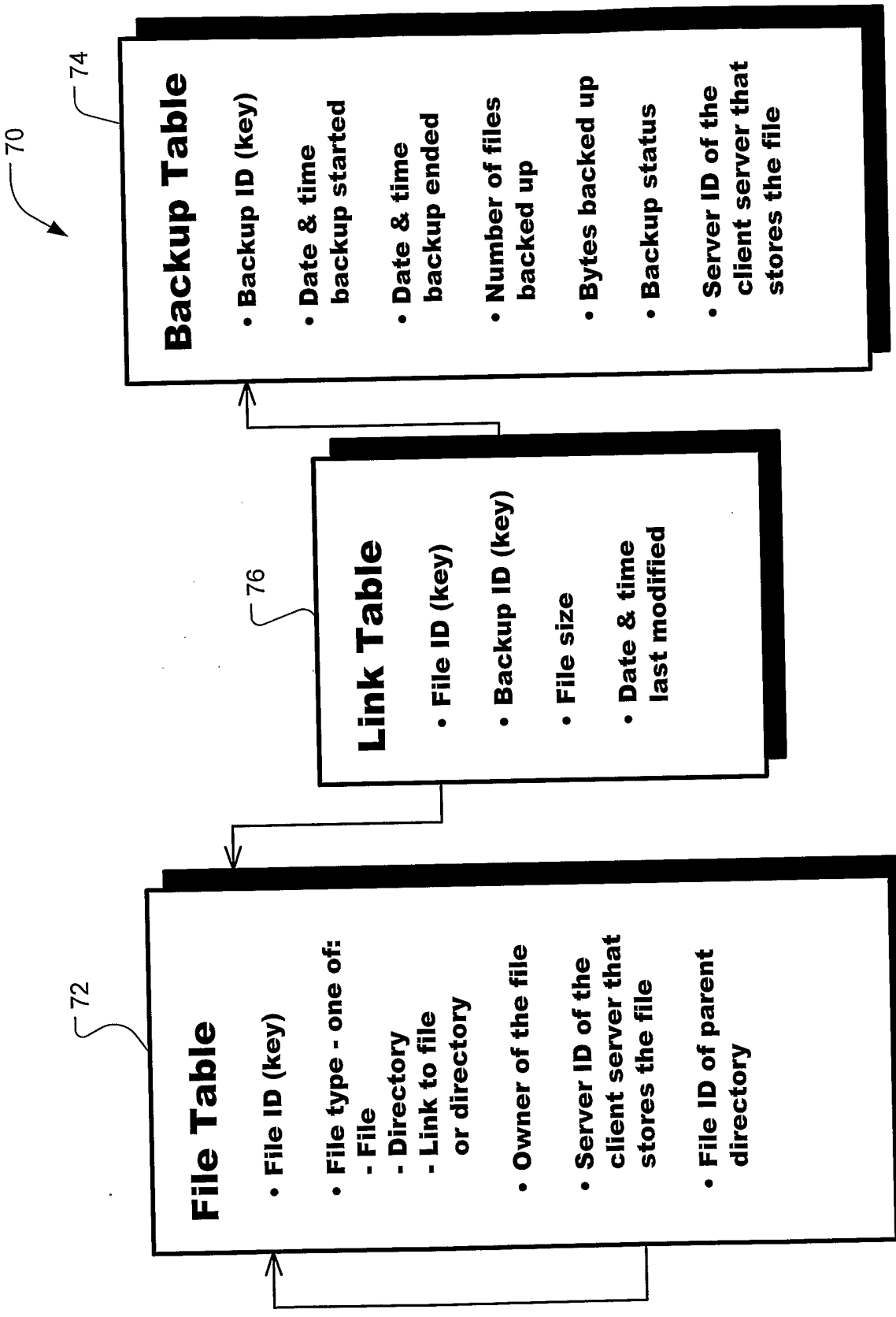
70
74
Backup Table
• Backup ID (key)
• Date & time backup started
• Date & time backup ended
• Number of files backed up
• Bytes backed up
• Backup status
• Server ID of the client server that stores the file
76
Link Table
• File ID (key)
• Backup ID (key)
• File size
• Date & time last modified
72
File Table
• File ID (key)
• File type - one of:
- File
- Directory
- Link to file or directory
• Owner of the file
• Server ID of the client server that stores the file
• File ID of parent directory

FIG. 5

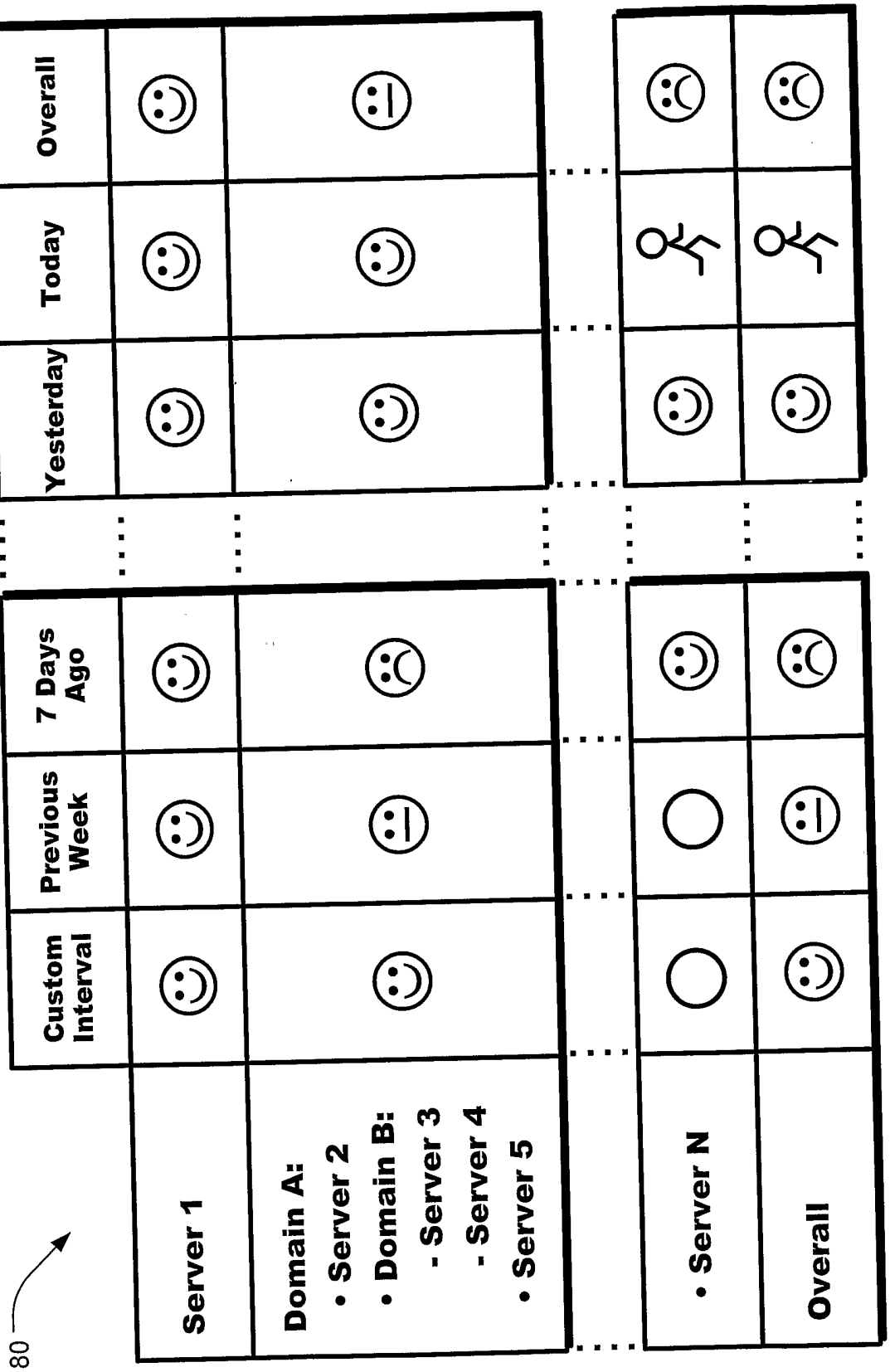
80
Server 1
Custom Interval
Previous Week
7 Days Ago
Yesterday
Today
Overall
Domain A:
• Server 2
• Domain B:
- Server 3
- Server 4
• Server 5
• Server N
Overall

