US 20040236781A1

(19) United States

(12) Patent Application Publication (10) Pub. No.: US 2004/0236781 A1

Williams (43) Pub. Date: Nov. 25, 2004

(54) METHOD AND SYSTEM FOR REGISTERING DATA FORMATS FOR OBJECTS

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(21) Appl. No.: **10/879,717**

(22) Filed: **Jun. 28, 2004**

Related U.S. Application Data

(63) Continuation of application No. 09/247,125, filed on Feb. 8, 1999, which is a continuation of application No. 08/884,448, filed on Jun. 27, 1997, now Pat. No. 5,905,884, which is a continuation of application No. 08/382,214, filed on Jan. 30, 1995, now Pat. No. 5,692,157, which is a continuation of application No. 07/900,968, filed on Jun. 17, 1992, now abandoned.

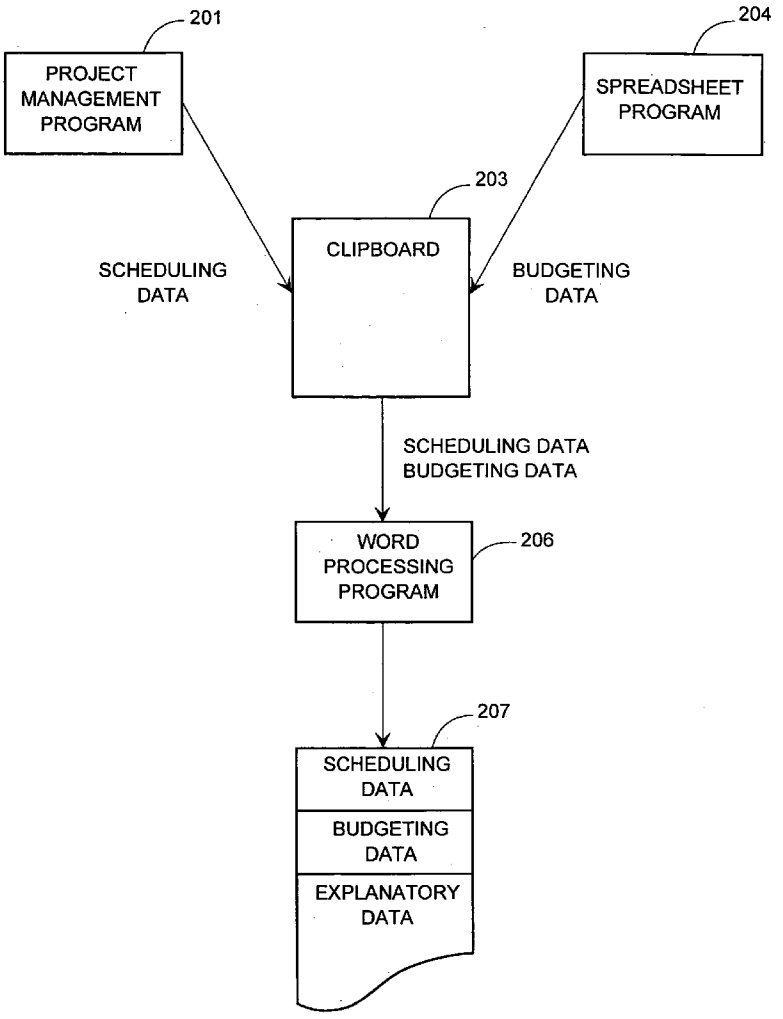
Publication Classification

(51) **Int. Cl.**[7] **G06F 17/00**

(52) **U.S. Cl.** **707/102**

(57) **ABSTRACT**

A method and system for registering data formats for objects are provided. In a preferred embodiment, a server application registers in a registration database data formats for receiving and for sending data. To send data to the server application, a client application retrieves and selects from the registration database a data format that the server application supports for receiving data and sends data to the server application in the selected data format. To receive data from the server application, the client application retrieves and selects from the registration database a data format that the server application supports for sending data and requests the server application to send data in the selected data format.



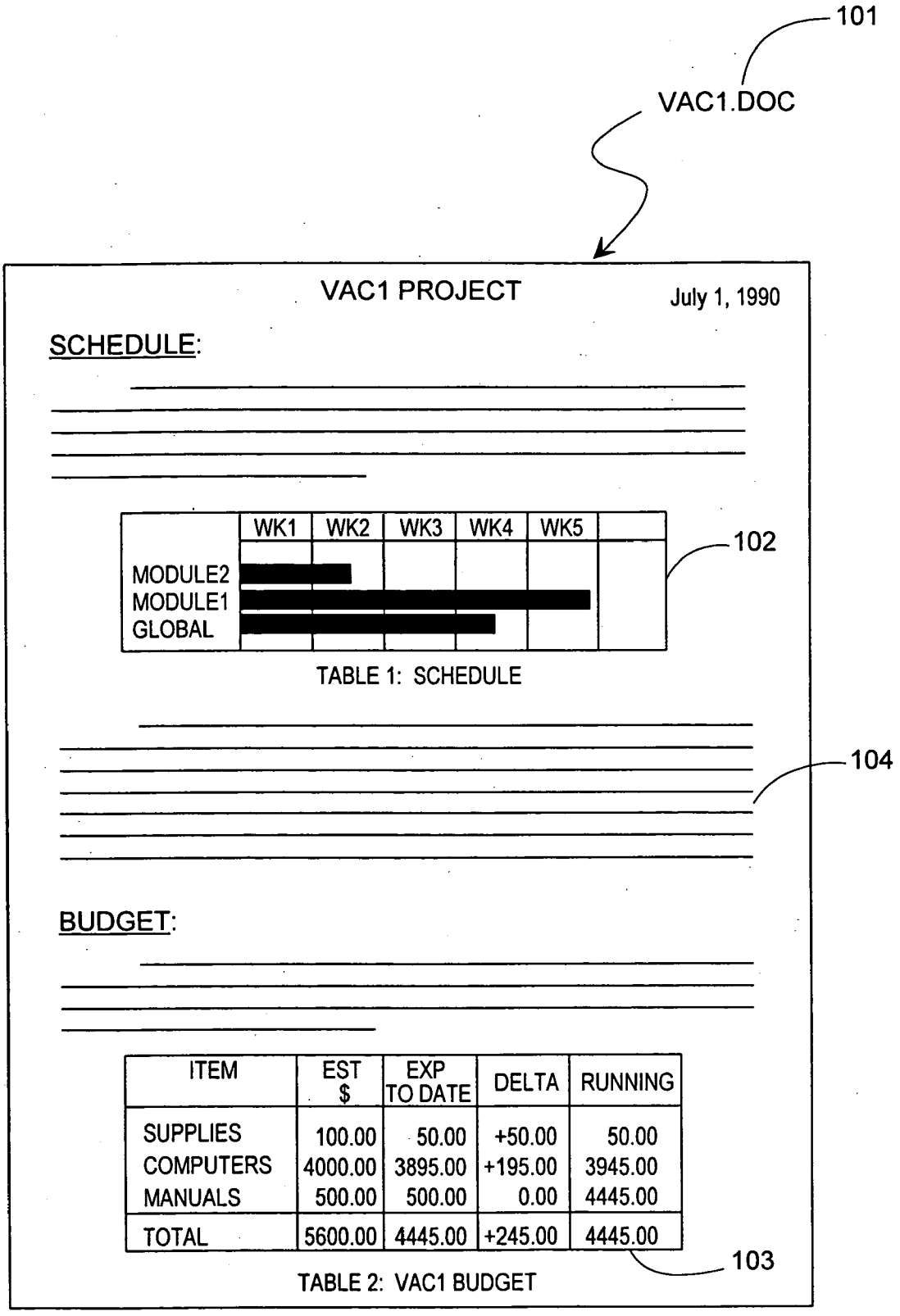

101
VAC1.DOC
VAC1 PROJECT
July 1, 1990
SCHEDULE:
WK1
WK2
WK3
WK4
WK5
MODULE2
MODULE1
GLOBAL
102
TABLE 1: SCHEDULE
104
BUDGET:
ITEM
EST $
EXP TO DATE
DELTA
RUNNING
SUPPLIES 100.00 50.00 +50.00 50.00
COMPUTERS 4000.00 3895.00 +195.00 3945.00
MANUALS 500.00 500.00 0.00 4445.00
TOTAL 5600.00 4445.00 +245.00 4445.00
103
TABLE 2: VAC1 BUDGET

Figure 1

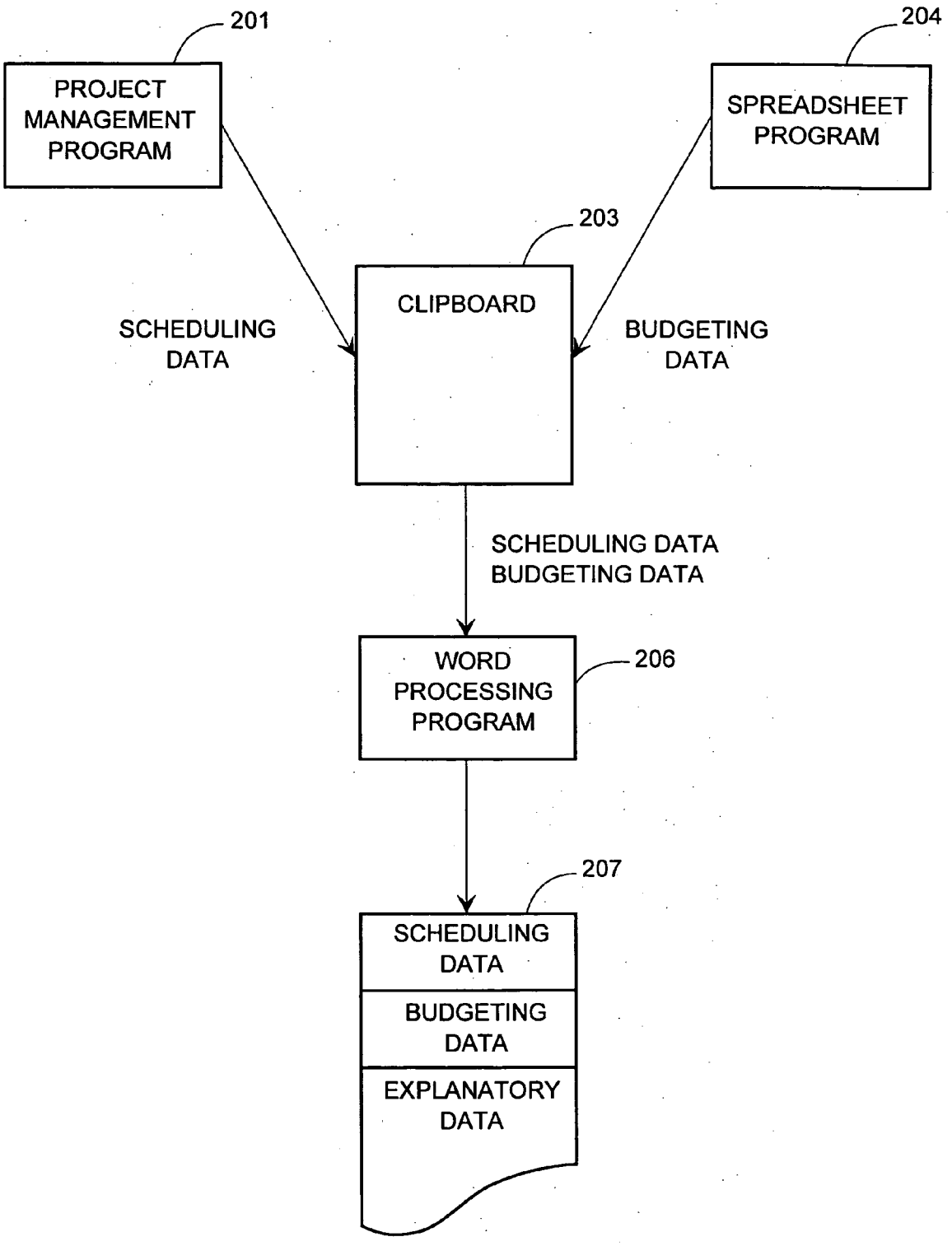

201
PROJECT MANAGEMENT PROGRAM
204
SPREADSHEET PROGRAM
203
CLIPBOARD
SCHEDULING DATA
BUDGETING DATA
SCHEDULING DATA
BUDGETING DATA
WORD PROCESSING PROGRAM
206
207
SCHEDULING DATA
BUDGETING DATA
EXPLANATORY DATA

Figure 2

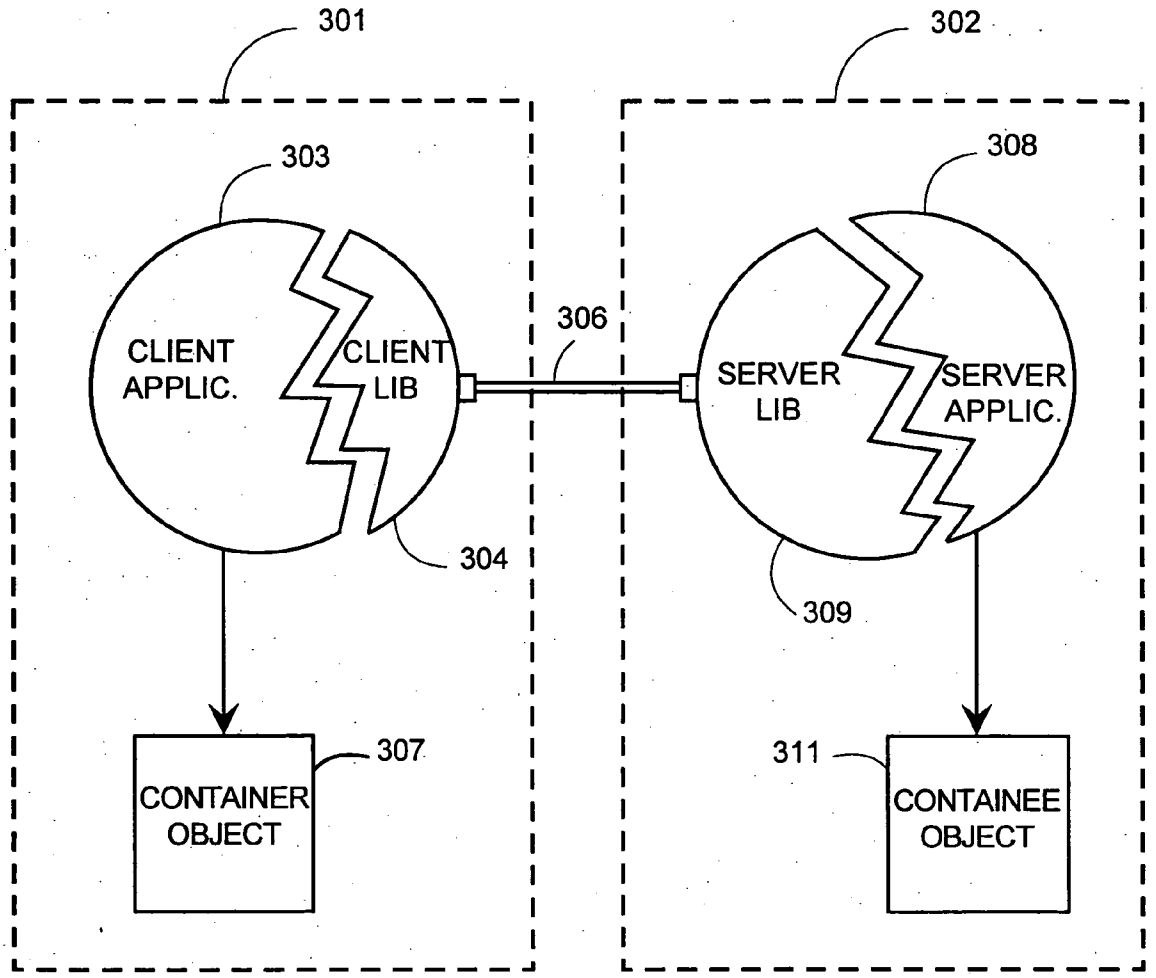

301
302
303
308
CLIENT APPLIC.
CLIENT LIB
306
SERVER LIB
SERVER APPLIC.
304
309
307
311
CONTAINER OBJECT
CONTAINEE OBJECT

Figure 3

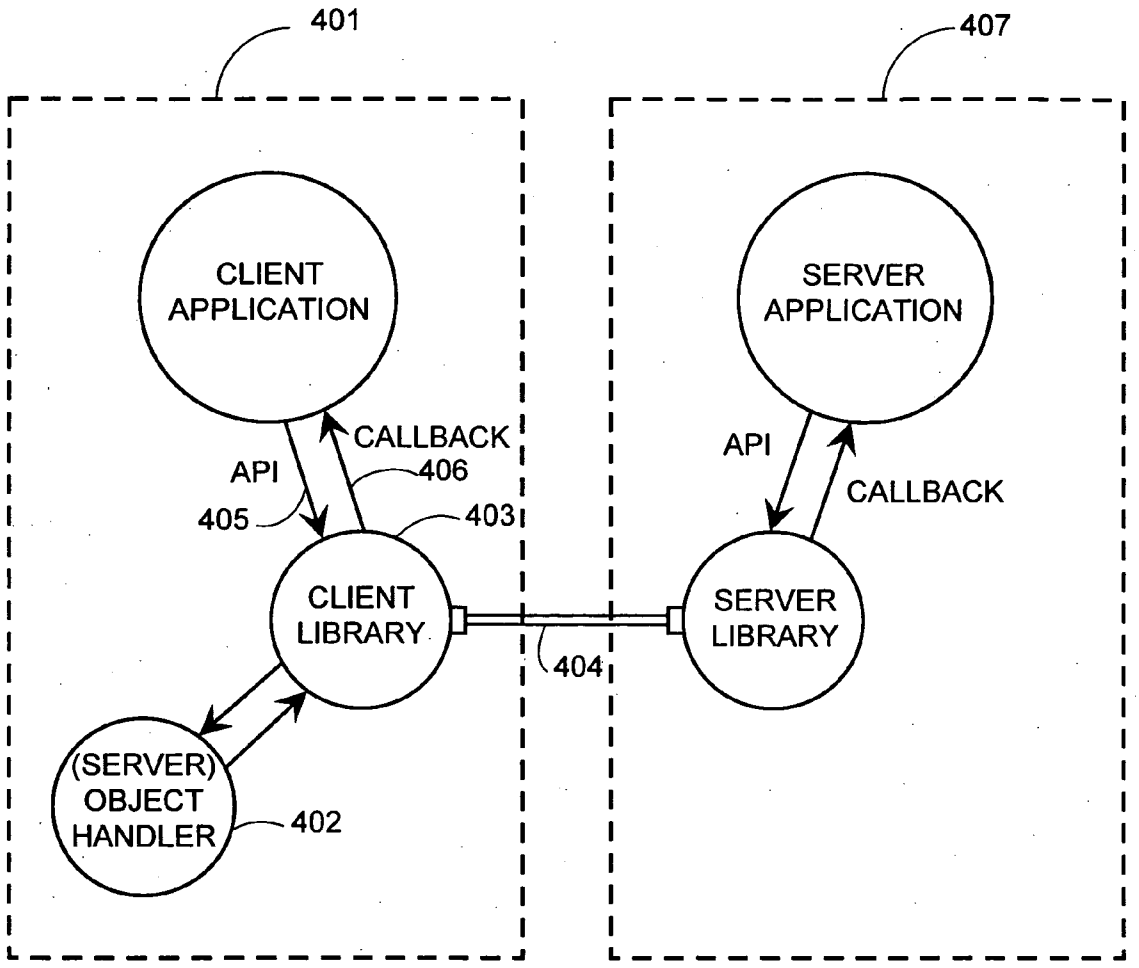

401
407
CLIENT APPLICATION
SERVER APPLICATION
CALLBACK
406
API
405
403
API
CALLBACK
CLIENT LIBRARY
SERVER LIBRARY
404
(SERVER) OBJECT HANDLER
402

