US00RE41706E

(19) **United States**

(12) **Reissued Patent**

Glass et al.

(10) **Patent Number: US RE41,706 E**

(45) **Date of Reissued Patent: Sep. 14, 2010**

(54) **MOVING OBJECTS IN A DISTRIBUTED COMPUTING ENVIRONMENT**

(76) Inventors: **Graham W. Glass**, 2293 Washington St., Apt. 3, San Francisco, CA (US) 94445; **Chris K. Wensel**, 346 Coronado Ave., Half Moon Bay, CA (US) 94019

(21) Appl. No.: **11/331,418**

(22) Filed: **Jan. 13, 2006**

Related U.S. Patent Documents

Reissue of:

(64) Patent No.: **6,678,743**
Issued: **Jan. 13, 2004**
Appl. No.: **09/451,495**
Filed: **Nov. 30, 1999**

(51) **Int. Cl.**
G06F 9/44 (2006.01)
G06F 9/54 (2006.01)

(52) **U.S. Cl.** **719/317**; 719/316; 719/315; 709/201; 709/202

(58) **Field of Classification Search** 719/316, 719/317, 328, 330; 709/201
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,325,524	A	6/1994	Black et al.
5,341,478	A	8/1994	Travis, Jr. et al.
5,396,630	A	3/1995	Banda et al.
5,432,924	A	7/1995	D'Souza et al.
5,481,721	A	1/1996	Serlet et al.
5,511,197	A	4/1996	Hill et al.
5,577,251	A	11/1996	Hamilton et al.
5,603,031	A	2/1997	White et al.
5,619,710	A	4/1997	Travis et al.
5,634,010	A	5/1997	Ciscon et al.
5,655,101	A	8/1997	O'Farrell et al.
5,724,503	A	3/1998	Kleinman et al.
5,737,607	A	4/1998	Hamilton et al.
5,745,703	A	4/1998	Cejtin et al.
5,778,227	A	7/1998	Jordan
5,781,633	A	7/1998	Tribble et al.
5,787,175	A	7/1998	Carter
5,793,965	A	8/1998	Vanderbilt et al.
5,812,781	A	9/1998	Fahlman et al.
5,812,793	A	9/1998	Shakib et al.
5,822,585	A	10/1998	Noble et al.
5,848,419	A	12/1998	Hapner et al.
5,862,325	A	1/1999	Reed et al.
5,867,665	A	2/1999	Butman et al.
5,881,230	A	3/1999	Christensen et al.
5,897,634	A	4/1999	Attaluri et al.
5,903,725	A	5/1999	Colyer
5,928,335	A	7/1999	Morita
5,956,737	A	9/1999	King et al.
5,983,233	A	11/1999	Potonniee
5,987,506	A	11/1999	Carter et al.
5,999,988	A	12/1999	Pelegri-Llopart et al.

(Continued)