FIG. 6

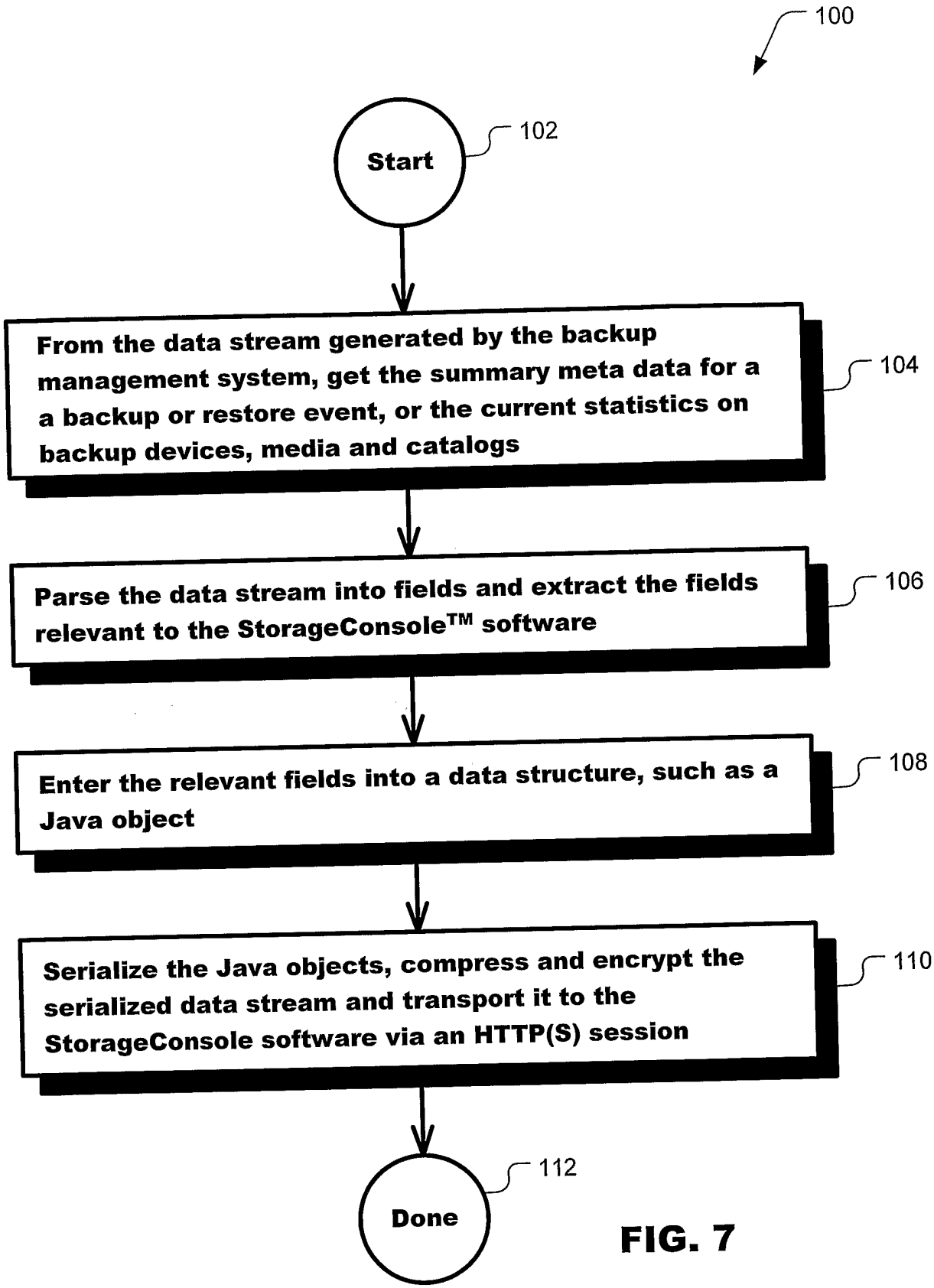
100
Start
102
From the data stream generated by the backup management system, get the summary meta data for a a backup or restore event, or the current statistics on backup devices, media and catalogs
104
Parse the data stream into fields and extract the fields relevant to the StorageConsole™ software
106
Enter the relevant fields into a data structure, such as a Java object
108
Serialize the Java objects, compress and encrypt the serialized data stream and transport it to the StorageConsole software via an HTTP(S) session
110
Done
112

FIG. 7

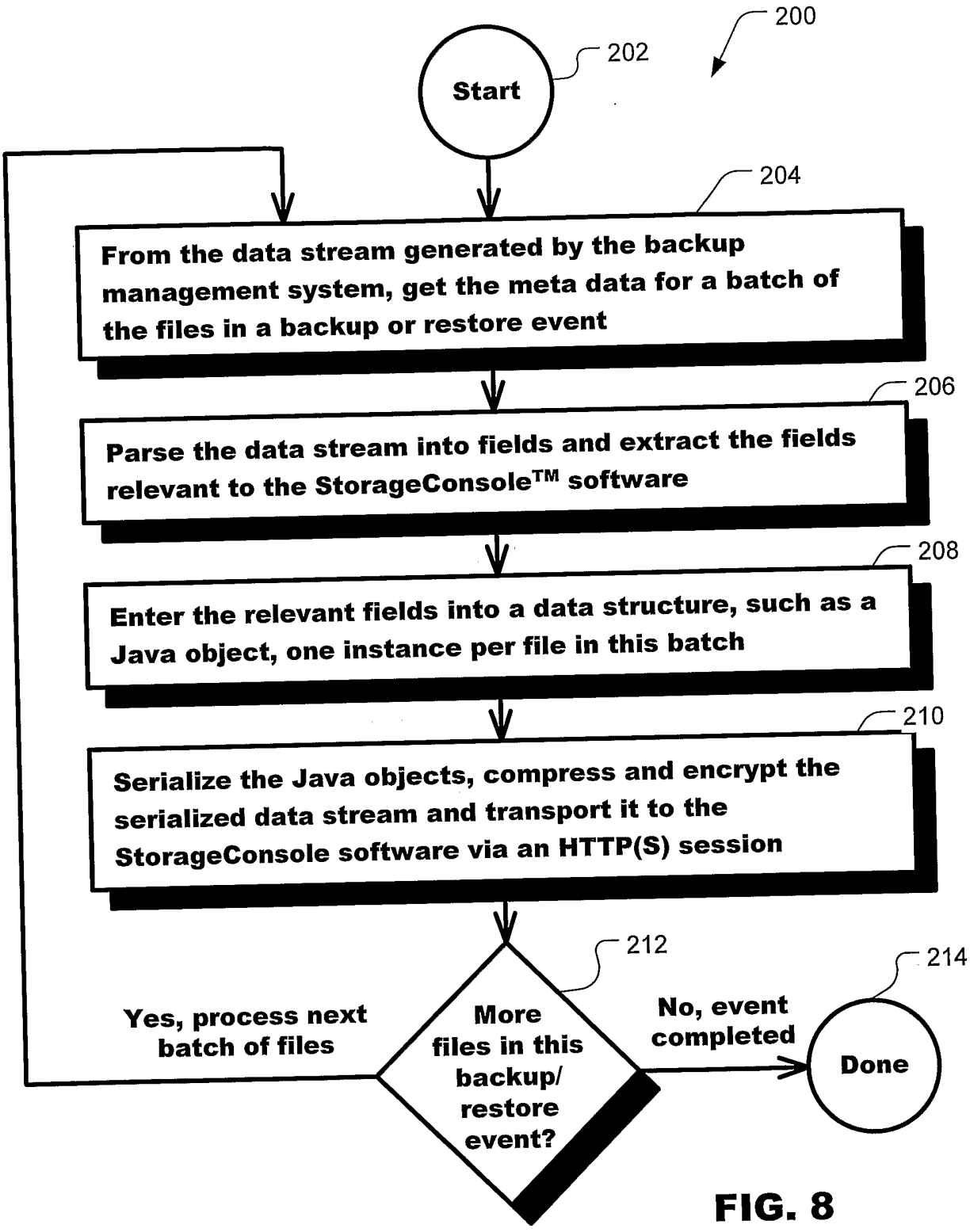
200
Start
202
204
From the data stream generated by the backup management system, get the meta data for a batch of the files in a backup or restore event
206
Parse the data stream into fields and extract the fields relevant to the StorageConsole™ software
208
Enter the relevant fields into a data structure, such as a Java object, one instance per file in this batch
210
Serialize the Java objects, compress and encrypt the serialized data stream and transport it to the StorageConsole software via an HTTP(S) session
212
More files in this backup/ restore event?
Yes, process next batch of files
No, event completed
214
Done