Figure 4

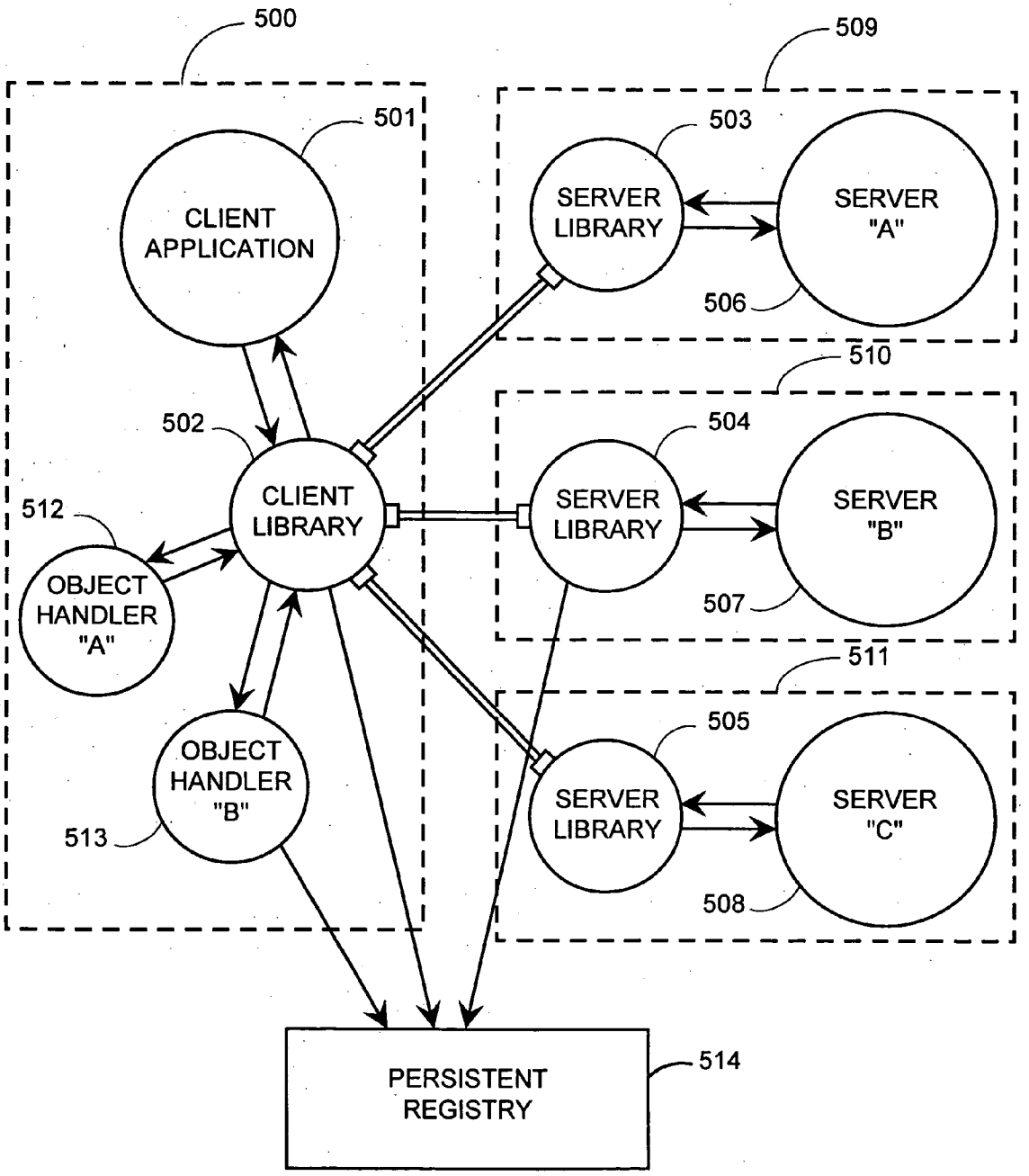

500
509
501
503
CLIENT APPLICATION
SERVER LIBRARY
SERVER "A"
506
510
502
504
CLIENT LIBRARY
SERVER LIBRARY
SERVER "B"
512
OBJECT HANDLER "A"
507
511
505
OBJECT HANDLER "B"
SERVER LIBRARY
SERVER "C"
513
508
PERSISTENT REGISTRY
514

Figure 5

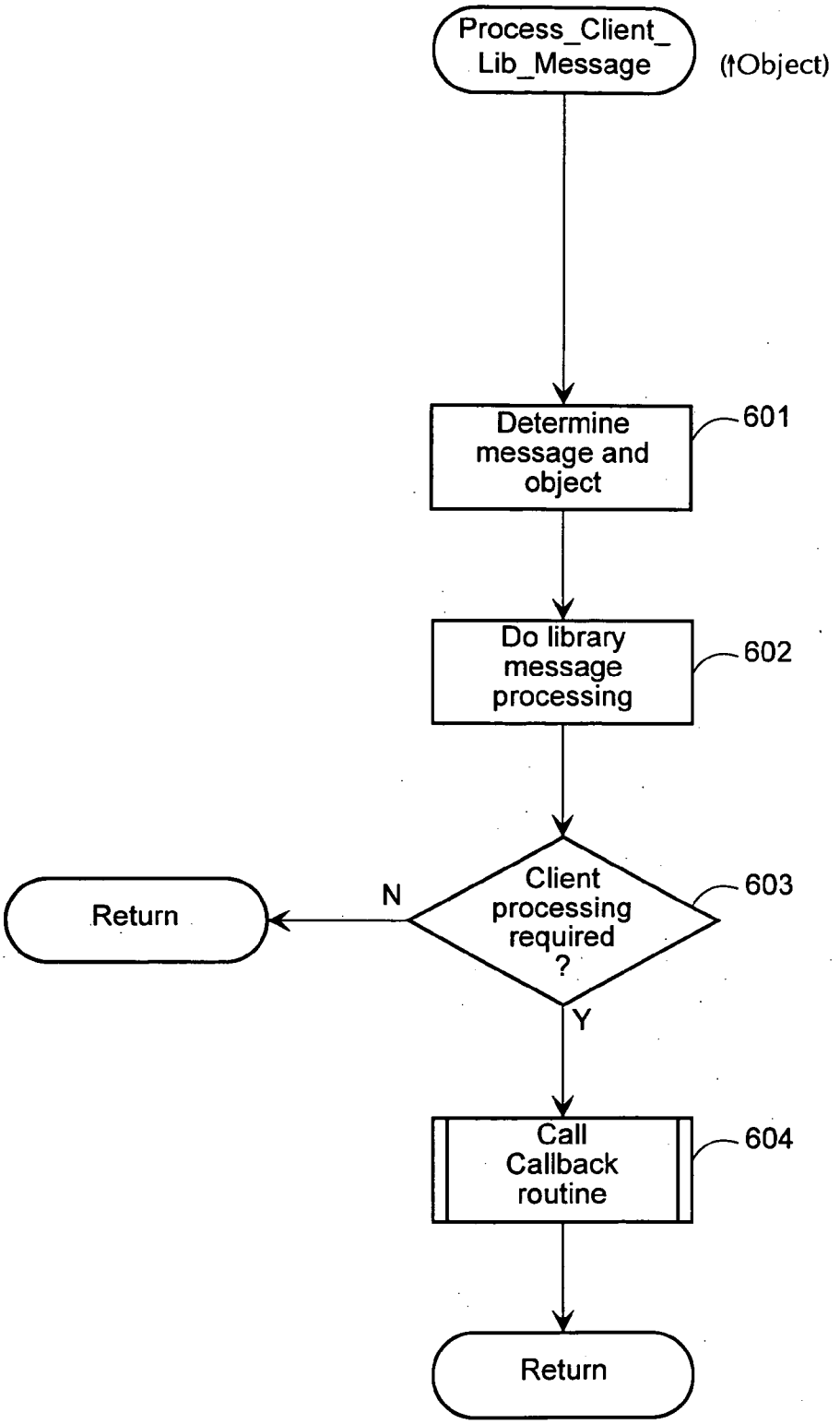

Process_Client_
Lib_Message
(↑Object)
Determine
message and
object
601
Do library
message
processing
602
Client
processing
required
?
603
N
Return
Y
Call
Callback
routine
604
Return

Figure 6A

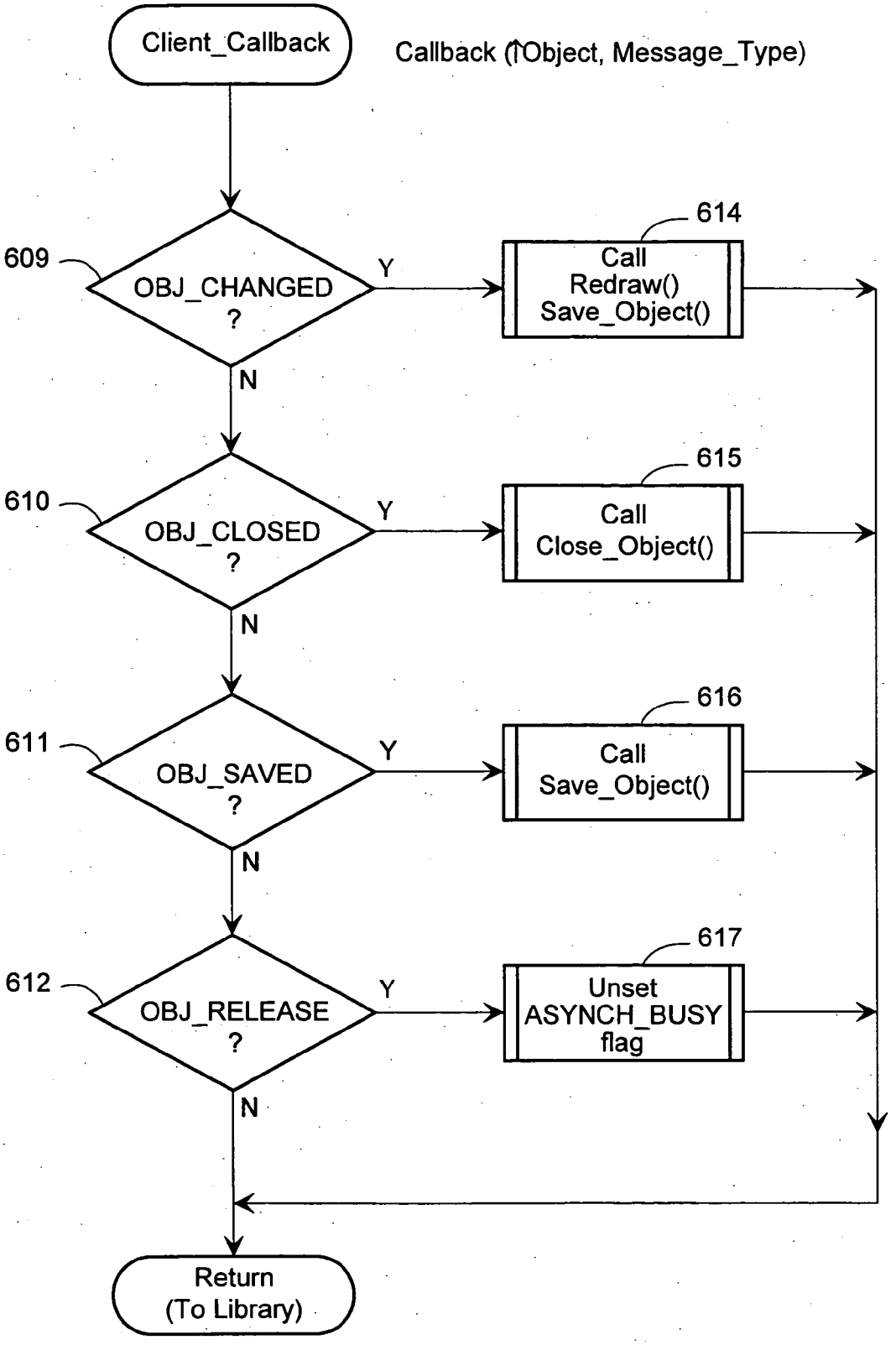

Client_Callback
Callback (lObject, Message_Type)
609
OBJ_CHANGED ?
Y
614
Call Redraw() Save_Object()
N
610
OBJ_CLOSED ?
Y
615
Call Close_Object()
N
611
OBJ_SAVED ?
Y
616
Call Save_Object()
N
612
OBJ_RELEASE ?
Y
617
Unset ASYNCH_BUSY flag
N
Return (To Library)

Figure 6B

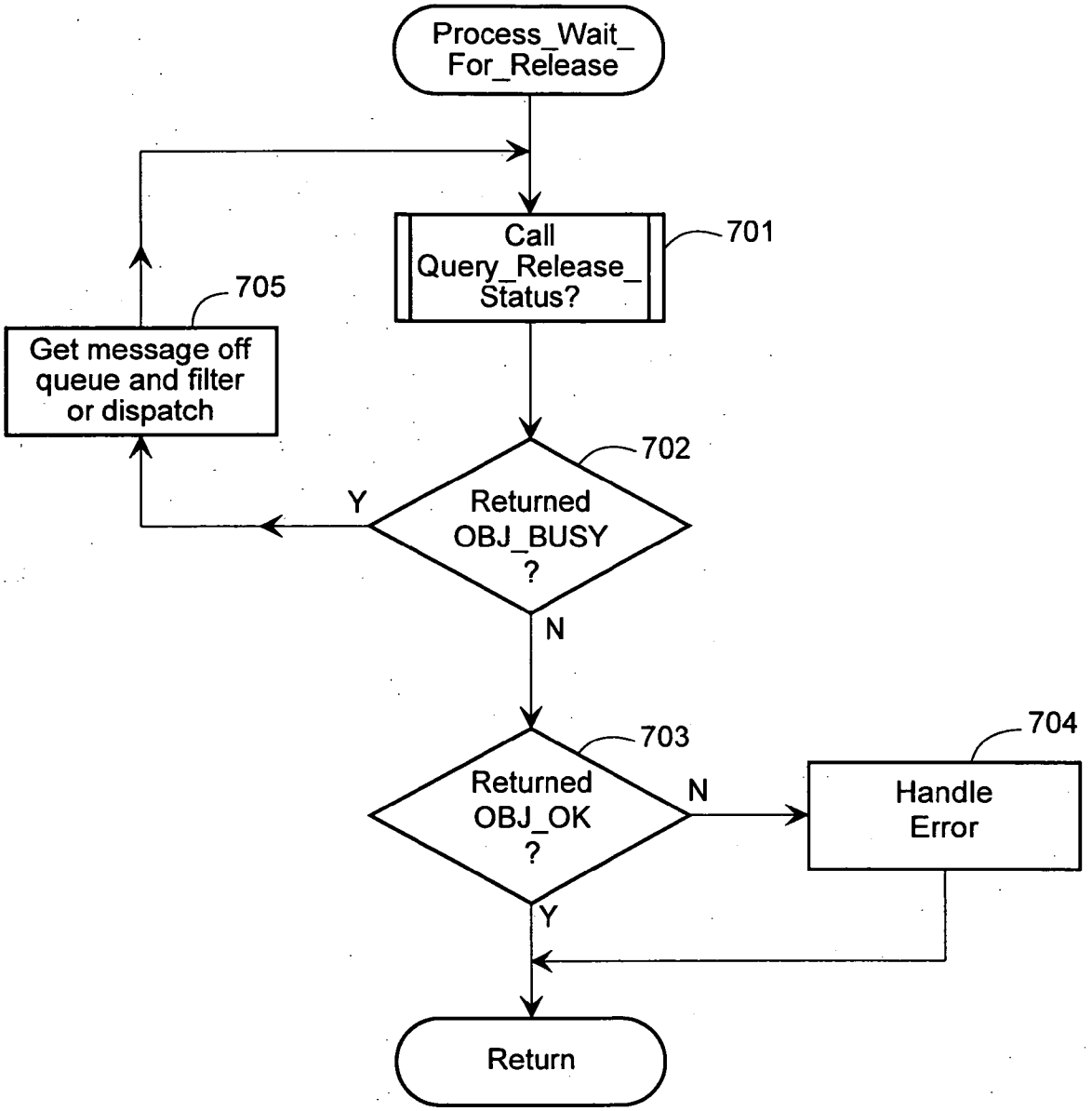

Process_Wait_
For_Release
Call
Query_Release_
Status?
701
705
Get message off
queue and filter
or dispatch
702
Y
Returned
OBJ_BUSY
?
N
703
Returned
OBJ_OK
?
N
704
Handle
Error
Y
Return