FOREIGN PATENT DOCUMENTS

EP	0727739 A1	8/1996
GB	2326255	12/1998

OTHER PUBLICATIONS

Glen McCluskey, "Using Java Reflection," Jan. 1998, 6 pages.*

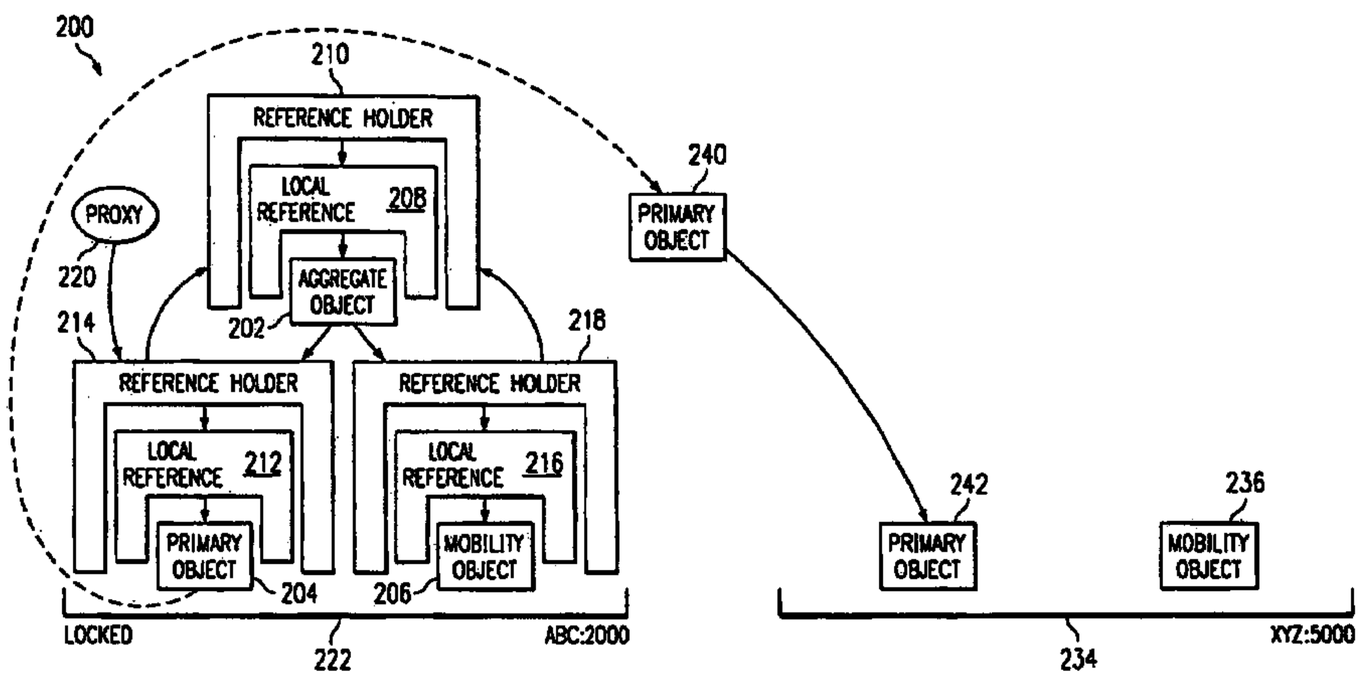
(Continued)

Primary Examiner—Li B Zhen

(57) **ABSTRACT**

A method for moving objects in a distributed computing system is provided that comprises receiving a move indication (**224**) at a mobility facet object (**206**) that is aggregated with a primary facet object (**204**) through an aggregate object (**202**) located at a current host address and port number (**222**). A new aggregate object (**246**) with the new version (**242**) of the primary facet object (**204**) as a new primary facet object (**248**) and the new version (**236**) of the mobility facet object (**206**) as a new mobility facet object (**250**) are created at a new host address and port number (**234**).