FIG. 8

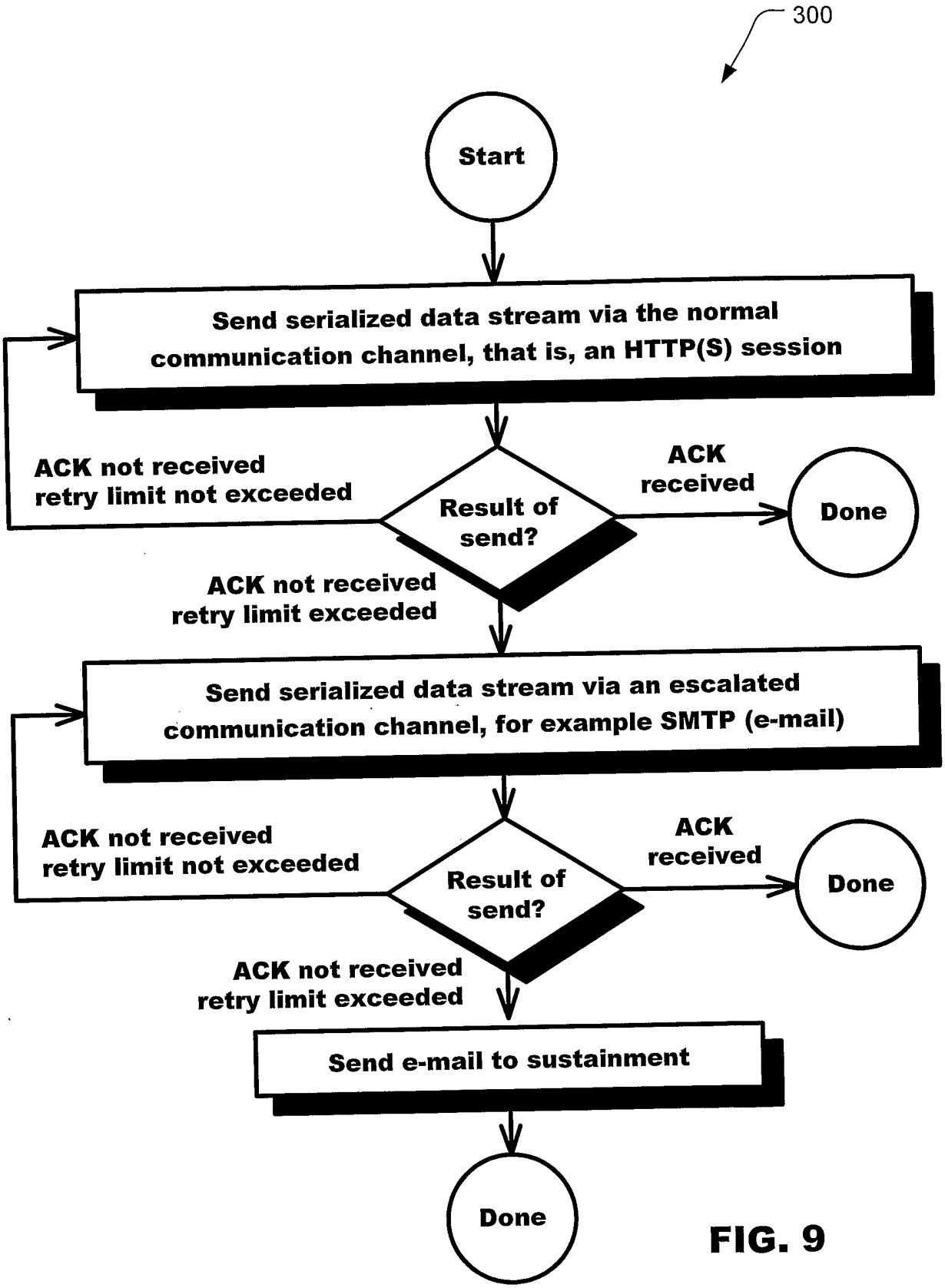
300
Start
Send serialized data stream via the normal communication channel, that is, an HTTP(S) session
ACK not received retry limit not exceeded
Result of send?
ACK received
Done
ACK not received retry limit exceeded
Send serialized data stream via an escalated communication channel, for example SMTP (e-mail)
ACK not received retry limit not exceeded
Result of send?
ACK received
Done
ACK not received retry limit exceeded
Send e-mail to sustainment
Done

FIG. 9

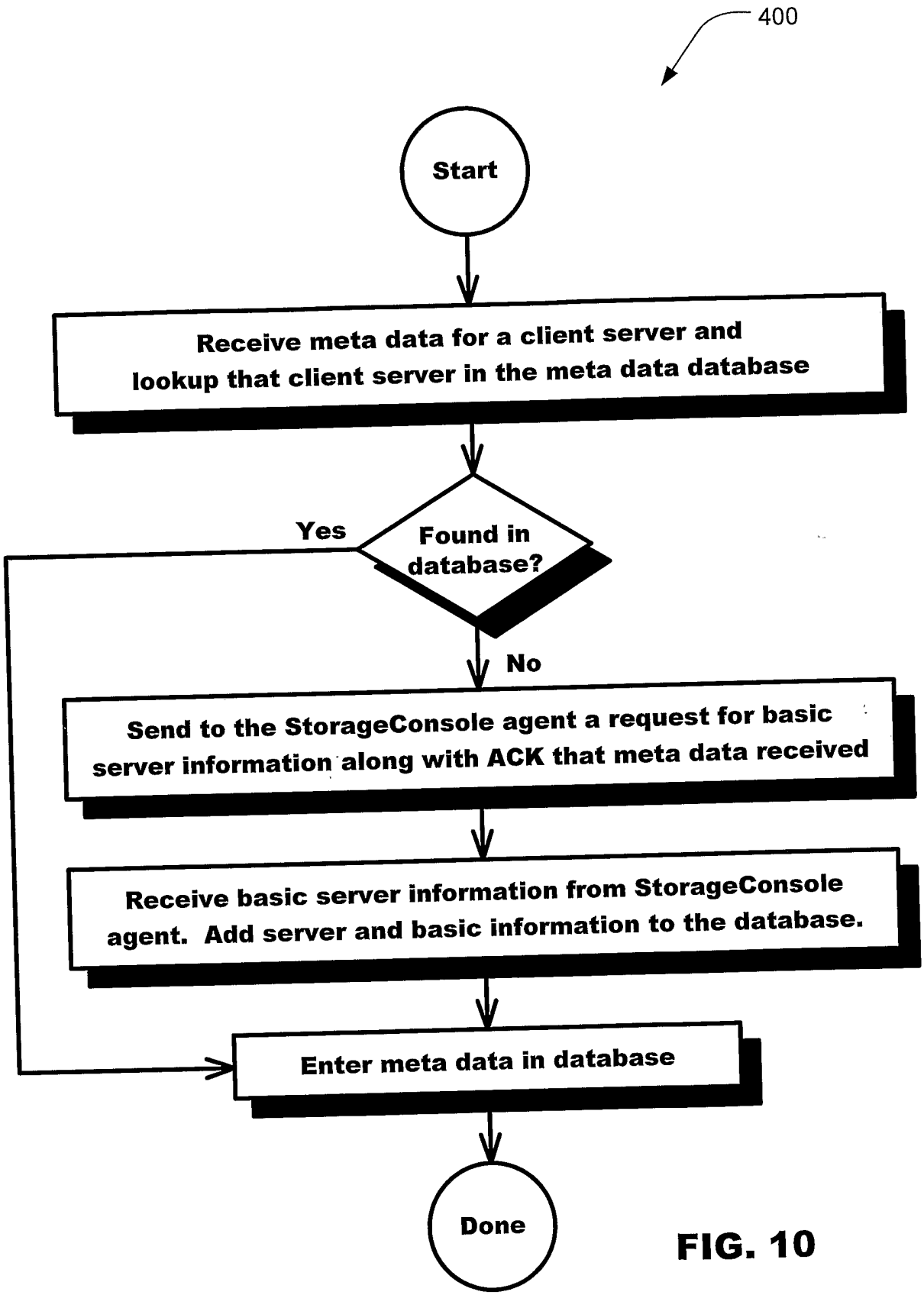
400
Start
Receive meta data for a client server and lookup that client server in the meta data database
Found in database?
Yes
No
Send to the StorageConsole agent a request for basic server information along with ACK that meta data received
Receive basic server information from StorageConsole agent. Add server and basic information to the database.
Enter meta data in database
Done