Figure 7

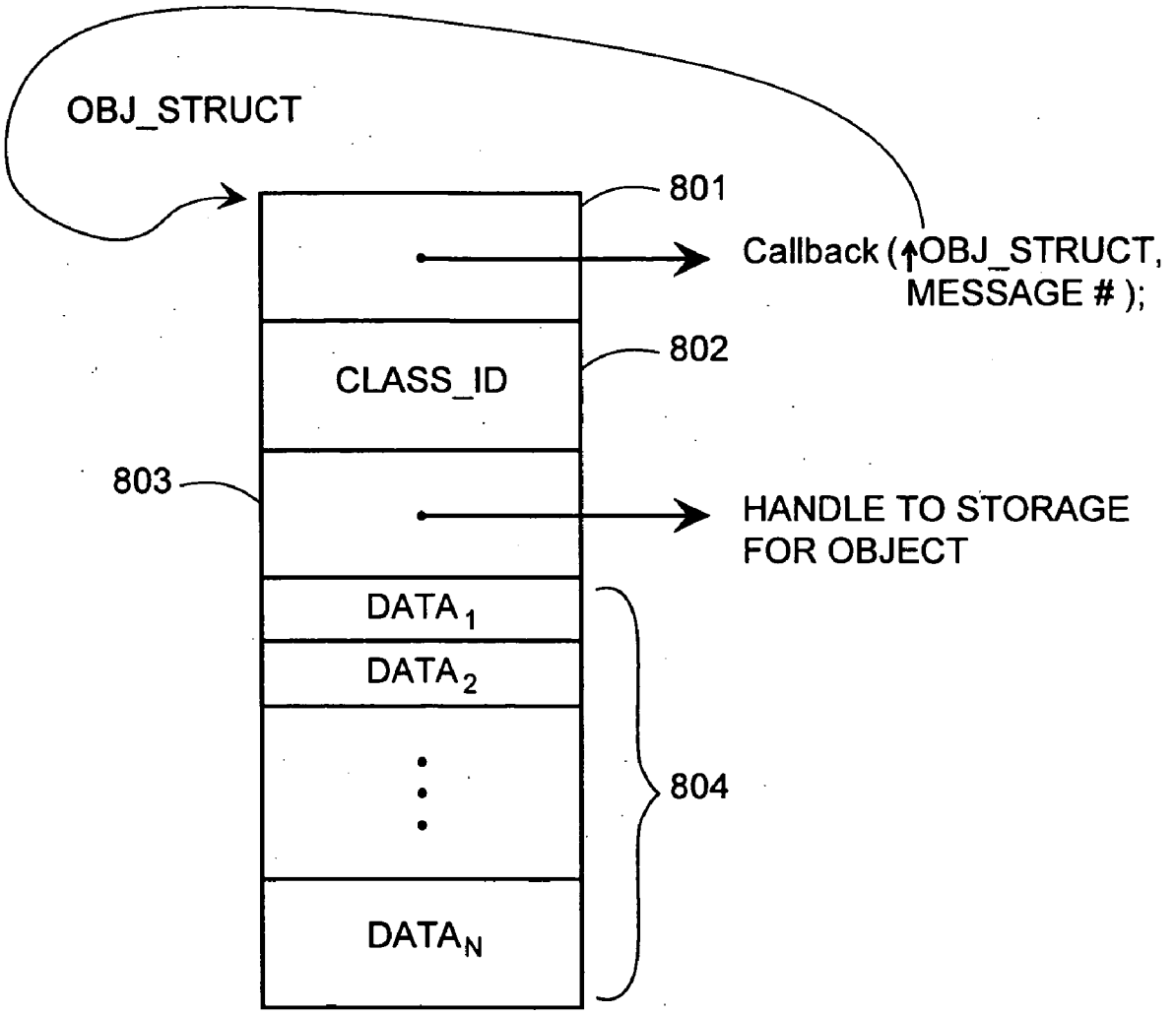

OBJ_STRUCT
801
Callback (↑OBJ_STRUCT,
MESSAGE #);
CLASS_ID
802
803
HANDLE TO STORAGE
FOR OBJECT
DATA 1
DATA 2
804
DATA N

Figure 8

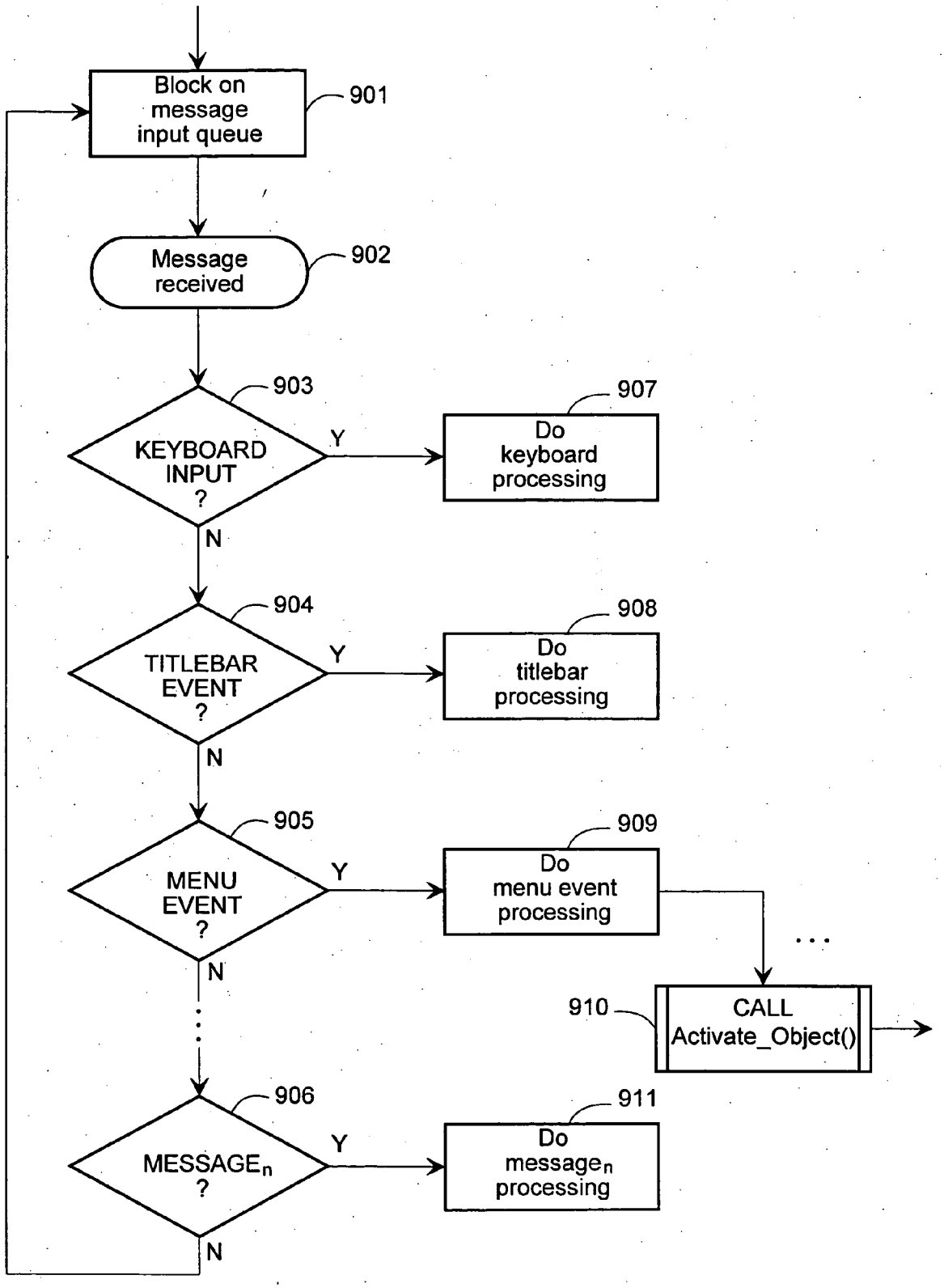

Block on message input queue
901
Message received
902
903
KEYBOARD INPUT ?
Y
907
Do keyboard processing
N
904
TITLEBAR EVENT ?
Y
908
Do titlebar processing
N
905
MENU EVENT ?
Y
909
Do menu event processing
N
910
CALL Activate_Object()
906
MESSAGEn ?
Y
911
Do messagen processing
N

Figure 9

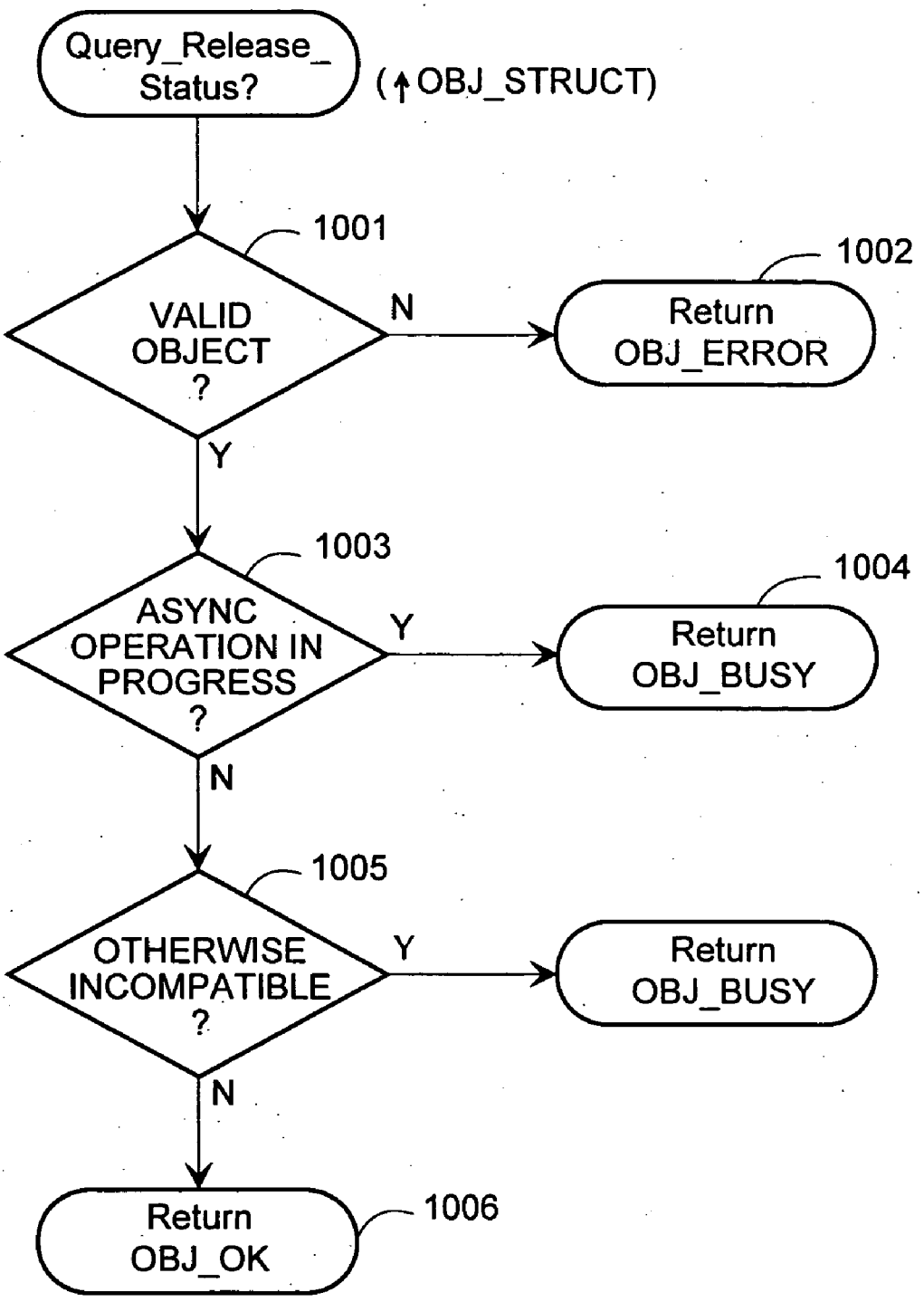

Query_Release_
Status?
(↑OBJ_STRUCT)
1001
VALID
OBJECT
?
N
1002
Return
OBJ_ERROR
Y
1003
ASYNC
OPERATION IN
PROGRESS
?
Y
1004
Return
OBJ_BUSY
N
1005
OTHERWISE
INCOMPATIBLE
?
Y
Return
OBJ_BUSY
N
Return
OBJ_OK
1006

Figure 10

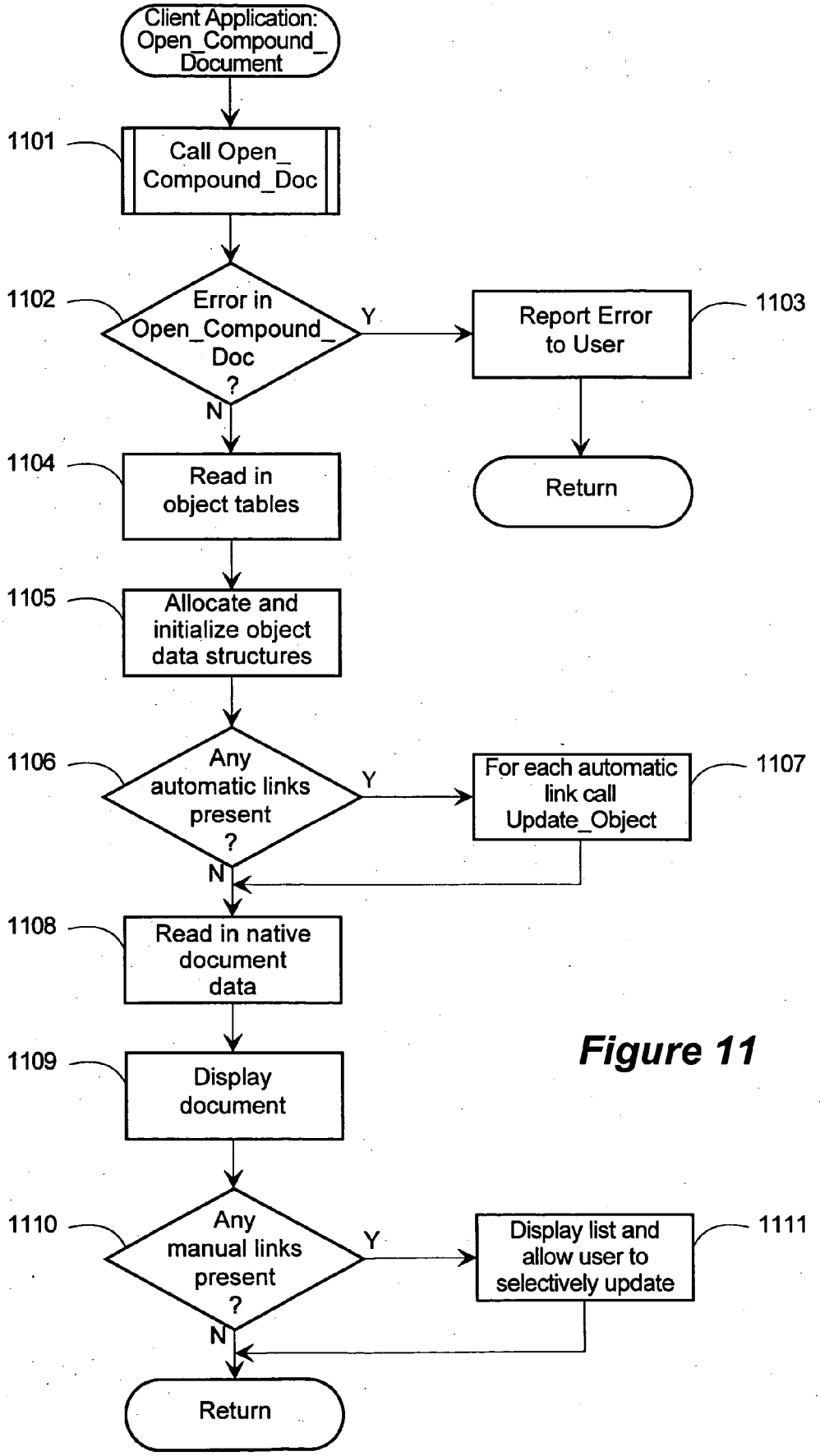

Client Application: Open_Compound_ Document
1101
Call Open_ Compound_Doc
1102
Error in Open_Compound_ Doc ?
Y
1103
Report Error to User
N
Return
1104
Read in object tables
1105
Allocate and initialize object data structures
1106
Any automatic links present ?
Y
1107
For each automatic link call Update_Object
N
1108
Read in native document data
1109
Display document
1110
Any manual links present ?
Y
1111
Display list and allow user to selectively update
N
Return

Figure 11

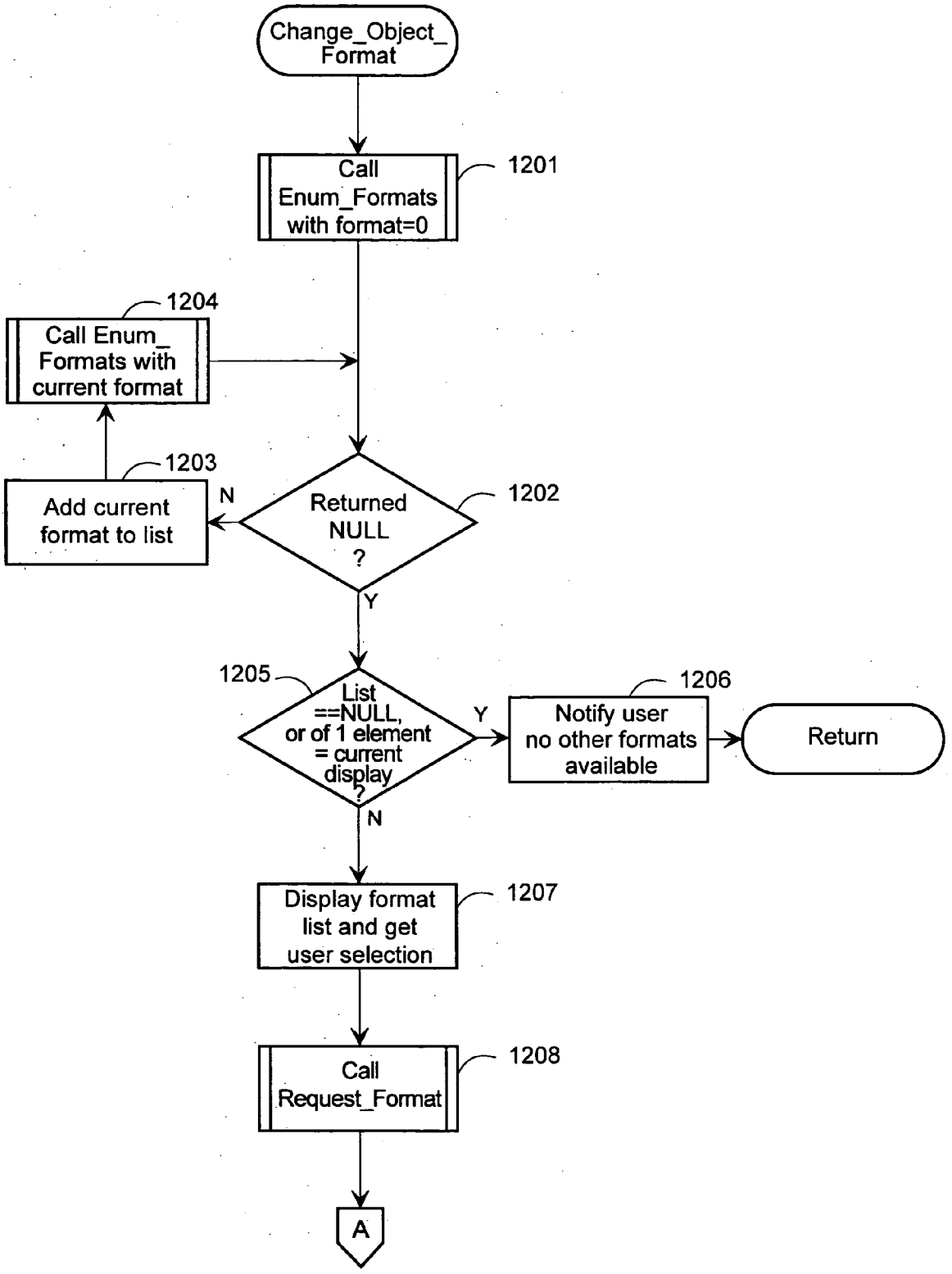

Change_Object_ Format
Call Enum_Formats with format=0
1201
1204
Call Enum_ Formats with current format
1203
Add current format to list
N
Returned NULL ?
1202
Y
1205
List ==NULL, or of 1 element = current display ?
Y
1206
Notify user no other formats available
Return
N
Display format list and get user selection
1207
Call Request_Format
1208
A