100 Claims, 14 Drawing Sheets



U.S. PATENT DOCUMENTS

6,006,018	A		12/1999	Burnett et al.
6,012,067	A		1/2000	Sarkar
6,012,081	A		1/2000	Dorn et al.
6,016,393	A		1/2000	White et al.
6,026,415	A		2/2000	Garst et al.
6,032,190	A		2/2000	Bremer et al.
6,041,166	A		3/2000	Hart et al.
6,044,409	A		3/2000	Lim et al.
6,061,740	A		5/2000	Ferguson et al.
6,085,030	A		7/2000	Whitehead et al.
6,085,086	A		7/2000	La Porta et al.
6,092,196	A		7/2000	Reiche
6,134,591	A		10/2000	Nickles
6,138,235	A		10/2000	Lipkin et al.
6,138,251	A		10/2000	Murphy et al.
6,141,759	A		10/2000	Braddy
6,151,639	A		11/2000	Tucker et al.
6,157,960	A		12/2000	Kaminsky et al.
6,178,505	B1		1/2001	Schneider et al.
6,182,153	B1		1/2001	Hollberg et al.
6,182,154	B1		1/2001	Campagnoni et al.
6,182,155	B1		1/2001	Cheng et al.
6,195,794	B1		2/2001	Buxton
6,205,491	B1		3/2001	Callsen et al.
6,212,574	B1		4/2001	O'Rourke et al.
6,230,160	B1		5/2001	Chan et al.
6,237,135	B1		5/2001	Timbol
6,253,253	B1		6/2001	Mason et al.
6,253,256	B1		6/2001	Wollrath et al.
6,260,078	B1		7/2001	Fowlow
6,269,373	B1		7/2001	Sato et al.
6,282,580	B1		8/2001	Chang
6,304,918	B1		10/2001	Fraley et al.
6,321,275	B1		11/2001	McQuistan et al.
6,324,543	B1	*	11/2001	Cohen et al. 707/200
6,338,089	B1		1/2002	Quinlan
6,343,332	B1		1/2002	Ueda
6,345,382	B1		2/2002	Hughes
6,347,341	B1		2/2002	Glassen et al.
6,347,342	B1		2/2002	Marcos et al.
6,356,930	B2		3/2002	Garg
6,374,308	B1		4/2002	Kempf et al.
6,385,661	B1		5/2002	Guthrie et al.
6,405,246	B1		6/2002	Hutchison
6,415,315	B1		7/2002	Glass
6,434,595	B1	*	8/2002	Suzuki et al. 709/202
6,438,616	B1		8/2002	Callsen et al.
6,442,620	B1		8/2002	Thatte et al.
6,446,084	B1		9/2002	Shaylor et al.
6,453,333	B1		9/2002	Glynias et al.
6,496,871	B1	*	12/2002	Jagannathan et al. 719/317
6,513,157	B1		1/2003	Glass
6,549,955	B2		4/2003	Guthrie et al.
6,567,861	B1		5/2003	Kasichainula et al.
6,601,018	B1		7/2003	Logan
6,629,128	B1		9/2003	Glass
6,701,382	B1		3/2004	Quirt
6,714,976	B1		3/2004	Wilson et al.
6,851,118	B1		2/2005	Ismael et al.
6,931,455	B1		8/2005	Glass
6,947,965	B2		9/2005	Glass
6,951,021	B1		9/2005	Bodwell et al.
6,993,774	B1		1/2006	Glass
7,347,342	B2		3/2008	Grandy
2001/0003824	A1		6/2001	Schnier

OTHER PUBLICATIONS

Matthew Izatt and Patrick Chan, "Ajents: Toward an Environment for Parallel, Distributed and Mobile Java Applications", Jun. 1999, pp. 1–10.*

Richard Hayton, Mike Bursell, Douglas Donaldson, Andrew Herbert, "Mobile Java Objects," 1998.

Richard Hayton and ANSA Team, "FlexiNet Architecture," Feb. 1999, p. 171–178.

"Life Cycle Service Specification", *CORBA Object Services Specification, Chp. 6, OMG*, c9i.omg.org/docs/formal/97–02–11.pdf,, (Feb. 11, 1997),pp. 6–1 through 6–62.

Bowers, "Some Principles for the Encapsulation of The Behavior of Aggregate Objects", *IEEE*, (1993),6/1–6/4.

Orfali, et al., "The Essentiai Distributed Objects Survival Guide", *Chapter 4, Published by John Wiley & Suns, Inc.*, (1996),67–90.

"The Component Object Model (DRAFT) Specification", *Microsoft Corporation*, Mar. 6, 1995),1–4, 39–46.

McKie, S. "Software Agents: Application Intelligence Goes Undercover", *DBMS*, (Apr. 1995),8.

Brando, Thom "Comparing COBRA and DCE", (Mar. 1996).

Roy, Mark et al., "Interworking COM with COBRA", (May 1996).

Roy, Mark et al., "IChoosing between COBRA and DCOM", (Oct. 1996).

Cappelo, Robert "Overview of RMI Architecture (Computer Science Online Course Notes)", *University of California Santa Barbara Department of Computer Science*, cs.ucsb.edu/–cappello/290i/lectures/rmi/architecture/sld001.htm, (Sep. 7, 1998).