FIG. 10

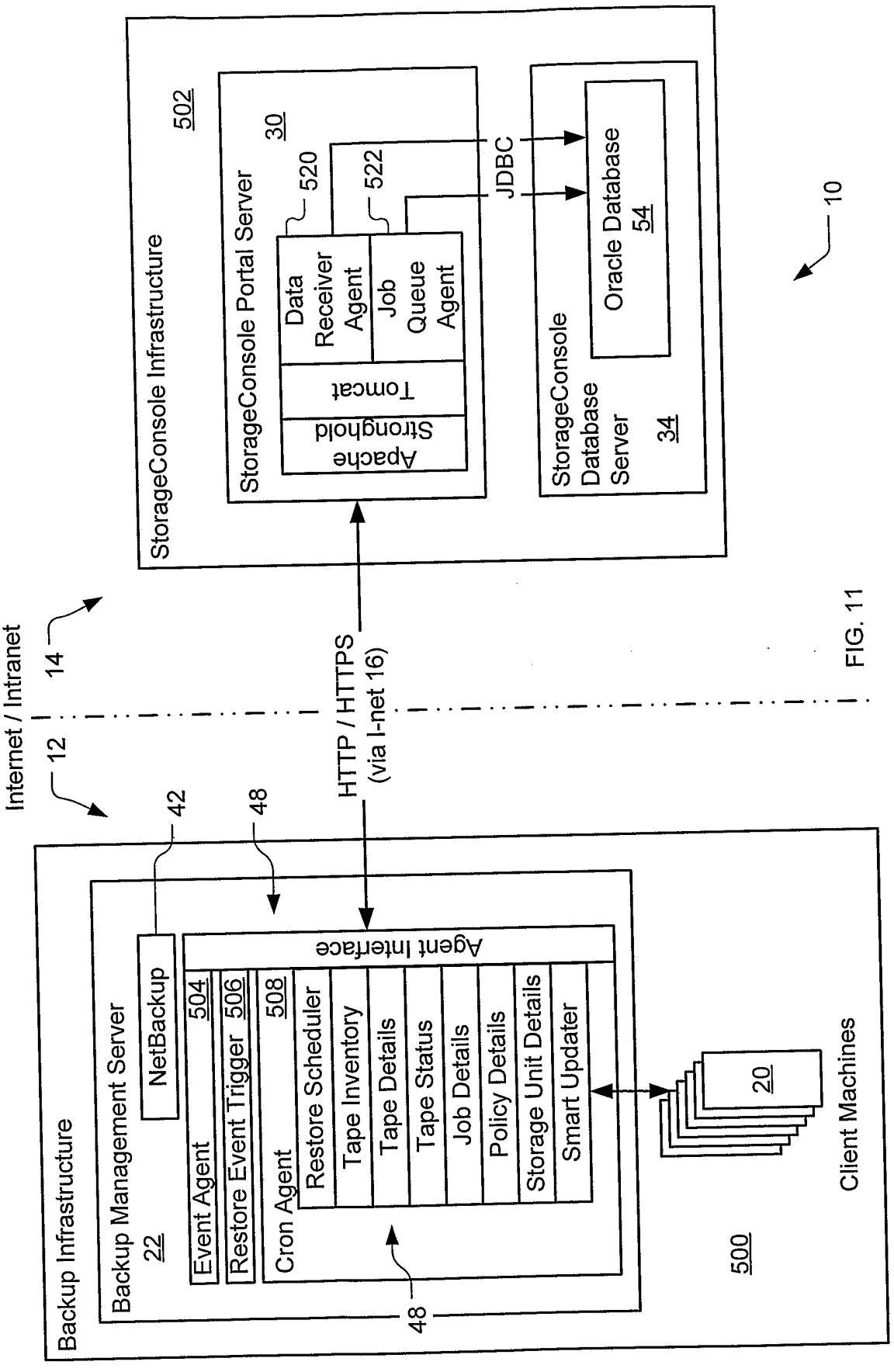
Internet / Intranet
12
14
HTTP / HTTPS
(via I-net 16)
StorageConsole Infrastructure
502
StorageConsole Portal Server
30
Apache Stronghold
Tomcat
Data Receiver Agent
520
Job Queue Agent
522
JDBC
StorageConsole Database Server
34
Oracle Database
54
10
Backup Infrastructure
Backup Management Server
22
NetBackup
42
48
Agent Interface
Event Agent
504
Restore Event Trigger
506
Cron Agent
508
Restore Scheduler
Tape Inventory
Tape Details
Tape Status
Job Details
Policy Details
Storage Unit Details
Smart Updater
48
20
Client Machines
500

FIG. 11

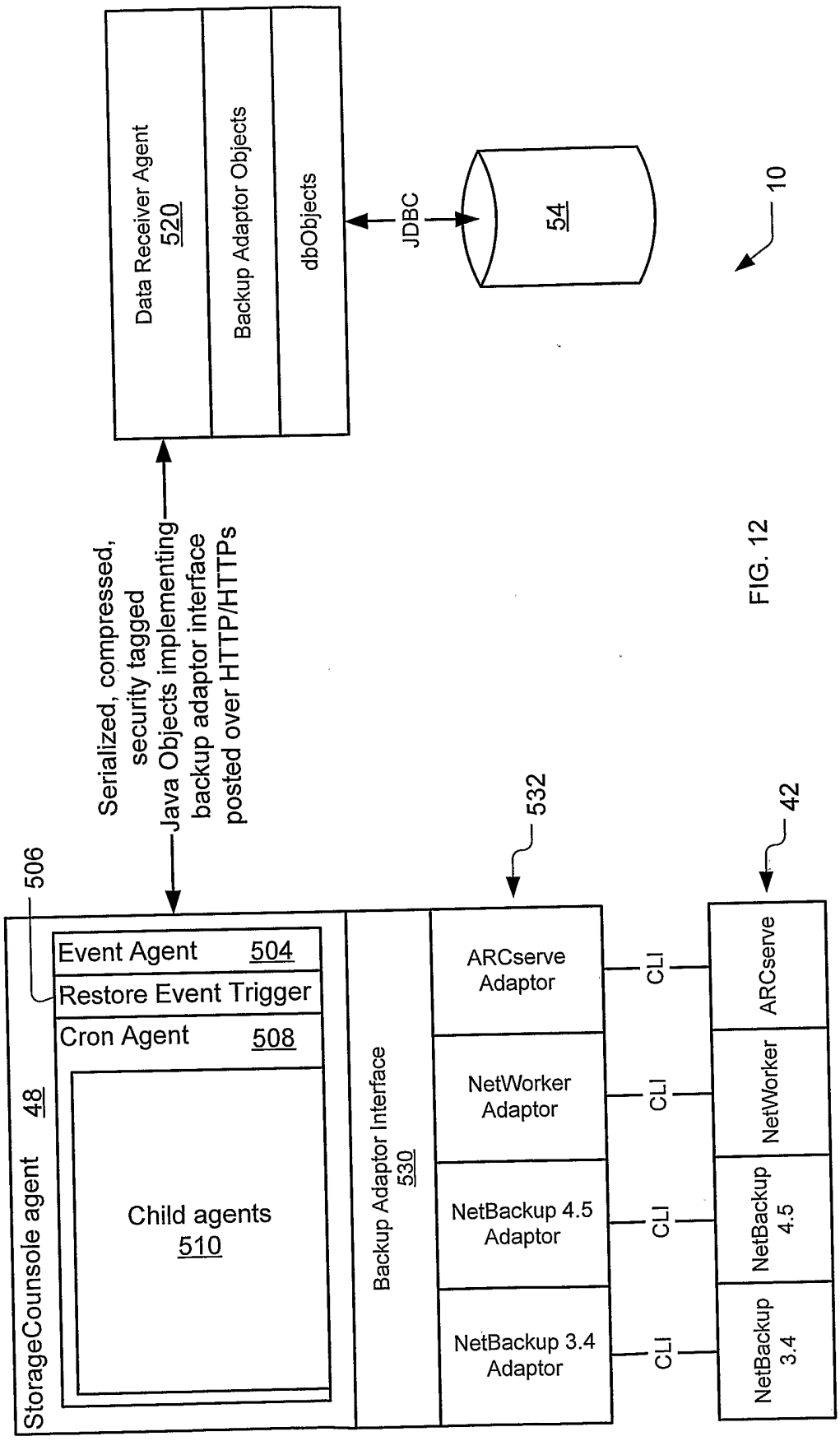
Data Receiver Agent 520
Backup Adaptor Objects
dbObjects
JDBC
54
10
Serialized, compressed, security tagged Java Objects implementing backup adaptor interface posted over HTTP/HTTPs
506
532
42
StorageCounsole agent 48
Event Agent 504
Restore Event Trigger
Cron Agent 508
Child agents 510
Backup Adaptor Interface 530
ARCserve Adaptor
NetWorker Adaptor
NetBackup 4.5 Adaptor
NetBackup 3.4 Adaptor
CLI
CLI
CLI
CLI
ARCserve
NetWorker
NetBackup 4.5
NetBackup 3.4

FIG. 12

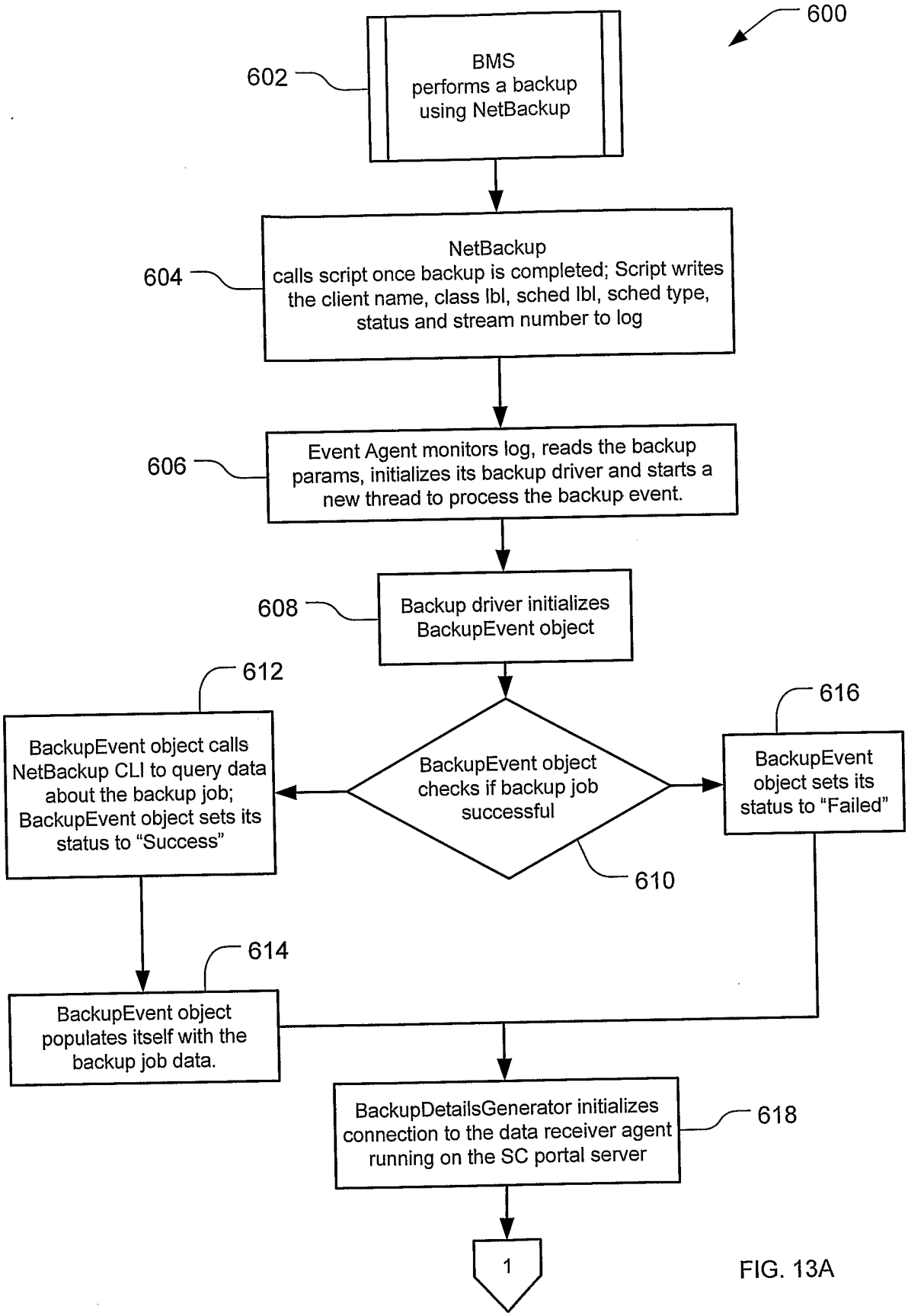
600
602
BMS performs a backup using NetBackup
604
NetBackup calls script once backup is completed; Script writes the client name, class lbl, sched lbl, sched type, status and stream number to log
606
Event Agent monitors log, reads the backup params, initializes its backup driver and starts a new thread to process the backup event.
608
Backup driver initializes BackupEvent object
612
BackupEvent object calls NetBackup CLI to query data about the backup job; BackupEvent object sets its status to "Success"
BackupEvent object checks if backup job successful
610
616
BackupEvent object sets its status to "Failed"
614
BackupEvent object populates itself with the backup job data.
BackupDetailsGenerator initializes connection to the data receiver agent running on the SC portal server
618
1