Figure 12A

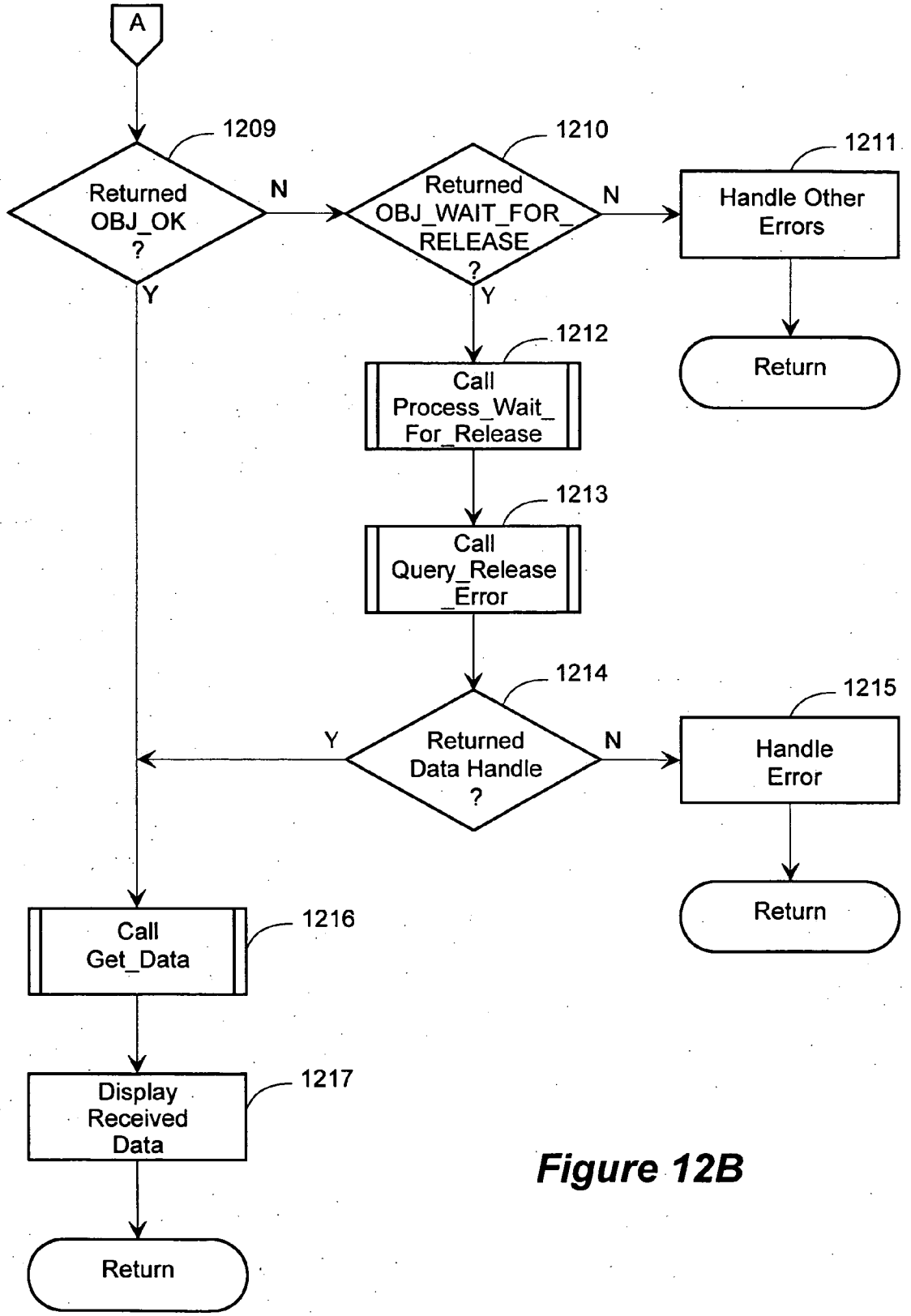

A
1209
Returned OBJ_OK ?
N
Y
1210
Returned OBJ_WAIT_FOR_ RELEASE ?
N
Y
1211
Handle Other Errors
Return
1212
Call Process_Wait_ For_Release
1213
Call Query_Release _Error
1214
Returned Data Handle ?
Y
N
1215
Handle Error
Return
Call Get_Data
1216
Display Received Data
1217
Return

Figure 12B

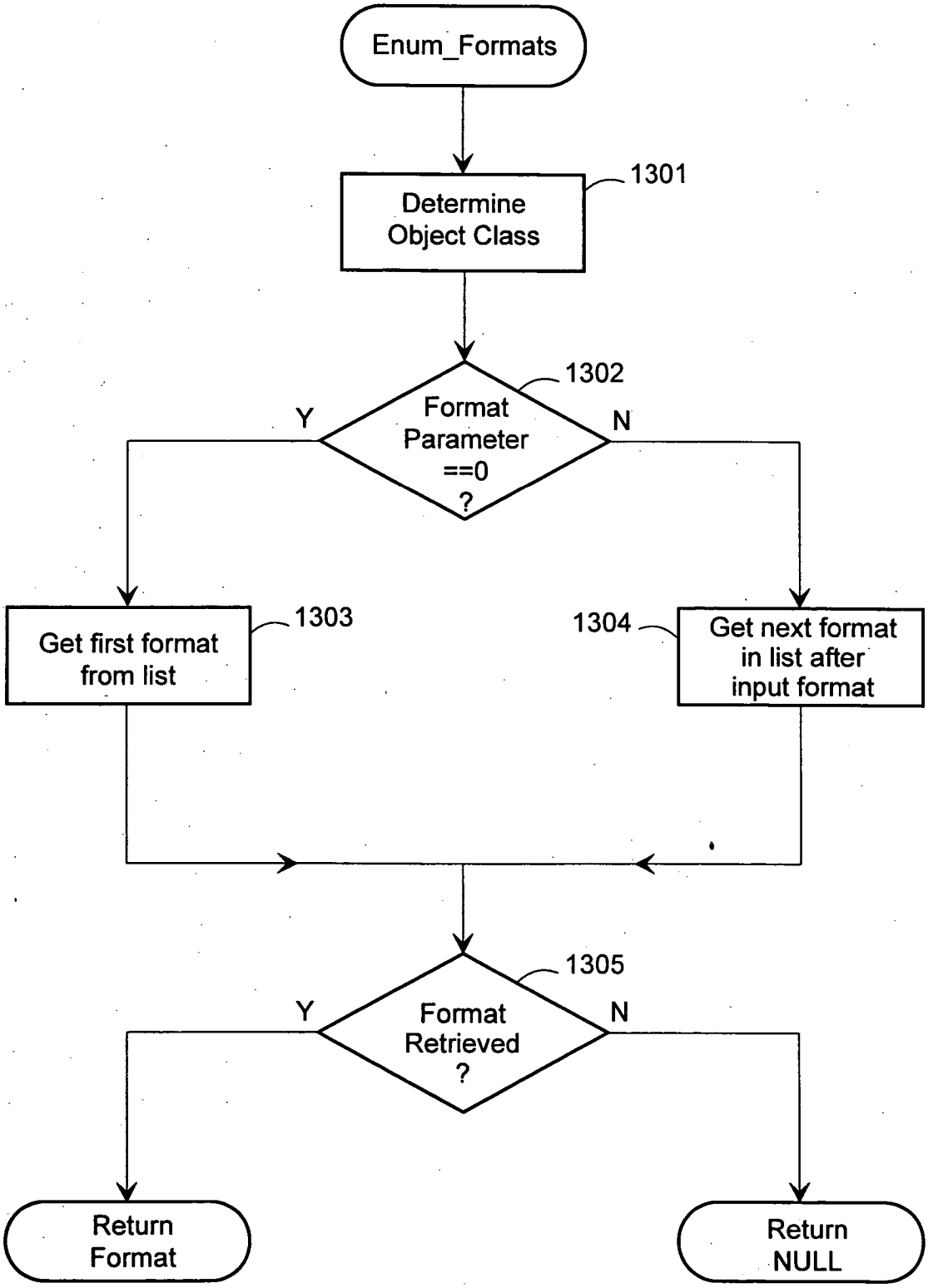

Enum_Formats
Determine Object Class
1301
Format Parameter ==0 ?
1302
Y
N
Get first format from list
1303
Get next format in list after input format
1304
Format Retrieved ?
1305
Y
N
Return Format
Return NULL

Figure 13

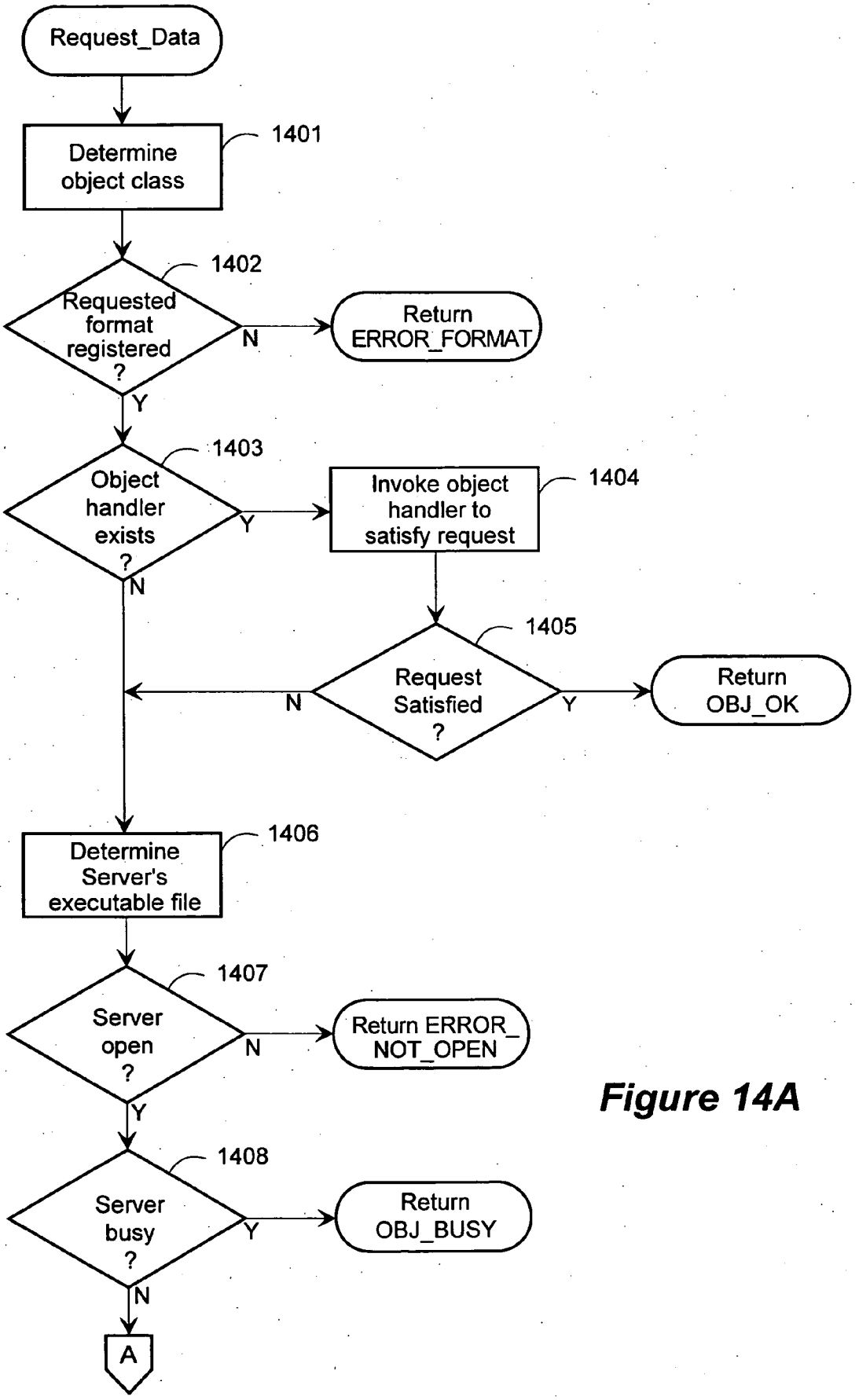

Request_Data
Determine object class
1401
Requested format registered ?
1402
N
Return ERROR_FORMAT
Y
Object handler exists ?
1403
Y
Invoke object handler to satisfy request
1404
N
Request Satisfied ?
1405
N
Y
Return OBJ_OK
Determine Server's executable file
1406
Server open ?
1407
N
Return ERROR_ NOT_OPEN
Y
Server busy ?
1408
Y
Return OBJ_BUSY
N
A

Figure 14A

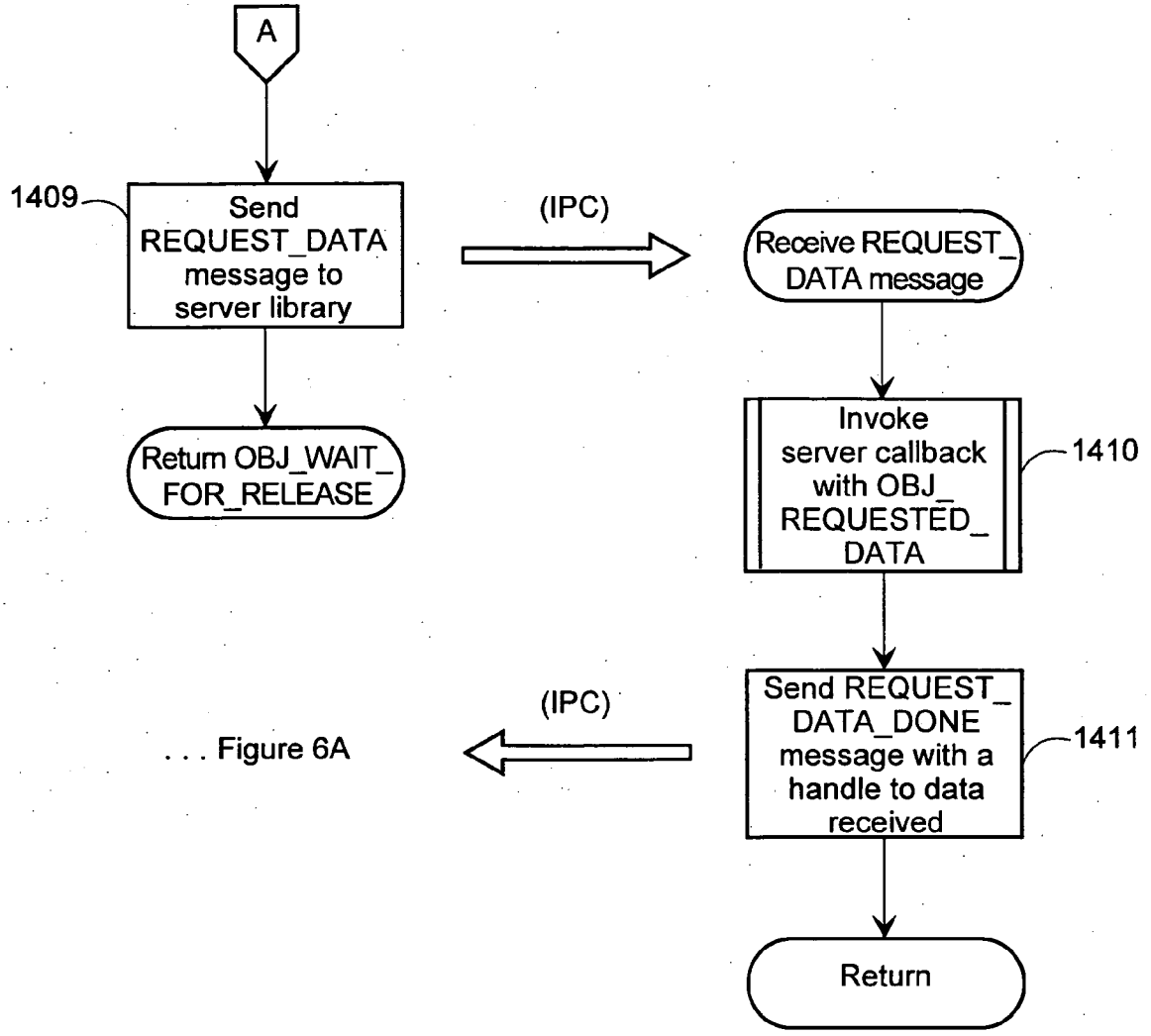

A
1409
Send REQUEST_DATA message to server library
(IPC)
Receive REQUEST_DATA message
Return OBJ_WAIT_FOR_RELEASE
Invoke server callback with OBJ_REQUESTED_DATA
1410
(IPC)
Send REQUEST_DATA_DONE message with a handle to data received
1411
. . . Figure 6A
Return
Client Process
Server Process