HOP;OMG's Internet Inter—ORG Protocol, A Brief discription, printed from omg.org,(1994).

McManis, Chuck "Take an in–depthlook at the java reflection API", *retrieved from JavaWorld.com,* (Sep. 1997),1–10.

Petrie, C. J., "Agent–based Engineering, the Web, and Intelligence", IEEE Expert, (Dec. 1996),12.

Wayner, P. "Free Agents", *BYTE*, (Mar. 1995),7.

Wescom, et al., "The object/agent approach: A computing model for the future", *Object Magazine*, (Mar.–Apr. 1995), 31–33.

Henderson, Sellers et al., "What is This Thing Called Aggregation?", *IEEE*, (Jun. 1999),236–250.

Hayton, Richard et al., "Mobile Java Objects", (1998).

Hayton, Richard et al., "FlexiNet Architecture", (Feb. 1999), 171–178.

Bieszczad, A. "Towards Plug–and–Play Networks wilh Mobile Code", *SCE Technical Report*, (Mar. 1997),17.

Henry, E. et al., "Fine–Grained Mobility in the Emerald System", *ACM*, (Feb. 1998),22.

"SOMobjects Developer's Toolkit Programmer's Guide", vol. I: SOM and DSOM, (Dec. 1996),275–276.

Moons, H. et al., "Object Migration In a Heterogeneous World—A Multi–Dimensional Affair", *IEEE*, (1993),62–72.

"Improved Process for Visual Development of Client/Server Programs", *IBM Technical Disclosure Bulletin,* vol. 41(1), XP–000772108,(Jan. 1998),281–283.

"Passing Proxies as Parameters to Methods and Return Values from Methods", *IBM Technical Disclosure Bulletin,* vol. 41(1), XP–000772037,(Jan. 1998),89–92.

"Distribution Object Activation and Communication Protocols", *IBM Technical Disclosure Bulletin, US, IBM Corp. New York,* vol. 37(7), (Jul. 1, 1994),539–542.

"Java RMI Tutorial", Revision 1.3, JDK 1.1 FCS, Sun Microsystems, (Feb. 10, 1997),1–14.

Spruit, Sandor "Reflections on Java, Beans, and Relational databases", retrieved from JavaWorld.com, (Sep. 1997),1–8.

"Java Core Reflection, API and Specification", *JavaSoft,* (Jan. 1997),40–47.

Glen, McCluskey "Using Java Reflection", *article retrieved from java.sun.com website.,* (Jan. 1998).

"PCT/US99/24510", International Search Report for Appl. No. PCT/US99/24510,(Apr. 19, 2000),4.

Robert, Gray et al., "Mobile agents for mobile computing", *Technical Report PCS–TR96–285, Dept. of Computer Science,* Dartmouth College,(May 1996).

Hof, Markus "Just–in–Time Stub Generation", *Proceedings of the Joint Modular Languages Conference* (*JMLC*) 97, Linz, Austria,(Mar. 19–21, 1997),197–206.

Johansen, Dag et al., "An Introduction to the TACOMA Distributed System Version 1.0", *Technical Report 95–23, Department of Computer Science, University of Troms, Norway,* (Jun. 1995).

Bent, Thomsen et al., "Mobile Agents", *External Report ECRC–92–21, European Computer–Industry Research Center,* (1995).

"The Component Object Model Specification", *Microsoft Corporation and Digital Equipment Corporation,* Chapters 1 and 2 (printed on Oct. 26, 2005 from daimi.au.dk*–datpete/COT/COM SPEC/html/com_spec.html),(Oct. 24, 1995),54.