FIG. 13A

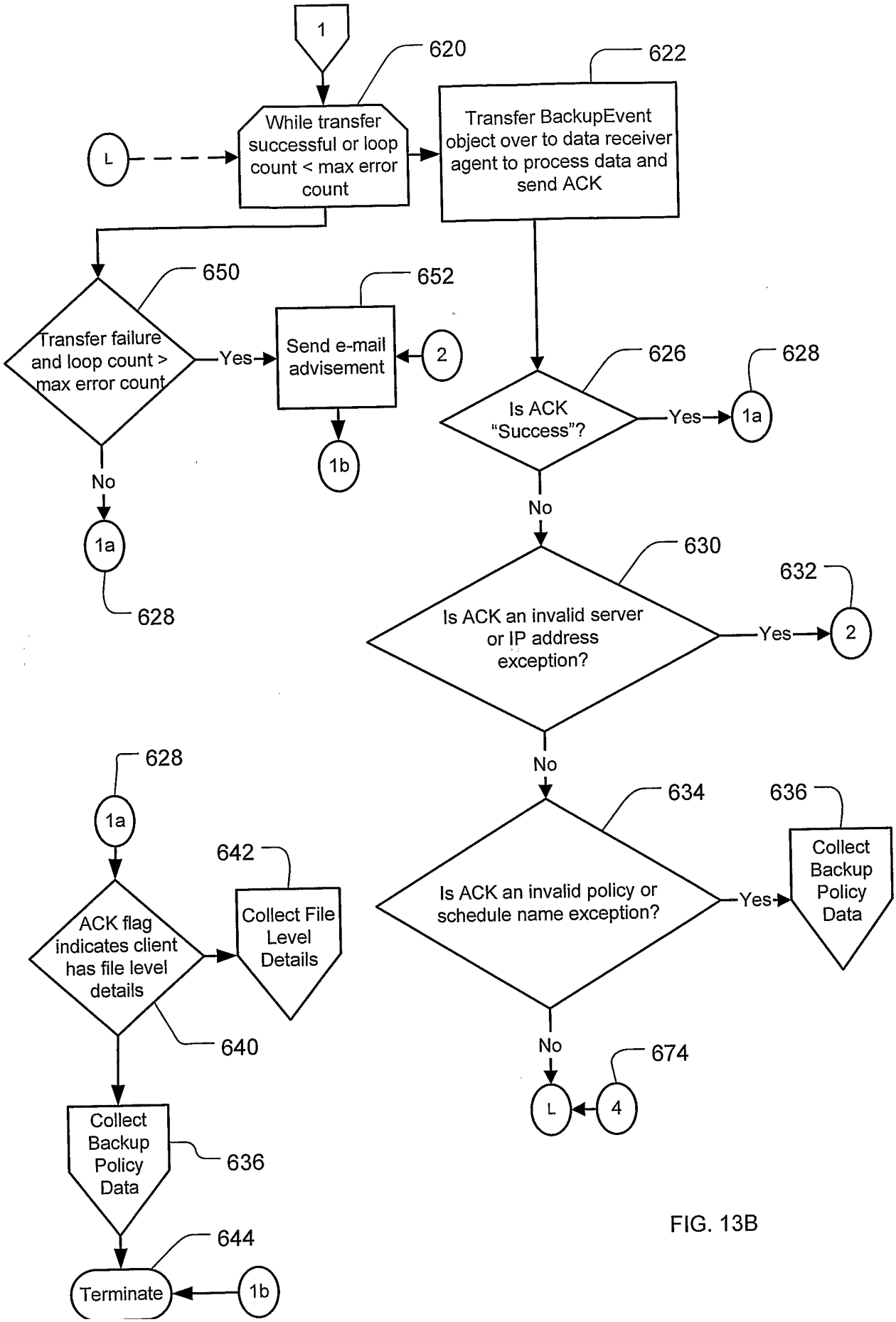
1
620
While transfer successful or loop count < max error count
L
622
Transfer BackupEvent object over to data receiver agent to process data and send ACK
650
Transfer failure and loop count > max error count
Yes
652
Send e-mail advisement
2
1b
No
1a
628
626
Is ACK "Success"?
Yes
628
1a
No
630
Is ACK an invalid server or IP address exception?
Yes
632
2
No
628
1a
642
Collect File Level Details
ACK flag indicates client has file level details
640
634
Is ACK an invalid policy or schedule name exception?
Yes
636
Collect Backup Policy Data
No
674
L
4
Collect Backup Policy Data
636
644
Terminate
1b

FIG. 13B

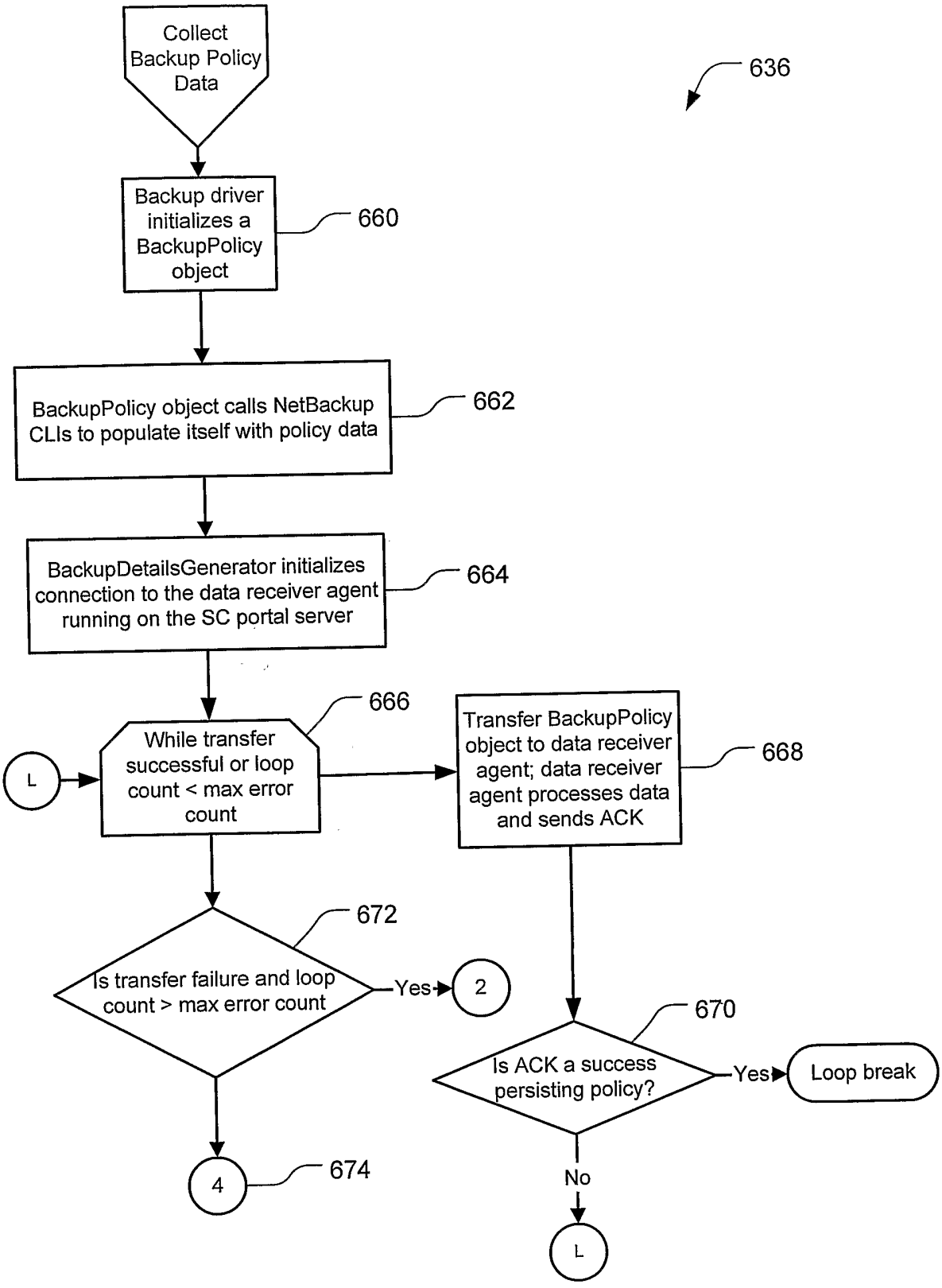
Collect Backup Policy Data
636
Backup driver initializes a BackupPolicy object
660
BackupPolicy object calls NetBackup CLIs to populate itself with policy data
662
BackupDetailsGenerator initializes connection to the data receiver agent running on the SC portal server
664
666
While transfer successful or loop count < max error count
L
Transfer BackupPolicy object to data receiver agent; data receiver agent processes data and sends ACK
668
672
Is transfer failure and loop count > max error count
Yes
2
670
Is ACK a success persisting policy?
Yes
Loop break
No
L
4
674