Figure 14B

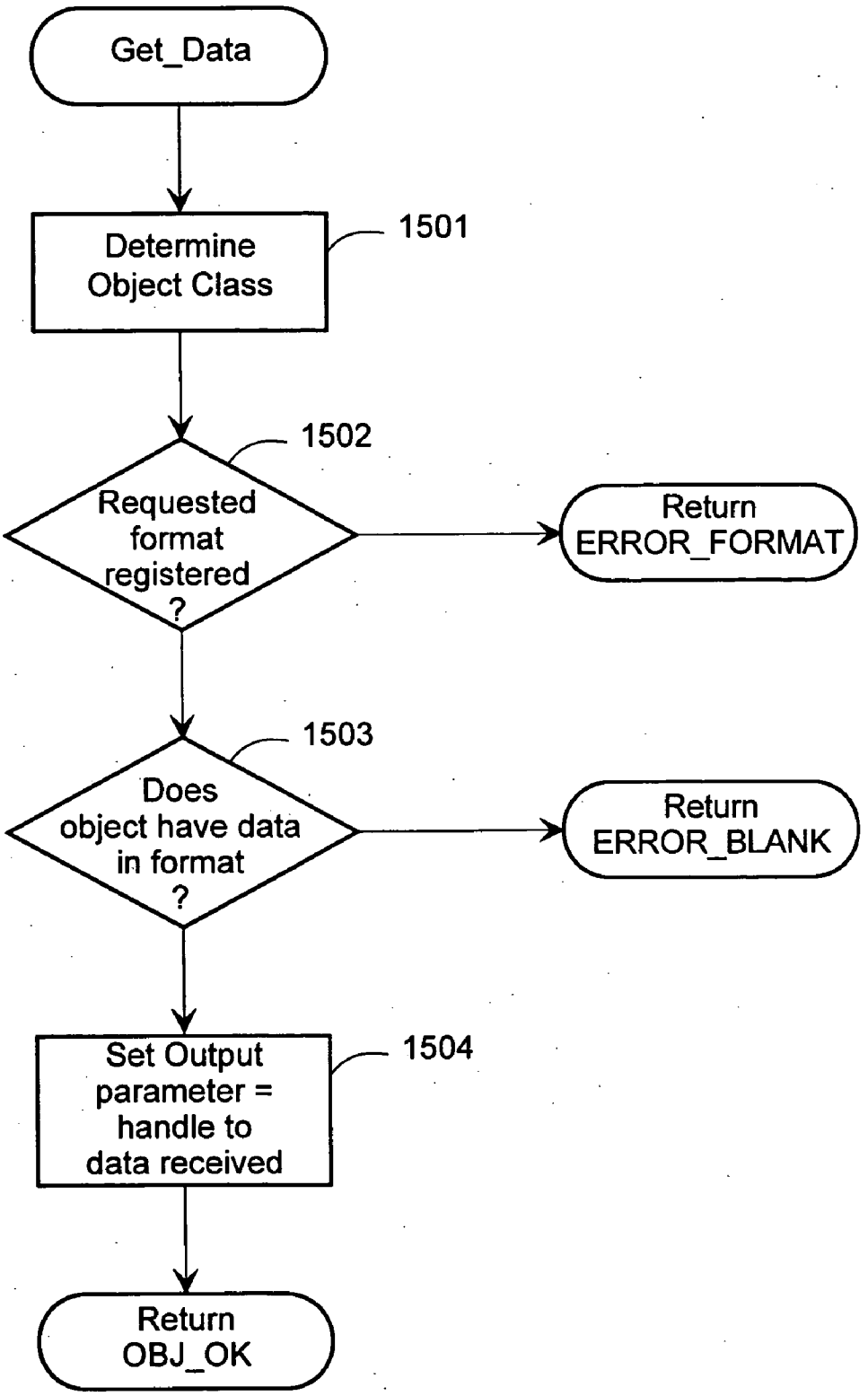

Get_Data
Determine Object Class
1501
Requested format registered ?
1502
Return ERROR_FORMAT
Does object have data in format ?
1503
Return ERROR_BLANK
Set Output parameter = handle to data received
1504
Return OBJ_OK

Figure 15

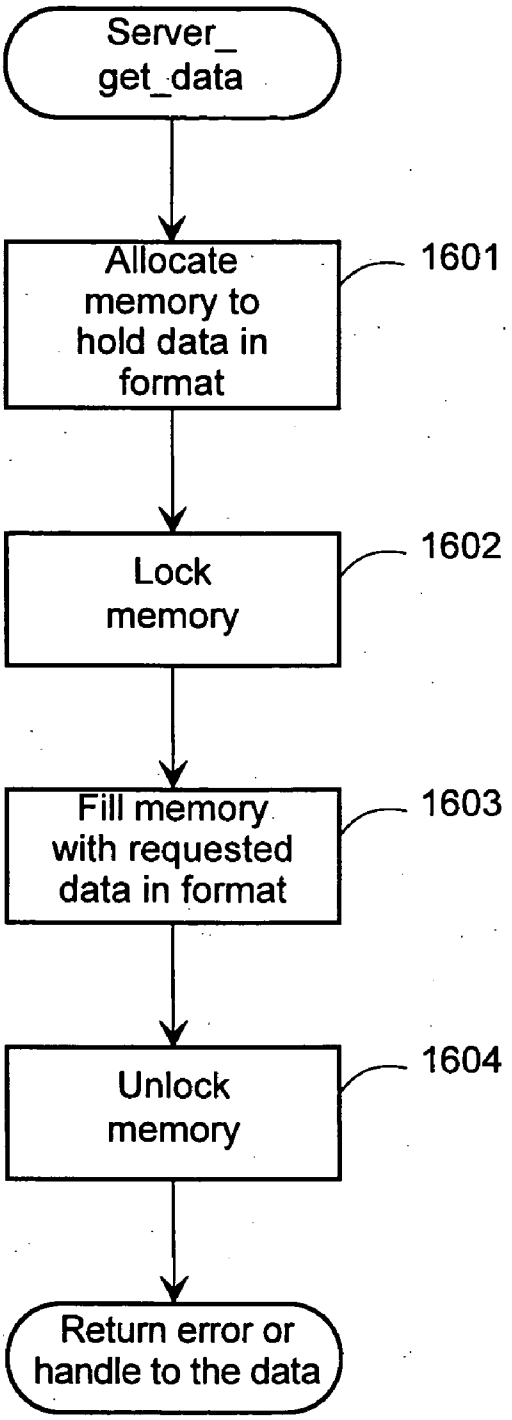

Server_
get_data
Allocate memory to hold data in format
1601
Lock memory
1602
Fill memory with requested data in format
1603
Unlock memory
1604
Return error or handle to the data

Figure 16

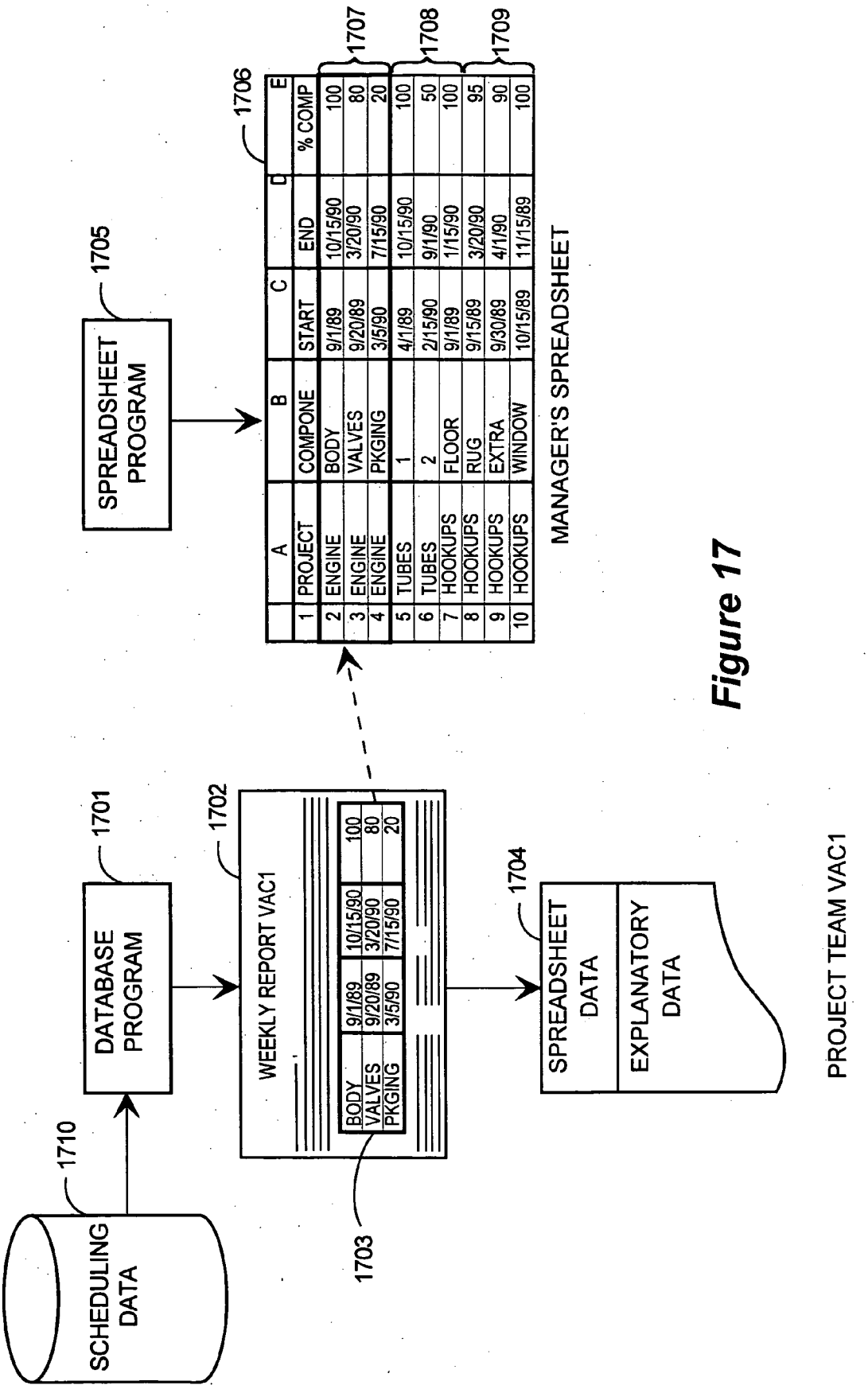

SCHEDULING DATA
1710
DATABASE PROGRAM
1701
WEEKLY REPORT VAC1
1702
BODY 9/1/89 10/15/90 100
VALVES 9/20/89 3/20/90 80
PKGING 3/5/90 7/15/90 20
1703
SPREADSHEET PROGRAM
1705
SPREADSHEET DATA
EXPLANATORY DATA
1704
PROJECT TEAM VAC1
1706
1707
1708
1709
MANAGER'S SPREADSHEET
A | B | C | D | E
1 PROJECT | COMPONE | START | END | % COMP
2 ENGINE | BODY | 9/1/89 | 10/15/90 | 100
3 ENGINE | VALVES | 9/20/89 | 3/20/90 | 80
4 ENGINE | PKGING | 3/5/90 | 7/15/90 | 20
5 TUBES | 1 | 4/1/89 | 10/15/90 | 100
6 TUBES | 2 | 2/15/90 | 9/1/90 | 50
7 HOOKUPS | FLOOR | 9/1/89 | 1/15/90 | 100
8 HOOKUPS | RUG | 9/15/89 | 3/20/90 | 95
9 HOOKUPS | EXTRA | 9/30/89 | 4/1/90 | 90
10 HOOKUPS | WINDOW | 10/15/89 | 11/15/89 | 100

Figure 17

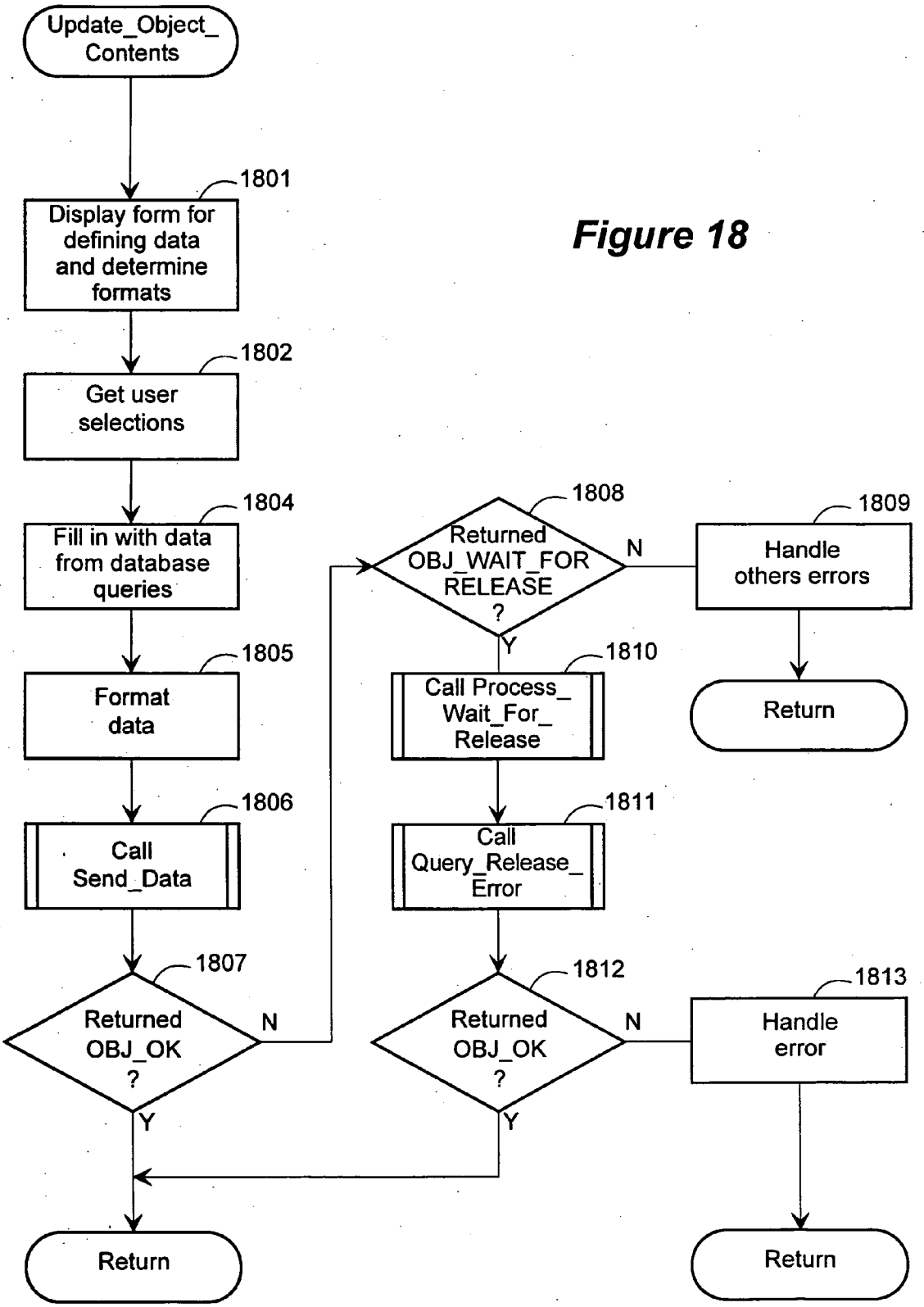

Update_Object_ Contents
1801
Display form for defining data and determine formats
1802
Get user selections
1804
Fill in with data from database queries
1805
Format data
1806
Call Send_Data
1807
Returned OBJ_OK ?
N
Y
1808
Returned OBJ_WAIT_FOR RELEASE ?
N
Y
1809
Handle others errors
Return
1810
Call Process_ Wait_For_ Release
1811
Call Query_Release_ Error
1812
Returned OBJ_OK ?
N
Y
1813
Handle error
Return
Return

Figure 18

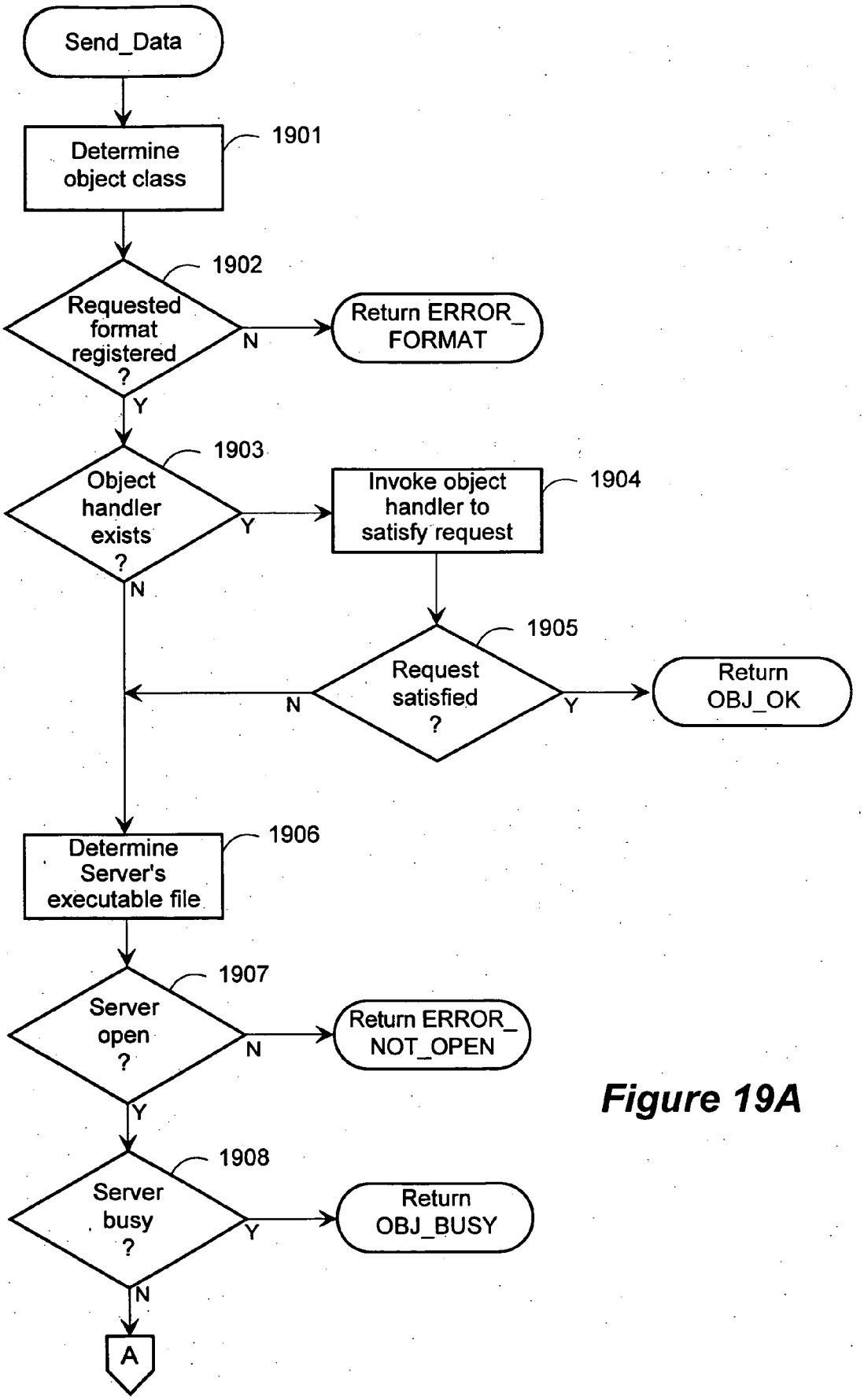

Send_Data
Determine object class
1901
Requested format registered ?
1902
N
Return ERROR_ FORMAT
Y
Object handler exists ?
1903
Y
Invoke object handler to satisfy request
1904
N
Request satisfied ?
1905
N
Y
Return OBJ_OK
Determine Server's executable file
1906
Server open ?
1907
N
Return ERROR_ NOT_OPEN
Y
Server busy ?
1908
Y
Return OBJ_BUSY
N
A

Figure 19A

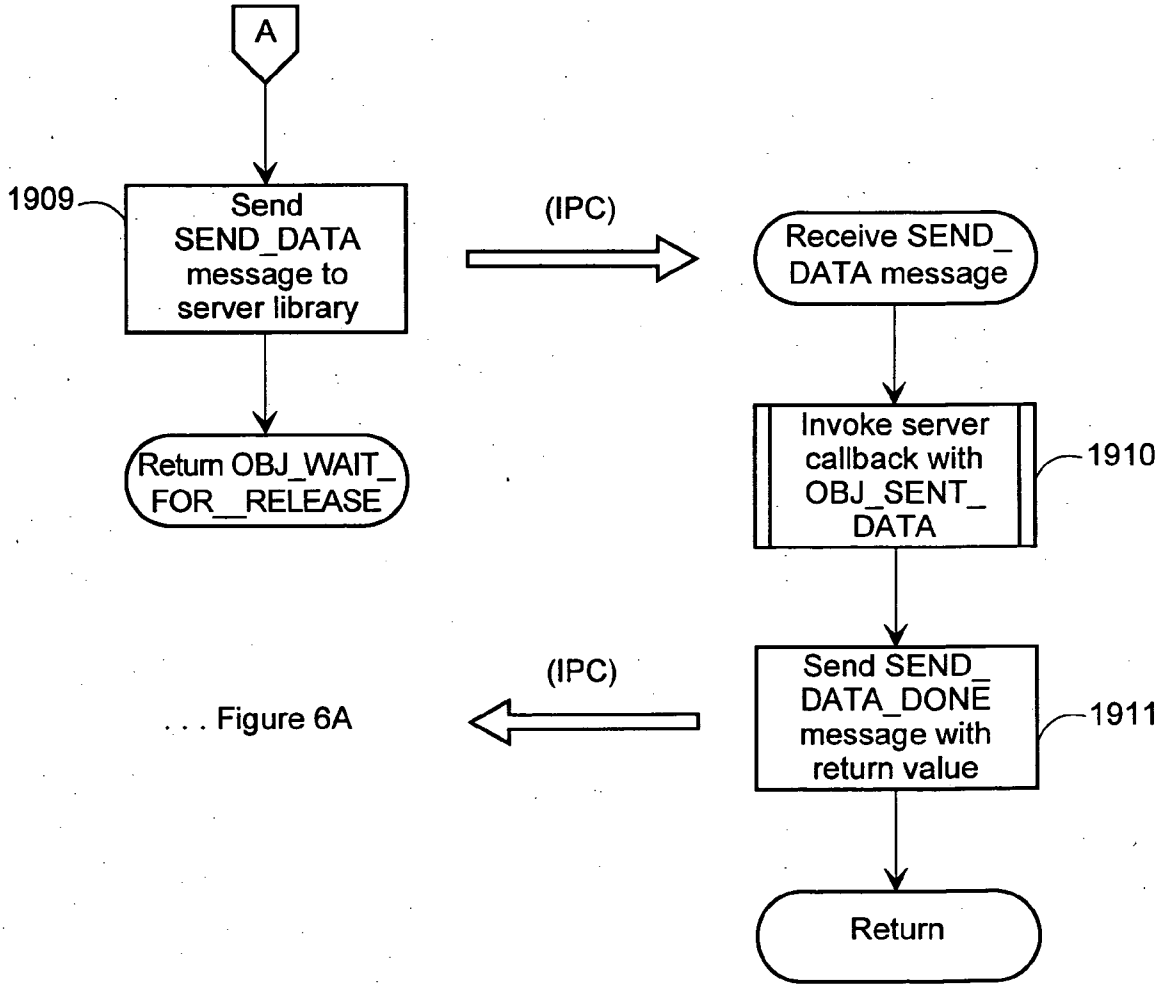

A
1909
Send SEND_DATA message to server library
Return OBJ_WAIT_FOR__RELEASE
(IPC)
Receive SEND_DATA message
Invoke server callback with OBJ_SENT_DATA
1910
Send SEND_DATA_DONE message with return value
1911
(IPC)
Return
. . . Figure 6A
Client Process
Server Process

Figure 19B

METHOD AND SYSTEM FOR REGISTERING DATA FORMATS FOR OBJECTS

TECHNICAL FIELD

[0001] This invention relates generally to a computer method and system for registering data formats for objects and, more specifically, to a method and system for storing data formats supported by a server, retrieving data formats supported by the server, and sending data to the server and requesting the server to return data in the retrieved format.

BACKGROUND OF THE INVENTION

[0002] Current document processing computer systems allow a user to prepare compound documents. A compound document is a document that contains information in various formats. For example, a compound document may contain data in text format, chart format, numerical format, etc. **FIG. 1** is an example of a compound document. In this example, the compound document **101** is generated as a report for a certain manufacturing project. The compound document **101** contains scheduling data **102**, which is presented in chart format; budgeting data **103**, which is presented in spreadsheet format; and explanatory data **104**, which is presented in text format. In typical prior systems, a user generates the scheduling data **102** using a project management computer program and the budgeting data **103** using a spreadsheet computer program. After this data has been generated, the user creates the compound document **101**, enters the explanatory data **104**, and incorporates the scheduling data **0.102** and budgeting data **103** using a word processing computer program.

[0003] **FIG. 2** shows how the scheduling data, budgeting data, and explanatory data can be incorporated into the compound document. The user generates scheduling data using the project management program **201** and then stores the data in the clipboard **203**. The user generates budgeting data using the spreadsheet program **204** and then stores the data in the clipboard **203**. The clipboard **203** is an area of storage (disk or memory) that is typically accessible by any program. The project management program **201** and the spreadsheet program **204** typically store the data into the clipboard in a presentation format. A presentation format is a format in which the data is easily displayed on an output device. For example, the presentation format may be a bitmap that can be displayed with a standard bitmap block transfer operation (BitBlt). The storing of data into a clipboard is referred to as "copying" to the clipboard.

[0004] After data has been copied to the clipboard **203**, the user starts up the word processing program **206** to create the compound document **101**. The user enters the explanatory data **104** and specifies the locations in the compound document **101** to which the scheduling data and budgeting data that are in the clipboard **203** are to be copied. The copying of data from a clipboard to a document is referred to as "pasting" from the clipboard. The word processing program **206** then copies the scheduling data **102** and the budgeting data **103** from the clipboard **203** into the compound document **101** at the specified locations. Data that is copied from the clipboard into a compound document is referred to as "embedded" data. The word processing program **206** treats the embedded data as simple bitmaps that it displays with a BitBlt operation when rendering the compound document **101** on an output device. In some prior systems, a clipboard may only be able to store data for one copy command at a time. In such a system, the scheduling data can be copied to the clipboard and then pasted into the compound document. Then, the budgeting data can be copied to the clipboard and then pasted into the compound document.

[0005] Since word processors typically process only text data, users of the word processing program can move or delete embedded data, but cannot modify embedded data, unless the data is in text format. Thus, if a user wants to modify, for example, the budgeting data **103** that is in the compound document **101**, the user must start up the spreadsheet program **204**, load in the budgeting data **103** from a file, make the modifications, copy the modifications to the clipboard **203**, start up the word processing program **206**, load in the compound document **101**, and paste the modified clipboard data into the compound document **101**.

[0006] Some prior systems store links to the data to be included in the compound document rather than actually embedding the data. When a word processing program pastes the data from a clipboard into a compound document, a, link is stored in the compound document. The link points to the data (typically residing in a file) to be included. These prior systems typically provide links to data in a format that the word processing program recognizes or treats as presentation format. For example, when the word processing program **206** is directed by a user to paste the scheduling data and budgeting data into the compound document by linking, rather than embedding, the names of files in which the scheduling data and budgeting data reside in presentation format are inserted into the document. Several compound documents can contain links to the same data to allow one copy of the data to be shared by several compound documents.

SUMMARY OF THE INVENTION

[0007] It is an object of the present invention to provide a method and system for registering data formats for a server application.

[0008] It is another object of the present invention to provide a method and system for registering data formats that the server application can both receive and send data in.

[0009] It is another object of the present invention to provide a method and system for a client application to determine which data formats a server application supports without launching the server application.

[0010] It is another object of the present invention to provide a method and system for transferring data between a server and client application.

[0011] These and other objects, which will become apparent as the invention is more fully described below, are obtained by a method and system for transferring data between a server and client application. In a preferred embodiment, the data formats that the server application supports are stored in a persistent global registry. The client application retrieves the data formats from the persistent global registry and requests the server application to supply data in the retrieved format. The server application, upon receiving the request, supplies the data in the retrieved format.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] **FIG. 1** is an example of a compound document.

[0013] **FIG. 2** is a block diagram illustrating the incorporation of the scheduling data, budgeting data, and explanatory data into the compound document.

[0014] **FIG. 3** is a block diagram illustrating the relationships between client and server applications in a preferred embodiment.

[0015] **FIG. 4** is a block diagram illistrating the relationship between an object handler and client and server processes.

[0016] **FIG. 5** is a block diagram illustrating the components that comprise the object linking and embedding facilities and the communications paths.

[0017] **FIG. 6A** is a flow diagram of a client library message dispatching routine.

[0018] **FIG. 6B** is a flow diagram of a typical client application callback routine.

[0019] **FIG. 7** is an overview flow diagram of a typical function used by a client application to handle waiting for an asynchronous request to complete.

[0020] **FIG. 8** is a schematic diagram of an object data structure.

[0021] **FIG. 9** is an overview flow diagram illustrating a typical input loop for an application in an event-driven windowing operating system environment.

[0022] **FIG. 10** is an overview flow diagram for the client library routine Query_Release_Status?

[0023] **FIG. 11** is an overview flow diagram of the procedure a client application follows to open or create a compound document.

[0024] **FIG. 12** is a flow diagram of the function Change_Object_Format implemented by a typical client application.

[0025] **FIG. 13** is a flow diagram of the client library function Enum_Formats.

[0026] **FIG. 14** is a flow diagram of the client library routine Request_Data and the corresponding server routine.

[0027] **FIG. 15** is a flow diagram of the client library function Get_Data.

[0028] **FIG. 16** is a flow diagram of the server application routine Server_Get_Data.

[0029] **FIG. 17** is a block diagram of the object linking and embedding used to generate the spreadsheet scheduling data and the weekly reports.

[0030] **FIG. 18** is a flow diagram of the function Update_Object_Contents.

[0031] **FIG. 19** is a flow diagram for the client library routine Send_Data and corresponding server routine.

DETAILED DESCRIPTION OF THE INVENTION

[0032] The present invention provides a method in which data that is contained within a compound document can be manipulated directly by the application program that creates the data. In a preferred embodiment, an application program that creates data can store data in various formats and receive data in various formats. The application program registers the formats by storing the formats in a persistent registry. Another application program can check the persistent registry to determine which formats are supported. The other application can send or receive data in a registered format. In a preferred embodiment, an application program that creates a compound document controls the manipulation of linked or embedded data that was generated by another application. In object-oriented parlance, this data is referred to as an object. (The reference Budd, T., "An Introduction to Object-Oriented Programming," Addison-Wesley Publishing Co., Inc., 1991, provides an introduction to object oriented concepts and terminology.) An object that is either linked or embedded into a compound document is "contained" within the document. Also, a compound document is referred to as a "container" object and the objects contained within a compound document are referred to as-"containee" objects. Referring to **FIGS. 1 and 2**, the scheduling data **102** and budgeting data **103** are containee objects and the compound document **101** is a container object. Continuing with the example of **FIGS. 1 and 2**, the user can indicate to the word processor that the user wants to edit a containee object, such as the budgeting data **103**. When the user indicates that the budgeting data **103** is to be edited, the word processing program determines which application should be used to edit the budgeting data (e.g., the spreadsheet program) and launches (starts up) that application. The user can then manipulate the budgeting data using the launched application, and changes are reflected in the compound document.

[0033] In a preferred embodiment of the present invention, applications cooperate using object linking and embedding facilities to create and manipulate compound documents. An application that creates a compound document is referred to as a client application, and applications that create and manipulate containee objects are referred to as server applications. Referring to **FIG. 2**, the project management program **201** and the spreadsheet program **204** are server applications, and the word processing program **206** is a client application. A client application is responsible for selection of the various objects within the container object and for invoking the proper server application to manipulate the selected containee object. A server application is responsible for manipulating the contents of the containee objects.

[0034] In a preferred embodiment, applications are provided with an implementation-independent Application Programming Interface (API) that provides the object linking and embedding functionality. The API is a set of routines (functions) that are invoked by client and server applications that support compound documents. These routines manage, among other things, the setup and initialization necessary for client applications to send and receive messages and data to and from server applications. The API routines are divided into a client library and a server library. The client library provides routines which invoke the correct server application to act upon a particular containee object. The server library provides routines which process requests to manipulate containee objects.

[0035] **FIG. 3** illustrates the relationships between client and server applications in a preferred embodiment. In this embodiment, client applications and server applications are

separate processes. The client process **301** includes client application code **303**, client library **304**, and container object **307**. The server process **302** includes server application code **308**, server library **309**, and containee object **311**. The client process **301** communicates with the server process **302** through the communications channel **306**. The client library and server library are dynamically linked with the client application code and server application code, respectively, when an application process is started up. One skilled in the art would appreciate other architectural configurations are possible. For example, the client library and server library functions could be implemented as processes separate from the client and server processes.

[**0036**] The use of the client library of the present invention allows a client application program to be developed independently of any particular containee object format. Indeed, a client application, in general, does not need to know anything about the contents of a containee object. It is also preferred that the libraries are linked to the applications dynamically when an application process is created. The dynamic linking allows applications to be marketed without library code and to be easily linked to new versions of the library.

[**0037**] The client library routines typically transfer requests to manipulate a containee object through the communications channel **306** to the server process **302**. One skilled in the art would appreciate that the communications channel **306** could be implemented through well-known interprocess communication mechanisms that are provided by various operating systems. The server process **302** responds to requests to manipulate containee objects received through communications channel **306**. The server library provides routines through which the server process receives requests to manipulate data and processes the requests accordingly.

[**0038**] An example will help illustrate the relationship between the client process **301** and the server process **302**. Referring again to **FIG. 1**, if a user wants to edit the budgeting data **103** of the compound document **101**, then the following sequence of events occurs. First, the user starts up the word processor program, which is dynamically linked to the client library. Second, the user opens the compound document for editing. Third, the user selects the budgeting data, which is a containee object, and indicates that the selected object is to be edited. Fourth, the client application invokes a client library routine for performing an action on an-object passing the routine a handle (which uniquely identifies the selected object) to the object and an indicator that the action is edit. Fifth, the client library routine determines that the spreadsheet program provides the actions for the budgeting data. Sixth, the client library starts up the spreadsheet program as a server process, if it is not already started. Seventh, the word processor application sends a message to the spreadsheet program that it should edit the budgeting data. Eighth, the server library receives the request to edit and invokes a routine in the spreadsheet program for editing the data. When editing is complete, the spreadsheet routine returns to the server library. The server library sends a message to the word processor application to indicate that editing is complete. The client library receives the message and returns from its invocation. Upon return from the invocation, the word processor application knows that the editing is complete.

[**0039**] Typically, the start up of a server process can be a relatively slow process. There are certain situations in which it may be unacceptable to incur this overhead. For example, if a user wants to print a compound document that includes many containee objects, it may take an unacceptably long time to start up the server process for each containee object and request each server process to print the object. To ameliorate this unacceptable performance, a server application can provide code that can be dynamically linked during runtime into the client process to provide certain functionality in a more expeditious manner. This code is called an "object handler." Object handlers provide actions on behalf of the server application so that the client library routines can avoid starting up server processes and passing messages to the server process. In the above example, an object handler could provide a print routine that the client library routines could invoke to print a containee object.

[**0040**] **FIG. 4** shows the relationship between an object handler and the client and server processes. The object handler **402** is linked into the client process address space during runtime by the client library routines. Typically, the client library **403** invokes the object handler **402** directly, and the client application code need not be aware that a handler is providing the services, rather than a server process.

[**0041**] **FIG. 5** shows the components that comprise the object linking and embedding facilities and communications paths when a compound document includes containee objects implemented by different server applications. The client process **500** contains the client application **501**, the client library **502**, and the object handlers "A" and "B"**512**, **513**. The server processes **509**, **510**, **511** contain the server applications **506**, **507**, **508** and server libraries **503**, **504**, **505**. The client process **500** establishes communications channels with each server process **509**, **510**, **511**. Each server process **509**, **510**, **511** implements a particular type of containee object of the container object that is opened by the client process **500**. The client application code **501** is dynamically linked to routines provided by the client library **502**. When the client process **500** is running, it communicates synchronously or asynchronously with the server processes **509**, **510**, **511** using the functionality provided by the client library routines. Similarly, each server process **509**, **510**, **511** is dynamically linked to routines provided by the server libraries. When the server processes **509**, **510**, **511** are running, they process messages sent from the client process **500**. The client library **502** sets up message passing structures and connections to each server **509**, **510**, **511**. When the client application **501** requests an action on a containee object, the client library **502** sends an appropriate message to the server process that implements the type of the contained object. Alternatively, if the server application has defined an object handler for the requested action, then the client library **502** invokes the object handler to perform the requested action. **FIG. 5** shows that two servers **506**, **507** have defined object handlers **512**, **513**. The client library routines access the persistent global registry **514** to determine information such as which server application to use for a particular containee object and whether an object handler is defined for a server application.