FIG. 13C

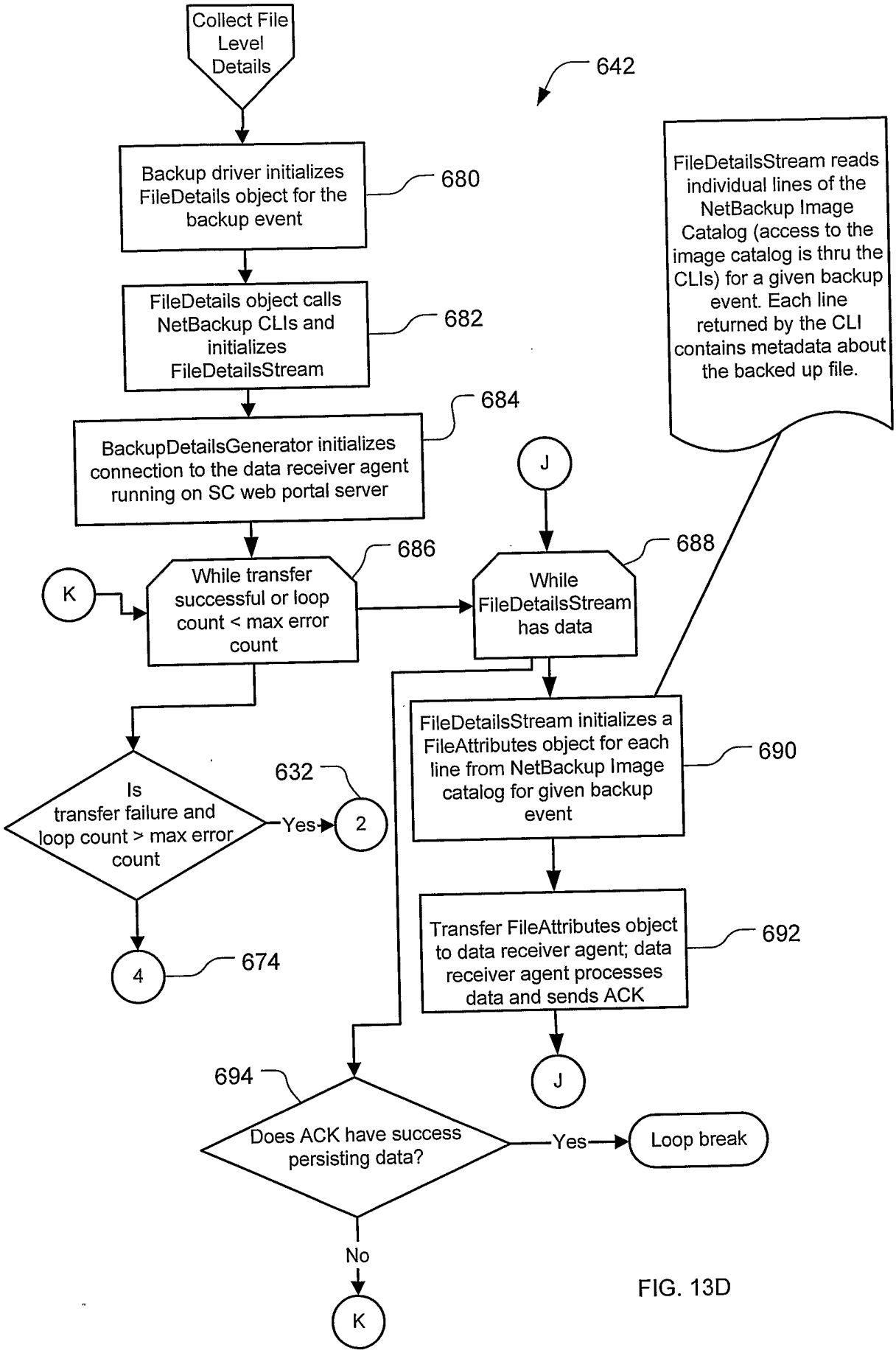
Collect File Level Details
642
Backup driver initializes FileDetails object for the backup event
680
FileDetails object calls NetBackup CLIs and initializes FileDetailsStream
682
BackupDetailsGenerator initializes connection to the data receiver agent running on SC web portal server
684
FileDetailsStream reads individual lines of the NetBackup Image Catalog (access to the image catalog is thru the CLIs) for a given backup event. Each line returned by the CLI contains metadata about the backed up file.
J
K
While transfer successful or loop count < max error count
686
While FileDetailsStream has data
688
FileDetailsStream initializes a FileAttributes object for each line from NetBackup Image catalog for given backup event
690
Is transfer failure and loop count > max error count
632
Yes
2
4
674
Transfer FileAttributes object to data receiver agent; data receiver agent processes data and sends ACK
692
J
694
Does ACK have success persisting data?
Yes
Loop break
No
K

FIG. 13D

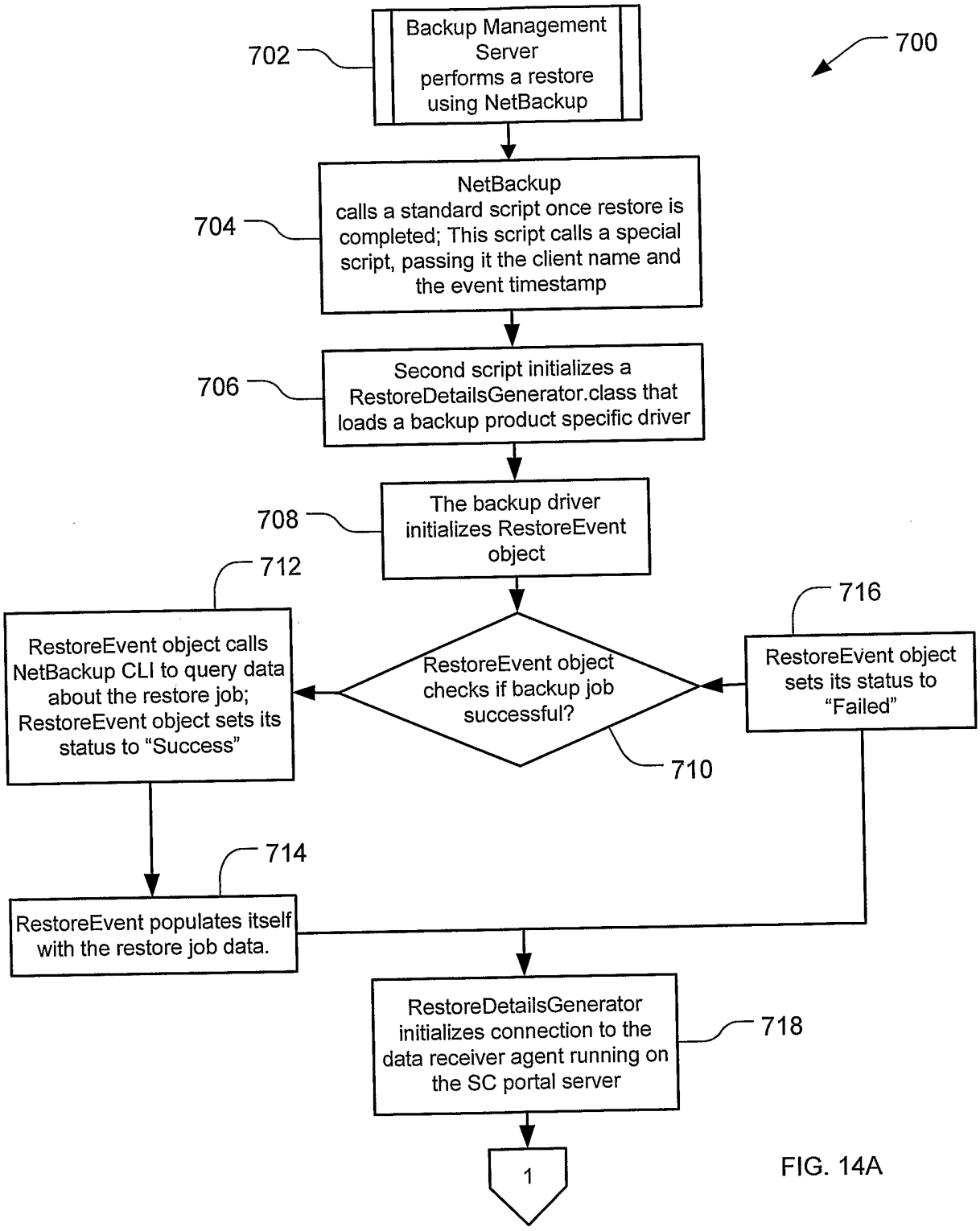
Backup Management Server performs a restore using NetBackup
702
700
NetBackup calls a standard script once restore is completed; This script calls a special script, passing it the client name and the event timestamp
704
Second script initializes a RestoreDetailsGenerator.class that loads a backup product specific driver
706
The backup driver initializes RestoreEvent object
708
712
RestoreEvent object calls NetBackup CLI to query data about the restore job; RestoreEvent object sets its status to "Success"
RestoreEvent object checks if backup job successful?
710
716
RestoreEvent object sets its status to "Failed"
714
RestoreEvent populates itself with the restore job data.
RestoreDetailsGenerator initializes connection to the data receiver agent running on the SC portal server
718
1