[**0042**] In addition to the client and server libraries, the object linking and embedding facilities of the present invention provide information to client and server applications

through a persistent global "registry." This registry is a database of information such as (1) for each type of object, the server application that implements the object type, (2) the actions that the each server application provides to client applications, (3) where the executable files for each server application are located, and (4) whether each server application has an associated object handler.

[0043] Communication between client and server processes occurs either synchronously or asynchronously. Synchronous communication occurs when one process sends a message to the other process and the sending process suspends activity until the other process completely processes the message. For example, when a client process wants to create a new containee object, the client process (through the client library routines) sends a message to the appropriate server process. The client process waits until the containee object is created before continuing execution. Asynchronous communication occurs when one process sends a message to the other process and the sending process continues execution while the receiving process responds to the message. Typically, when the receiving process has completed responding to the request, it sends a message indicating such completion to the sending process. For example, when a client process wants a containee object saved in a compound document file, the client process sends a message to the server process. The client process can continue to execute (e.g. responding to users requests) while the server process is saving the object. When the server process has completed saving the object, it send a completion message to the client process.

[0044] In a preferred embodiment, messages are passed between client and server processes using interprocess communications mechanisms provided by the underlying operating system. The client and server library routines provide an interface through which the details of the interprocess communication are shielded from the client and server applications. A client or server application requests a synchronous action by invoking a library routine. When the routine returns to the requesting application, then the action requested has been completed. Similarly, a client or server application requests an action to occur asynchronously by invoking a library routine. The library routine initiates the action and returns to the requesting application. The requesting application can then continue executing. When the requested action is complete, a message is received which the library routines process. In a preferred embodiment, the library routines use a "callback" routine to respond to the asynchronously received completion message. A callback routine is provided by the requesting application. The address of the callback routine is made available to the corresponding library so that when the library receives an asynchronous message, the library can invoke the callback routine to process the message. One skilled in the art would appreciate that there are numerous ways to accomplish this invocation depending upon the programming language employed.

[0045] **FIG. 6A** is a flow diagram of a client library message dispatching routine. When a client process receives a message from a server process, the message is dispatched by the client library to the appropriate routine for processing. This dispatching occurs by invoking the Process_Client_Lib_Message routine. This routine determines to which object the message is directed and invokes the client callback routine to process the message when required. In steps **601** through **604**, the client library receives a message, processes the message, and optionally invokes a client callback routine to process the message. In step **601**, the routine determines for which containee object the message is directed. In step **602**, the routine performs the client library provided processing. In step **603**, if client application processing is needed, then the routine continues at step **604**, else the routine returns. Client application processing is typically needed to respond to asynchronous messages. In step **604**, the routine invokes the client application callback routine indicating the type of message received. The routine then returns.

[0046] **FIG. 6B** is a flow diagram of a typical client application callback routine. This callback routine invokes the appropriate subroutine defined by the client application to process the asynchronous message. In steps **609** through **617**, the callback routine determines the type of message and invokes the appropriate code to process the message. The client callback routine is passed a handle to the object (†object) to which the message is directed and the message type. A client application callback routine typically processes the following messages:

[0047] OBJ_CHANGED

[0048] OBJ_CLOSED

[0049] OBJ_SAVED

[0050] OBJ_RELEASE

[0051] Server applications also provide callback routines that are invoked by the server library. Typically, all messages that a server receives are asynchronous. A server callback routine typically processes the following messages:

[0052] OBJ_OPEN

[0053] OBJ_CLOSE

[0054] OBJ_SAVE

[0055] OBJ_DOACTION

[0056] OBJ_RELEASE

[0057] OBJ_SHOW

[0058] OBJ_UPDATE

[0059] In addition to being passed an object handle and message type, the server callback routine receives a parameter to indicate the action that is to be performed when the message is OBJ_DOACTION. The additional parameter may also be used to point to arbitrary data. The server library can then pass more than three parameters to the callback routine.

[0060] In a preferred embodiment, only one asynchronous action can be pending at any one time for any one object. This restriction ensures that the response received from the client library and dispatched to the client application will be associated with a certain action request such that no computation is needed to decipher which action request the asynchronous message is responding to. One skilled in the art would appreciate that sending additional information during message passing would eliminate the need for this restriction.

[0061] The client application requests an asynchronous action by invoking a client library routine. The client library routine, after initiating the request, returns the message, OBJ_WAIT_FOR_RELEASE. At that point, the client application waits to receive an OBJ_RELEASE message through its callback routine before requesting another asynchronous operation upon that object. There are basically two ways a client application can wait for the asynchronous operation to complete. One way is for the client application to continue to process all messages including user input and not generate any additional asynchronous requests for that object. The other way is for the client application to ignore all user input, but continue to get and dispatch all other messages in order to allow the client library to receive and process server library messages. From a user's perspective, the latter method will cause the application to appear unresponsive until the asynchronous request completes.

[0062] **FIG. 7** is an overview flow diagram of a typical function used by a client application to handle waiting for an asynchronous request to complete. The function returns only when the client library says that it is no longer processing an asynchronous request on the object. In step **701**, the function calls the client library routine Query_Release_Status? to determine whether an asynchronous operation has completed on the object passed as a parameter. In step **702**, if Query_Release_Status? returned OBJ BUSY, then the function continues at step **705**, otherwise the function continues at step **703**. In step **703**, if Query_Release_Status? returned OBJ_OK, then the asynchronous operation has completed and the function can return. Otherwise, the function must handle an error first and then return; error handling is performed in step **704**. In step **705**, the function enters a message receive-dispatch loop which effectively blocks until there is input, and when there is, the message is retrieved and dispatched to the appropriate message handler. As described above, user messages can either be dispatched or filtered out. If all messages are read and dispatched, then user input continues to be processed. Otherwise, the function may choose to filter out user messages by reading them and dropping them instead of dispatching them. Once the message is processed, either after a dispatch returns or after filtering the message, the function continues at step **701**.

[0063] Eventually, one of the messages received in step **705** will be the notification from the server library that the server is done processing the requested asynchronous operation. This message will get dispatched as part of step **705** to the client library message dispatching routine show in **FIG. 6A** with a pointer to the object passed in as a parameter. As part of step **602** in **FIG. 6A**, the client library will clear the flag that indicated there was an asynchronous operation underway on the object. In step **604**, the client library will invoke the callback routine with the OBJ_RELEASE notification as discussed in reference to **FIG. 6B**. The client callback routine then returns to the client library message dispatch routine which then returns to the beginning of the loop in step **701** in **FIG. 7**. At this point, when the client application calls the Query_Release_Status? routine, Query_Release_Status? will return OBJ_OK because the asynchronous operation has completed and the function will return.

[0064] Note that, during step **705**, if the client application attempts to process another asynchronous request from the user (which is not filtered) on the same containee object, the client library will return OBJ_BUSY in response to the new request. The client application can choose to loop on this call until it returns OBJ_OK, or it can display an error notification to the user.

[0065] Client Library Services:

[0066] In addition to providing support for the various communication paths, the client library provides a set of linking and embedding functions which can be used by any client application to create and maintain a compound document. The following functions are supported by the client library:

[0067] Open_CompoundDoc

[0068] Save_CompoundDoc

[0069] Close_CompoundDoc

[0070] Create_Object

[0071] Update_Object

[0072] Close_Object

[0073] Delete_Object

[0074] Display_Object

[0075] Activate_Object

[0076] Query_Release_Status?

[0077] Query_Release_Error

[0078] Use of these library functions requires the client application to initialize certain data structures upon invocation which are released when the compound document is closed. For example, when a client application is started, it opens the compound document and then allocates and initializes object data structures for each embedded or linked object contained in the compound document. These object data structures are passed as parameters to the library routines. One use of these data structures is to allow the library functions to identify and invoke the appropriate callback routine when an asynchronous operation is performed. Another use of the object data structure is to store the object type so that information can be retrieved for the object from a persistent global registry. The client application should release these data structures when the compound document is closed.

[0079] **FIG. 8** shows a schematic diagram of an object data structure. It consists of several items of information **801**, **802**, and **803**, and optional information **804** that the client application may provide to hold object specific information. Item **801** is a pointer to the client application callback routine for the object. The client library uses this field in its message processing routine **(FIG. 6A)** to invoke the callback routine when notification to the client application is required. Item **802** is the object type. In object-oriented parlance, this is known as the item "class id". The CLASS_ID field **802** identifies the particular server that implements the object class. A server can store class specific information in the persistent global registry indexed by this CLASS_ID. Item **803** is a handle to the permanent storage of the object. Item **804** comprises the remainder of the object data structure and is provided by the client application when it defines a wrapper data structure that contains the required information **801** through **803**. One skilled in the art would

appreciate that the exact definition of the wrapper structure depends upon the programming language used.

[0080] The client library routines are invoked by the client application code in the usual course or processing user input. In an event-driven windowing system, the client application calls the appropriate library routine in response to receiving a message indicating that the user has selected a particular menu item or object on the screen.

[0081] **FIG. 9** is an overview flow diagram which shows a typical input loop for an application in an event-driven windowing operating system environment. It is the loop that dispatches messages to the appropriate subroutines. In step **901**, the application waits for a message. When it receives a message in step **902**, the application decodes the message to determine what type of input event has occurred in steps **903** through **906**. Typically, for each type of input event, the application calls a different subroutine, steps **907** through **910**. These subroutines in turn may call functions implemented by the object linking and embedding libraries. For example, when a Menu Event is received in step **905**, the application will invoke the subroutine that handles processing menu selections in step **909**. Step **909** will eventually call routine Activate_Object in step **910** if the object selected is an embedded or linked object and the user selects an action to perform on the object that requires communication with the server application.

[0082] In order to understand how these library functions work, it is useful to understand how the storage of compound documents differ from the storage of ordinary documents. An important distinction is that, in a compound document, data managed by different applications resides together (e.g. in the same file); whereas in an ordinary document, all of the data is managed and must be understood by the application that created the ordinary document. Specifically, in a compound document, embedded data is stored along with the native data of the compound document even though the client application cannot interpret the embedded data. Native data refers to data in a format that an application can process directly. For example, a word processor may use a text format for its native data. Embedded data is handled by the client application that maintains the compound document as a stream of bytes because it does not know how to interpret the embedded data. For example, if a compound document contains an embedded spreadsheet range, storage for the compound document will include the actual spreadsheet data in the format native to the server application used to implement the spreadsheet data.

[0083] One skilled in the art would appreciate that there are many ways for a client application to store data it does not understand and thus provide storage for embedded objects. One way is for the client application to store the location of the stream of bytes for each object in an object table so the client application knows how to locate and retrieve the embedded object data when needed. Using this method, the embedded data could be stored within the same file as the client application native data. Alternatively, although logically embedded within the compound document, the data for each embedded object could actually be stored in a separate file by the client application.

[0084] The following scenario will help illustrate use of the client library linking and embedding functionality in a typical application. When the client application (e.g. a word processing program) creates a compound document that contains text and two embedded objects, such as a graph and spreadsheet data, it first creates and initializes storage for the entire compound document. At that point, the client application has a handle to the entire document and a handle to the native application data (the text). The procedure used by the client application to open a compound document is discussed in more detail below.

[0085] In a preferred embodiment of the present invention, the user then inserts the graph and spreadsheet objects by using an "Insert Object" command on the application "Edit" menu. In response to selection of the "Insert Object" menu item, the client application presents the user with a list of the kinds of objects that can be created. The client application constructs this list from the data in the persistent global registry. Once the user selects the desired object (in this case a graph or spreadsheet object), the client application invokes the Create_Object function to create the object. The Create_Object function sends a message to the server application that implements the graph object (through the server library) to create a graph object and to allow the user to edit the object. In one embodiment, the server application returns a handle to the newly-created graph object. Similarly, when the user inserts the spreadsheet object, the client application invokes the Create_Object function to send a message to the server application that implements the spreadsheet object to create a spreadsheet object and to allow the user to edit the object. The server application returns a handle to the spreadsheet object.

[0086] Once these embedded objects have been created, the user can edit or otherwise manipulate the objects by selecting an object and selecting an action available on the client application menu. To execute the action, the client application invokes the client library function Activate_Object. Activate_Object invokes the server application that implements the selected object and sends the server application a message indicating the selected action and a handle to the selected object. The server application can then read and write the data of the embedded object in its normal fashion. In addition, the user can "open" an embedded object by either double clicking on the object or by selecting the object and then choosing the application menu item "Open." This "Open" action will result in the client application invoking Activate Object on the selected object with a default action, determined from the global registry, which is typically "edit." If the user then selects a different object inside the compound document, or selects any of the native text data, the client application closes the previously selected object by invoking the Close_Object client library routine. This routine sends a message to the associated server to shut itself down.

[0087] The above scenario was described assuming that the user wanted to work with embedded objects. The same steps would be used to create and manipulate the graph and spreadsheet objects if they were instead linked objects. However, the user would specify that the client application should create a linked object when the user selects the "Insert Object" command.

[0088] In addition to the client library routines already discussed, there are several other functions used by the client application to communicate with the server. These functions are Update_Object, Display_Object, Query_Release_Sta-

tus?, and Query_Release_Error. Update_Object is used by the client application to request an updated presentation format from the server. The presentation format is what is actually displayed in the window of the client application. The presentation may become out of date, for example, if a linked object has not been updated with respect to its source data.

[0089] Display_Object is used by the client application to request an object to be redisplayed. The client library passes the request to the server application or the object handler. A bounding rectangle (a display context) is passed to the server or object handler indicating the area of redisplay.

[0090] Query_Release_Status? and Query Release Error are used by the client application to obtain information about a previously completed asynchronous server operation. The Query_Release_Status? function is used to determine whether an outstanding asynchronous call has been completed on the specified object. That is, once a client application has been returned an OBJ_WAIT_FOR_RELEASE value as a result of a function call to the client library, the client application then waits until it receives a OBJ_RELEASE message through its callback routine before the client application initiates additional asynchronous actions upon the same object. This waiting is accomplished by looping on a call to Query_Release_Status? until it returns OBJ_OK (see **FIG. 7**]. Once the client application has received the OBJ_RELEASE message, it can invoke the client library routine Query_Release_Error to determine the value returned by the most recent asynchronous server operation on the specified object.

[0091] **FIG. 10** shows an overview flow diagram for the client library routine Query_Release_Status? This routine takes one parameter, a pointer to an object (an OBJ_STRUCT as shown in **FIG. 8**) and returns OBJ BUSY if the server for the object is unavailable or OBJ_OK if the server can process an asynchronous operation. In step **1001**, the function first ensures that the parameter is a valid pointer to an object and returns OBJ_ERROR in step **1002** if it is not. In step **1003**, if an asynchronous operation is in progress on the object, the function returns OBJ_BUSY in step **1004**. This occurs when a RELEASE message for the object has not yet been sent to the client. The client library is responsible for keeping track of any asynchronous operations it invokes on behalf of an object. In step **1005**, the client library also checks to ensure the server is not busy for other reasons, for example, the server has requested the server library to postpone all linking and embedding activities. Once a RELEASE message has been sent to the client application, Query_Release_Status? returns OBJ_OK in step **1006**.

[0092] Opening a Compound Document

[0093] **FIG. 11** shows an overview flow diagram of the typical procedure a client application follows to open or create a compound document. In step **110.1**, the client application calls the client library function Open_CompoundDcc to open (or create) a file for the specified compound document. In step **1102**, if the Open_CompoundDoc returns an error, then the client application reports this to the user in step **1103** and returns to the message-dispatch loop. In step **1104**, the application reads in its linked and embedded object tables. In step **1105**, the client application allocates and initializes object data structures for each embedded linked object. In step **1106**, if there are any automatic links contained in the compound document, then the function continues at step **1107**, else it continues at step **1108**. In step **1107**, the client application calls function Update_Object for each automatic link found. Next, in step **1108**, it reads in the native data and displays the data in step **1109** using its standard application specific mechanism. In the process of displaying its data, if the client application encounters an embedded object, it calls function Display_Object, which invokes the appropriate server to display the object. In step **1110**, the client application checks to see if there are any manual links. If so, the client application continues at step **1111**, otherwise the application returns to the message-dispatch loop. In step **1111**, the application lists the manual links and allows the user to selectively update them. A manual link is one that requires the user to explicitly tell the client application to perform the update. After the desired manual links are updated, the client application returns to the message-dispatch loop.

[0094] Registering Data Formats

[0095] The present invention allows a client and server application to exchange data in particular formats. The formats can be defined dynamically and displayed to the user of a client application without intervention by a server application. In a preferred embodiment, the client application obtains the formats available for a particular object class from a server application supplied list of the formats stored in the persistent global registry. The server application (or an object handler) can update the list of formats (register the formats) at any time. The client application uses the registering data format capabilities to perform operations like changing the display representation of an arbitrary object on user demand and to incorporate an independently implemented server application as an engine for processing the client native data.

[0096] As discussed above, the persistent global registry is a database of information to support the object linking and embedding functions. The persistent global registry is preferably stored on a long-term storage device, such as a disk. Data formats are stored in the persistent global registry indexed by CLASS_ID. A server application that implements an object is responsible for storing the data formats that it supports in the persistent global registry. The server applications store the data formats that it supplies data in and the data formats that it can receive data.

[0097] Two examples will serve to illustrate these capabilities of the present invention. In the example of **FIG. 1**, a user is generating a report for a certain manufacturing project. Suppose the user wishes to change the representation of the scheduling data **102**, which was produced using the project management program **201 (FIG. 2)** from a Gantt chart to a Pert chart. (A Gantt chart displays scheduling data as a sideways barchart with a bar for each task, and a Pert chart displays such data using circles to show tasks and connects them to show dependencies and critical paths.) The client application, the word processor program **206 (FIG. 2)**, can provide this capability to the user through a "Change Formats" command on the client application "View"-menu. When the user selects "Change Formats" for the selected object, the client application determines from the persistent global registry what formats the server application for the selected object supports, displays a list of these formats to

the user for selection, and then, once the user has selected a format, requests the data from the server application in the selected format and displays the new representation.

[0098] **FIG. 12** shows a flow diagram of the function Change_Object_Format implemented by a typical client application. This function is called by the client application when the client determines that the user has selected "Change Formats" from its "View" menu. The function determines what formats the selected object supports, gets the data from the server application in the format the user selects, and displays the data. In steps **1201** through **1204**, the function calls the client library routine Enum_Formats in a loop until the client application obtains a list of all the available formats for the selected object. The client library function Enum_Formats is described in detail below. In step **1201**, the function calls Enum_Formats with 0 as an input parameter. Function Enum_Formats returns the first available format. In step **1202**, if the format returned was NULL, then all formats have been obtained and the function continues at step **1205**, otherwise it continues at step **1203**. In step **1203**, the function stores the returned format in a list. In step **1204**, the function calls Enum_Formats with the format that was returned from the previous call to Enum_Formats. The function then loops to step **1202** to test the result returned from Enum_Formats. Once all of the formats have been retrieved and added to the list, the test in step **1202** will cause the function to continue at step **1205**. In step **1205**, the function tests to see if there is anything on the list or if there is only one format available and it is the same as what is currently being displayed. If either case is true, the function informs the user in step **1206** that no other formats are available and returns. Otherwise, the function continues in step **1207**.

[0099] In step **1207**, the function displays the list of formats to the user and obtains a format selection from the user. In step **1208**, the function calls the client library function Request_Data to tell the server application to deliver the data in the desired format to the client library if the server application is available to do so. The function Request_Data is described below in detail. In step **1209**, if function Request_Data returns OBJ_OK, then the function continues at step **1216**, otherwise the function continues at step **1210**. In step **1210**, if function Request_Data returns OBJ_WAIT_FOR_RELEASE, then the function continues in step **1212**, else the function handles the error in step **1211** and returns. In step **1212**, the function calls the client application routine Process_Wait_For_Release, shown in **FIG. 7**, in a mode that blocks all user input. Step **1212** completes when the client library has received an answer from the server application and has notified the client application. In step **1213**, the function calls the client library function Query_Release_Error to determine the result from the Request_Data call. The function Query_Release_Error allows a client application to determine whether the asynchronous operation completed successfully. In step **1214**, if this result is a handle to data, then the function can continue in step **1216** to get the data. Otherwise, the function handles the error in step **1215** and returns. In step **1216**, the function calls the client library function Get_Data, described in detail **20** below, to retrieve the data in the format selected by the user. Finally, in step **1217**, the function calls a routine to display the retrieved data and returns.

[0100] **FIG. 13** is a flow diagram of the client library function Enum_Formats. In a preferred embodiment, Enum_Formats retrieves from the persistent global registry the next format from the list of formats available for the class of the selected object. This function takes an input parameter which is the format retrieved from a previous call to Enum_Formats and a pointer to the selected object data structure. If the format retrieved from the previous call indicates a 0, then this function returns the first format in the list. In step **1301**, the function determines the object CLASS_ID from the selected object data structure. In step **1302**, if the format input parameter is 0, then the function continues at step **1303**, else it continues at step **1304**. In step **1303**, the function looks up the format list corresponding to the object CLASS_ID and returns the first format in the list, or NULL if the format list is empty. In step **1304**, the function looks up the format list corresponding to the object CLASS_ID, finds the format that matches the format input parameter, and returns the next format in the list, or NULL if there are no more formats in the list. In step **1305**, the function checks to see if a format was retrieved and if one was, then it is returned, otherwise the function returns NULL.

[0101] **FIG. 14** is a flow diagram of the client library routine Request_Data and the corresponding server application processing required. The Request_Data function retrieves object data in a specified format from a server application. If the server application is busy, the function Request_Data returns with a WAIT_FOR_RELEASE message and the client application should not call the function Get_Data until the callback notification has been received. A client application calls Request_Data before calling Get_Data. Function Get_Data retrieves the data in the requested format from the object. Request_Data takes two input parameters: a pointer to the selected object data structure and the requested format. In step **1401**, the function determines the object CLASS ID from the selected object data structure. In step **1402**, if the requested format is registered in the persistent global registry for the object class, then the function continues at step **1403**, otherwise the function returns ERROR_FORMAT. In step **1403**, the function checks the registry to determine whether there is an object handler defined for the object class. If there is none, the function continues at step **1406**, otherwise it continues at step **1404**. In step **1404**, the function invokes the object handler to satisfy the data request. In step **1405**, if the handler can satisfy the request (it returned OBJ_OK), then the function returns OBJ_OK. A handler is likely to be able to satisfy a Request_Data call in situations where the requested data format is a presentation format. If the handler cannot satisfy the request, the program continues at step **1406**. In step **1406**, the function determines which server application implements the selected object by checking the persistent global registry. In step **1407**, the function determines whether the server application is connected or launched (open). If the server application is not open, then the function returns ERROR_NOT_OPEN, otherwise it continues at step **1408**. In step **1408**, the function checks to see if the server application is busy, and if it is, it returns OBJ_BUSY, otherwise it continues at step **1409**. In step **1409**, the function sends a REQUEST_DATA message to the server asynchronously, passing it the requested format, and a handle to the object. Finally, the function returns

OBJ_WAIT_FOR_RELEASE to the client application so that the client knows it must wait for an asynchronous response.

[0102] On the server side, when the server library receives the REQUEST_DATA message, it invokes the callback routine of the server application in step **1410** passing it a OBJ_REQUESTED_DATA notification and the handle to the object. The server application processes the request, and the callback routine returns a handle to the data in the requested format to the server library. If an error occurs, the callback routine returns an error value instead. In step **1411**, the server library sends the message REQUEST_DATA-_DONE to the client library passing the handle to the data or the error value returned by the server application.

[0103] Then, when the client library asynchronously receives the REQUEST_DATA_DONE message in its message handling routine (see **FIG. 6A**), in step **604**, the library invokes the callback routine of the client application passing it a OBJ_RELEASED notification. At this point, step **1212** (see **FIG. 12**) of the client application function Change_Object_Format will complete and user input to the client will no longer be blocked. As described in **FIG. 12**, if the value returned by the server is a handle to data, then the client application will be free to retrieve the data using function Get_Data. One skilled in the art would appreciate that different mechanisms can be used to actually pass the data. Typical examples are that the data can be passed in shared memory or that each process is provided support from the underlying operating system to copy the data into its own address space by passing the operating system a handle to the data.

[0104] **FIG. 15** is a flow diagram of the client library function Get_Data. The function Get Data checks the object to determine if it has data in the requested format and returns the data to the client application. Three parameters are passed to the function Get_Data: a pointer to the object data structure, the requested format, and an output parameter which is a handle to the data. In step **1501**, the function determines the object CLASS_ID from the object data structure. In step **1502**, if the input format is registered in the persistent global registry for the class of the object, then the function continues at step **1503**, otherwise the function returns ERROR_FORMAT. In step **1503**, the function checks to see if client library has received data from the server application in the requested format. The object data structure maintains a list of available formats for the data. This list is updated when a Request_Data call results in a new format being received. If the test in step **1503** fails, the function returns ERROR_BLANK to the client application. In step **1504**, the function sets the output parameter to the handle of the data in the requested format and returns OBJ OK.

[0105] **FIG. 16** is a flow diagram of the server application routine Server_Get_Data. This function is invoked from the server application callback routine when it receives the OBJ_REQUESTED_DATA notification from the server library (see step **1410** in **FIG. 14**). The function Server-_Get_Data allocates memory and fills it with the object data in the requested format and returns a handle to the data or an error value. The function requires two parameters: a handle to the object and the requested format. In step **1601**, the function allocates enough memory to hold the data in the requested format. In step **1602**, it locks the memory in order to provide an atomic operation. In step **1603**, the function fills the memory with data from the object in the requested format. In step **1604**, it unlocks the memory. Finally, it returns either the handle to the data or an error value.

[0106] A second example will help illustrate how a client application incorporates registering data format capabilities to use a server application as an engine for filtering its data. Suppose that the user generating the manufacturing project report in **FIG. 1** is actually working on a project which is a subpart of a much larger manufacturing project that involves multiple project teams. Suppose further that the user's manager maintains a spreadsheet of the scheduling data of the entire manufacturing project, and each project team is responsible for entering the scheduling data for its subpart into the manager's spreadsheet. Each project team is also responsible for producing a weekly status report to the manager.

[0107] **FIG. 17** shows how object linking and embedding is used to generate the spreadsheet scheduling data and the weekly reports. Each project team uses the database program **1701** to enter scheduling data, which is stored in a database **1710**, to update the manager's spreadsheet **1706**, and to produce weekly reports **1703** using a report form **1702**.

[0108] In this example, the database program allows the user to generate reports from the data in the layout specified by a report form **1702** that the user has previously created. The report form **1762** contains display fields that are database queries which are filled in by the database program when the report is actually generated. The report form **1702** is a compound document and can contain arbitrary embedded or linked objects created by other applications. On the report form **1702**, the user has placed a linked object **1703**, which is the scheduling data for the user's project team. The data for the linked object is stored in the manager's spreadsheet **1706**.

[0109] In this example, database program **1701** provides the ability to insert an arbitrary object (here a linked spreadsheet object) and to set or update its contents with native data through two commands, "Insert Object," and "Update Object Contents," found on the "Edit" menu of the database program. When the user selects the "Insert Object" command, the database program **1701** presents the user with a list of the classes of objects defined in the persistent global registry. Once the user has selected the type of object to create and specifies whether the object should be linked or embedded, the database program **1701** creates a default object of that CLASS_ID using the standard client library routine, Create_Object. In our example, a linked default spreadsheet object is created.

[0110] To initially set the data, or at any later time when the user wishes to update the data, the user selects the command "Update Object Contents". When "Update Object Contents" is invoked on a selected object, the database program presents a form for the user to fill in with database queries specifying the data to be placed in the selected object. Once the user has completed this form, the database program **1701** causes the data of the object to be changed by invoking the client library routine Send_Data. The range in the manager's spreadsheet **1706** is updated to reflect the scheduling data that was specified in the "Update Object Contents" form.

[0111] The spreadsheet program **1705** is used by the user's manager to view the scheduling data for the entire manufacturing project in the manager's spreadsheet **1706**. This spreadsheet contains the ranges of data that were actually created by the component project teams as described above. Whenever each project team chooses to update the manager's spreadsheet using Update Object Contents, the manager will have an updated synopsis of project progress.

[0112] **FIG. 18** shows the flow diagram for function Update_Object_Contents. This function allows the user to specify which data is to be sent to the object. In a preferred embodiment, this function is passed an object that is to have its data set. The function determines the object class and retrieves from the persistent registry which data formats the object supports for setting data. The function determines if it can support any of these data formats (e.g., standard spreadsheet format). If it can, then the function allows the user to specify which data from the database is to be sent to the object. In step **1801**, the function displays a standard input selection form for a format that the object server supports (e.g., a spreadsheet). In step **1802**, the function inputs the user input selections. In step **1804**, the function retrieves the data from the database as indicated by the user selections. In step **1805**, the function puts the data in a format that is compatible with the object server. In step **1806**, the function invokes the function Send_Data to send the formatted data to the object. In step **1807**, if function Send_Data returns an OBJ_OK message, the function returns, else the function continues as step **1808**. In step **1808** through **1813**, the function waits for the asynchronous invocation of function Send_Data to complete and the function returns. This is the same process as is described in steps **1110** through **1115** of **FIG. 11**.

[0113] **FIG. 19** shows the flow diagram for the client library routine Send_Data and the corresponding server processing required. The Send_Data function checks to ensure the server for the selected object can set the object data in'the requested format and sends the data to the server if it can. The function Send_Data has three input parameters: a pointer to the selected object data structure, a handle to the data, and the requested format. In step **1901**, the function determines the object CLASS_ID from the selected data structure. In step **1902**, if the input format is registered in the persistent global registry for the object class, then the function continues at step **1903**, otherwise the function returns ERROR_FORMAT. In step **1903**, the function checks in the registry to see if there is an object handler defined for the object. If there is none, the function continues at step **1906**, otherwise it continues at step **1904**. In step **1904**, the function invokes the object handler to satisfy the send request. In step **1905**, if the handler can satisfy the request (it returned OBJ_OK) then the function returns OBJ_OK. If the handler cannot satisfy the request, the program continues at step **1906**. In step **1906**, the function determines the location of the server for the object class. In step **1907**, the function determines whether the server is connected (open). If the server is not open, the function returns ERROR_NOT_OPEN, otherwise, it continues at step **1908**. In step **1908**, the function checks to see if the server is busy and, if it is, it returns OBJ_BUSY, otherwise it continues at step **1909**. In step **1909**, the function sends a SEND_DATA message to the server asynchronously, passing it a handle to the data, the requested format, and a pointer to the object. Finally, the function returns OBJ_WAIT_FOR_RELEASE to the client application so that the client knows it must wait for an asynchronous response.

[0114] On the server side, when the server library receives the SEND_DATA message, it invokes the callback routine of the server application in step **1910** passing it a OBJ_SENT_DATA notification, a handle to the data, the requested format, and the handle to the object. If the server application successfully processes the request, the callback routine will return an OBJ_OK value to the server library, otherwise the callback will return an error value. In step **1911**, the server library sends the message SEND_DATA_DONE to the client library with the value returned by the server application.

[0115] Then, when the client library asynchronously receives the SEND_DATA_DONE message in its message handling routine (see **FIG. 6A**), in step **604**, the library invokes the callback routine of the client application passing it an OBJ_RELEASE notification. At this point, step **1810** (see **FIG. 18**) of the client application function Update_Object_Contents will complete.

[0116] Although the present invention has been described in terms of a preferred embodiment, it is not intended that the invention be limited- to his embodiment. Modifications within the spirit of the invention will be apparent to those skilled in the art. The scope of the present invention is defined by the claims which follow.

1-26. (canceled)

27. A computer-based method for providing a client with data format information relating to data formats supported by a server, the method comprising:

under control of server code, providing the data format information;

storing the provided data format information in a persistent registry; and

under control of the client,

retrieving from the persistent registry the stored data format information; and

determining from the retrieved data format information data formats supported by the server.

28. The method of claim 27 wherein the server code is code executed during installation of the server.

29. The method of claim 27 wherein the server code is code executed when the server is launched.

30. The method of claim 27 including when the server supports a data format that is compatible with the client, launching the server.

31. The method of claim 30 wherein the client is executing in a process and the server is launched in a separate process.

32. The method of claim 30 wherein the client is executing in a process and the server is launched in the same process.

33. The method of claim 30 wherein the client and the server exchange data using a compatible format.

34. The method of claim 27 wherein the client determines the data formats while the server is not executing.

35. A computer-based method for determining the data formats that are supported by a server, the method comprising:

retrieving from a persistent registry data format information, the data format information being provided by server code for storage in the persistent registry; and

determining from the retrieved data format information data formats supported by the server.

36. The method of claim 35 including when the server supports a data format that is compatible with the client, launching the server.

37. The method of claim 36 wherein the client is executing in a process and the server is launched in a separate process.

38. The method of claim 36 wherein the client is executing in a process and the server is launched in the same process.

39. The method of claim 36 wherein the client and the server exchange data using a compatible format.

40. The method of claim 35 wherein the client determines the data formats while the server is not executing.

41. A computer-based method for supplying data format information for data formats supported by a server, the method comprising:

under control of server code,

retrieving the data format information; and

storing the data format information in a persistent registry so that a client can retrieve the data format information from the registry and determine the data formats that are supported by the server.

42. The method of claim 41 wherein the client determines the data formats while the server is not executing.

43. The method of claim 41 wherein the server code is code executed during installation of the server.

44. The method of claim 41 wherein the server code is code executed when the server is launched.

45. The method of claim 41 including when the server supports a data format that is compatible with the client launching the server.

46. The method of claim 45 wherein the client is executing in a process and the server is launched in a separate process.

47. The method of claim 45 wherein the client is executing in a process and the server is launched in the same process.

48. The method of claim 45 wherein the client and the server exchange data using a compatible format.

49. One or more computer-readable media containing computer-executable instructions for performing a method to provide a client with data format information relating to data formats supported by a server, the method comprising:

under control of server code, providing the data format information;

storing the provided data format information in a persistent registry; and

under control of the client,

retrieving from the persistent registry the stored data format information; and

determining from the retrieved data format information data formats supported by the server.

50. The computer-readable media of claim 49 wherein the server code is code executed during installation of the server.

51. The computer-readable media of claim 49 wherein the server code is code executed when the server is launched.

52. The computer-readable media of claim 49 including when the server supports a data format that is compatible with the client, launching the server.

53. The computer-readable media of claim 52 wherein the client is executing in a process and the server is launched in a separate process.

54. The computer-readable media of claim 52 wherein the client is executing in a process and the server is launched in the same process.

55. The computer-readable media of claim 52 wherein the client and the server exchange data using a compatible format.

56. The computer-readable media of claim 49 wherein the client determines the data formats while the server is not executing.

57. A computer-readable media containing computer-executable instructions for performing a method to determine data formats that are supported by a server, the method comprising:

retrieving from a persistent registry data format information, the data format information being provided by server code for storage in the persistent registry; and

determining from the retrieved data format information data formats supported by the server.

58. The computer-readable media of claim 57 including when the server supports a data format that is compatible with the client, launching the server.

59. The computer-readable media of claim 58 wherein the client is executing in a process and the server is launched in a separate process.

60. The computer-readable media of claim 58 wherein the client is executing in a process and the server is launched in the same process.

61. The computer-readable media of claim 58 wherein the client and the server exchange data using a compatible format.

62. The computer-readable media of claim 57 wherein the client determines the data formats while the server is not executing.

63. A computer-readable media containing computer-executable instructions for performing a method to supply data format information for data formats supported by a server, the method comprising:

under control of server code,

retrieving the data information; and

storing the data format information in a persistent registry so that a client can retrieve the data format information from the registry and determine the data formats that are supported by the server.

64. The computer-readable media of claim 63 wherein the client determines the data formats while the server is not executing.

65. The computer-readable media of claim 63 wherein the server code is code executed during installation of the server.

66. The computer-readable media of claim 63 wherein the server code is code executed when the server is launched.

67. The computer-readable media of claim 63 including when the server supports a data format that is compatible with the client launching the server.

68. The computer-readable media of claim 67 wherein the client is executing in a process and the server is launched in a separate process.

69. The computer-readable media of claim 67 wherein the client is executing in a process and the server is launched in the same process.

70. The computer-readable media of claim 67 wherein the client and the server exchange data using a compatible format.

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