FIG. 14A

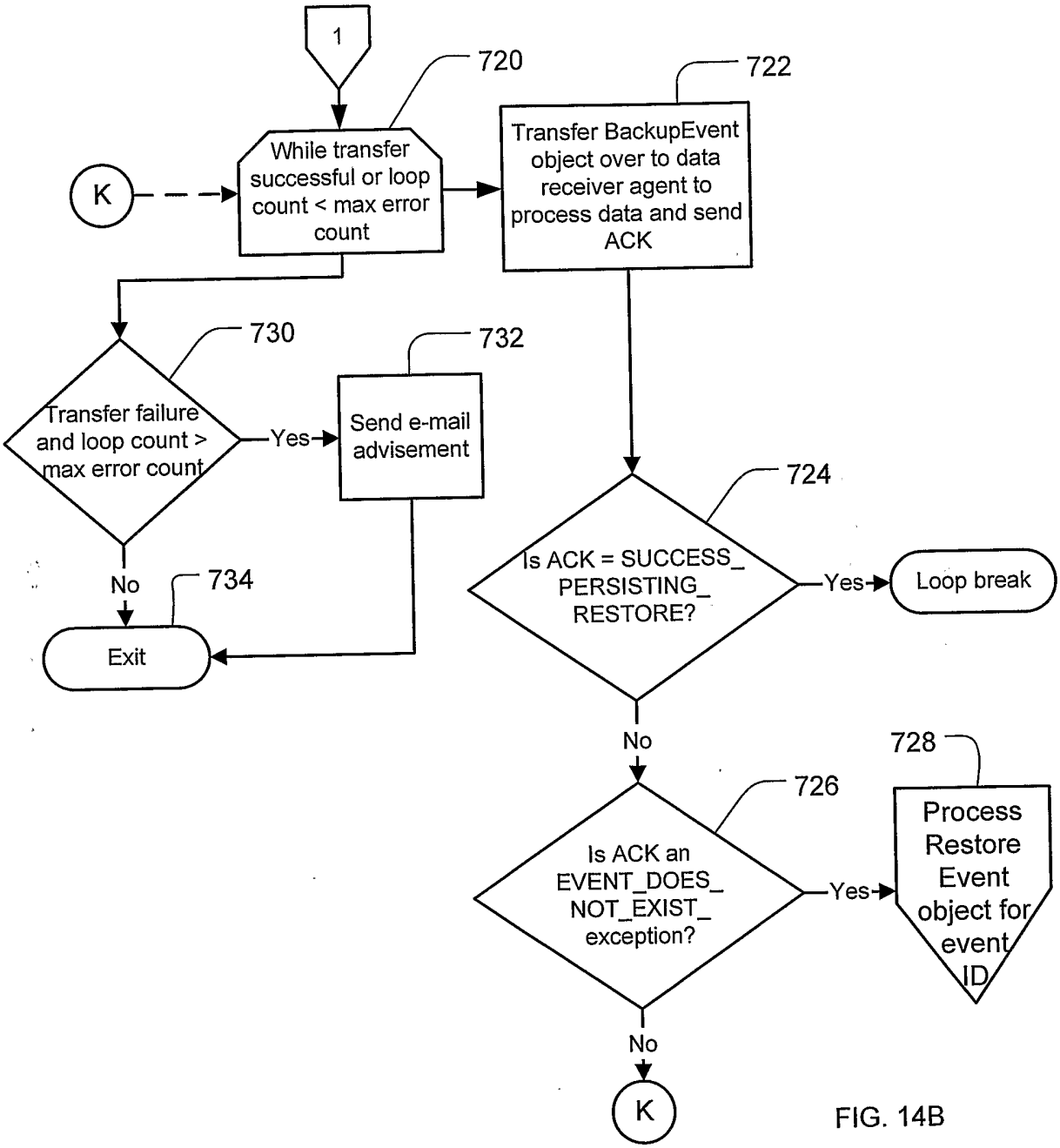
1
720
722
While transfer successful or loop count < max error count
Transfer BackupEvent object over to data receiver agent to process data and send ACK
K
730
732
Transfer failure and loop count > max error count
Yes
Send e-mail advisement
724
Is ACK = SUCCESS_ PERSISTING_ RESTORE?
Yes
Loop break
No
734
Exit
No
728
726
Is ACK an EVENT_DOES_ NOT_EXIST_ exception?
Yes
Process Restore Event object for event ID
No
K

FIG. 14B

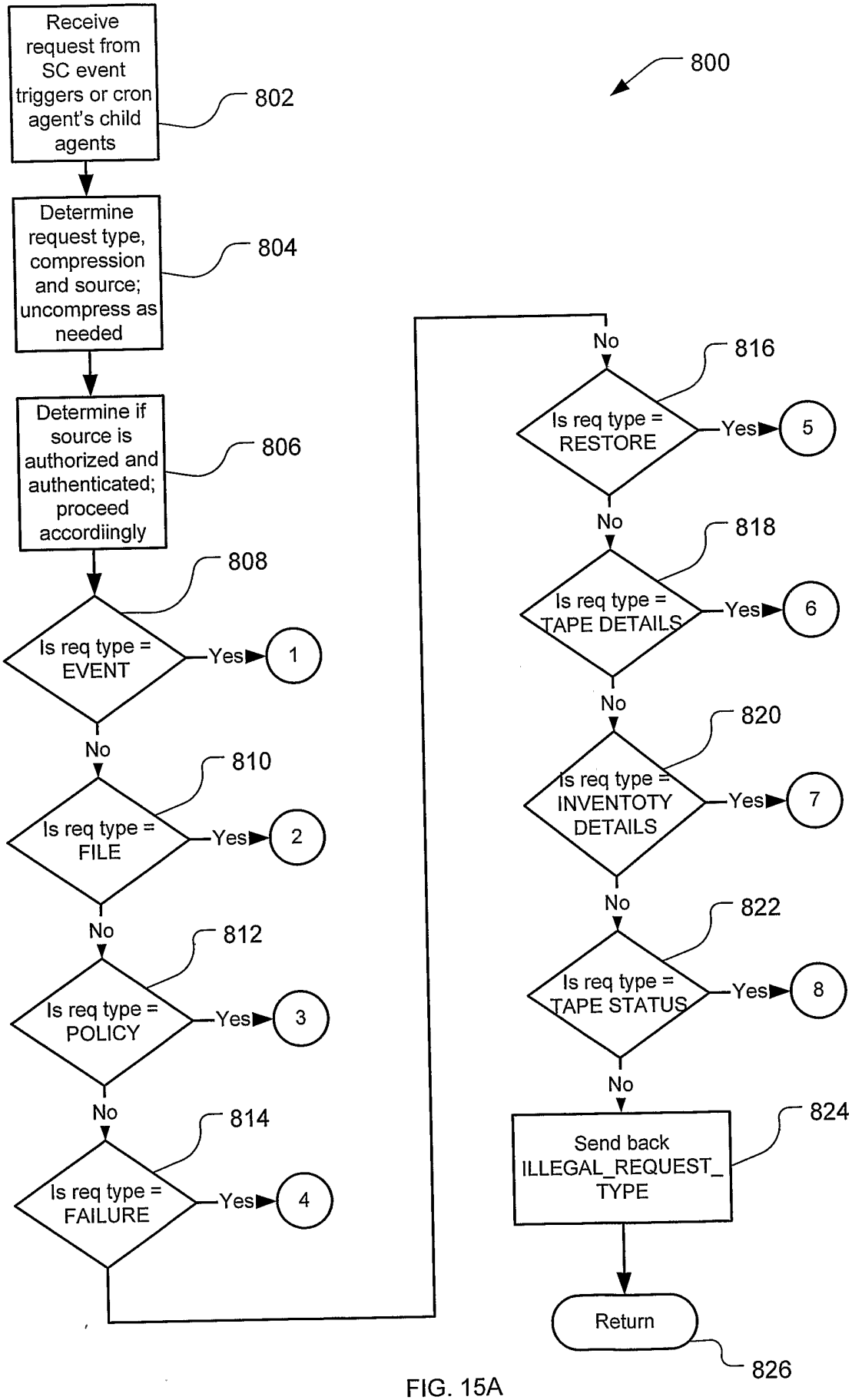
800
Receive request from SC event triggers or cron agent's child agents
802
Determine request type, compression and source; uncompress as needed
804
Determine if source is authorized and authenticated; proceed accordiingly
806
808
Is req type = EVENT
Yes
1
No
810
Is req type = FILE
Yes
2
No
812
Is req type = POLICY
Yes
3
No
814
Is req type = FAILURE
Yes
4
No
816
Is req type = RESTORE
Yes
5
No
818
Is req type = TAPE DETAILS
Yes
6
No
820
Is req type = INVENTOTY DETAILS
Yes
7
No
822
Is req type = TAPE STATUS
Yes
8
No
Send back ILLEGAL_REQUEST_ TYPE
824
Return
826

FIG. 15A

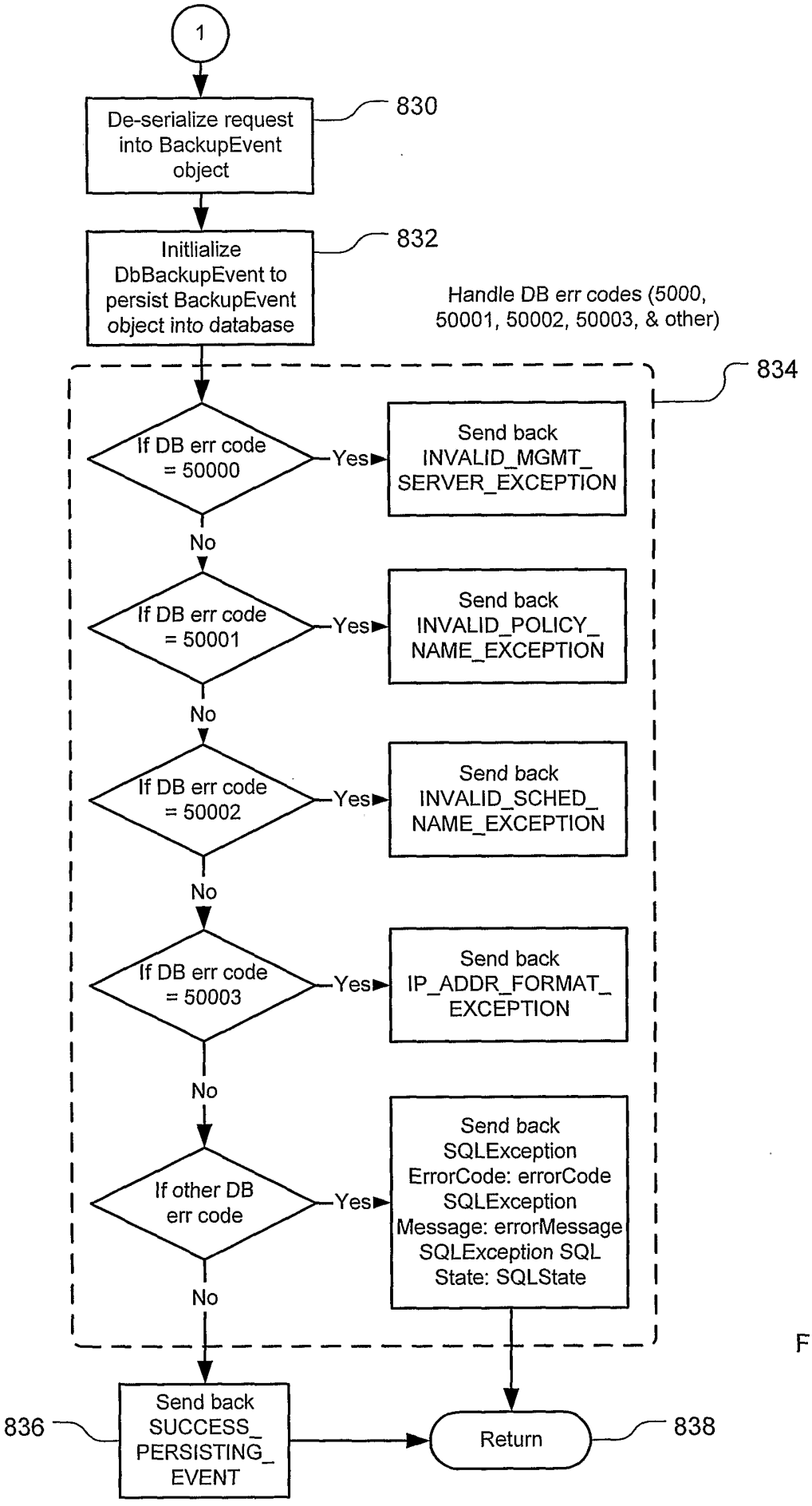
1
De-serialize request into BackupEvent object
830
Initlialize DbBackupEvent to persist BackupEvent object into database
832
Handle DB err codes (5000, 50001, 50002, 50003, & other)
834
If DB err code = 50000
Yes
Send back INVALID_MGMT_ SERVER_EXCEPTION
No
If DB err code = 50001
Yes
Send back INVALID_POLICY_ NAME_EXCEPTION
No
If DB err code = 50002
Yes
Send back INVALID_SCHED_ NAME_EXCEPTION
No
If DB err code = 50003
Yes
Send back IP_ADDR_FORMAT_ EXCEPTION
No
If other DB err code
Yes
Send back SQLException ErrorCode: errorCode SQLException Message: errorMessage SQLException SQL State: SQLState
No
836
Send back SUCCESS_ PERSISTING_ EVENT
Return
838

FIG. 15B

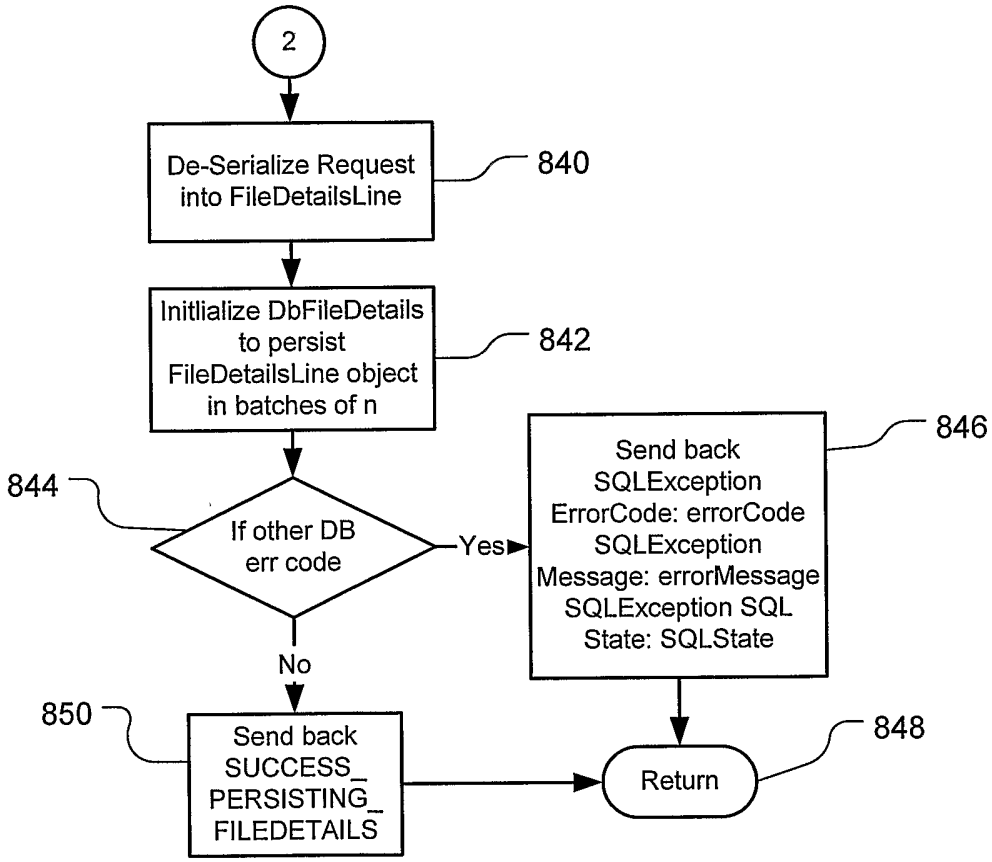
2
De-Serialize Request into FileDetailsLine
840
Initlialize DbFileDetails to persist FileDetailsLine object in batches of n
842
844
If other DB err code
Yes
Send back SQLException ErrorCode: errorCode SQLException Message: errorMessage SQLException SQL State: SQLState
846
No
850
Send back SUCCESS_ PERSISTING_ FILEDETAILS
Return
848

FIG. 15C