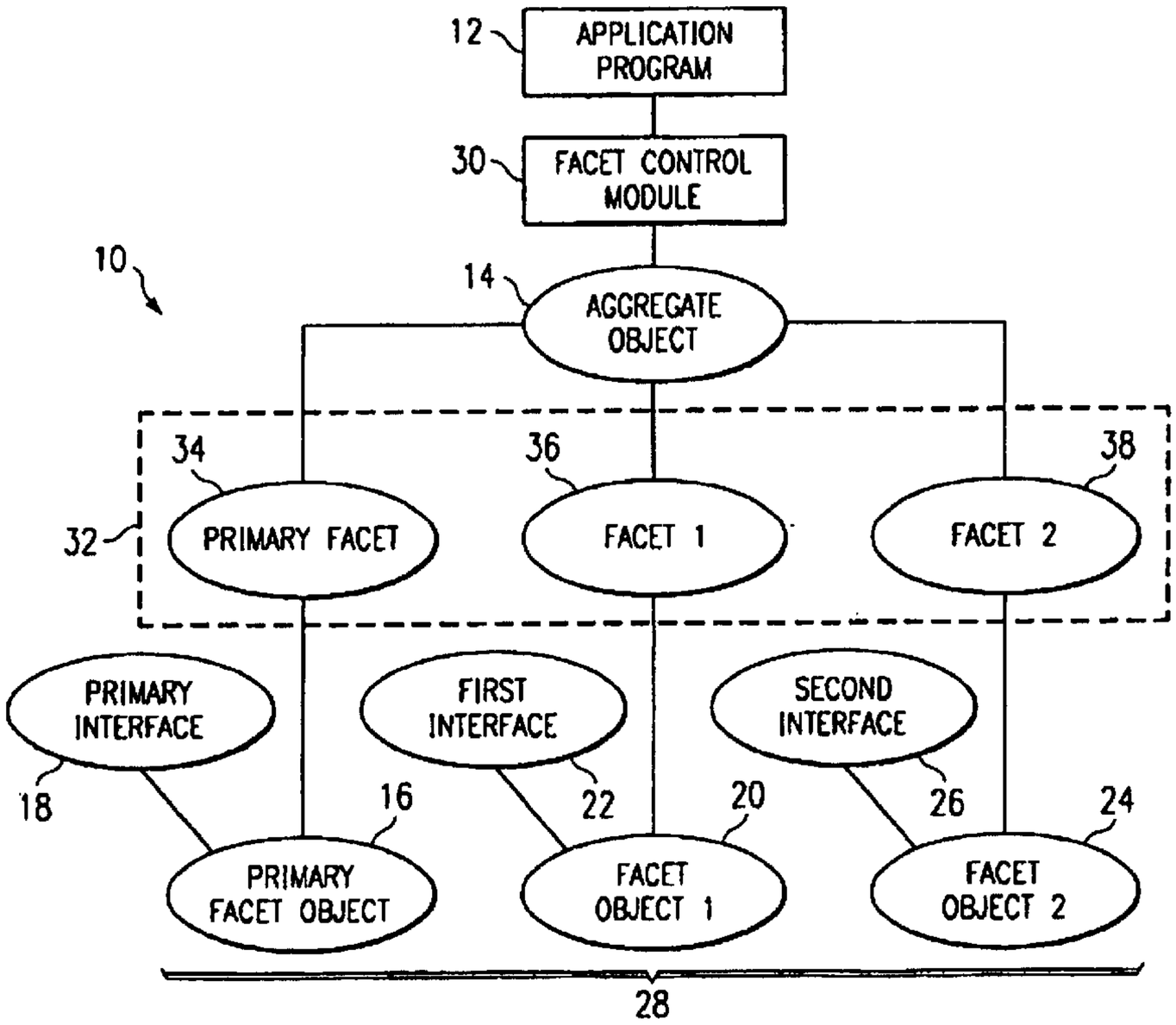
"Final Office Action", U.S. Appl. No. 11/158,734, (Aug. 20, 2009), 18 pages.

"Non Final Offce Action", U.S. Appl. No. 11/158,734, (Feb. 19, 2010), 21 pages.

"Non Final Action", U.S. Appl. No. 11/858,878, (Mar. 29, 2010), 30 pages.

* cited by examiner

FIG. 1


12
APPLICATION PROGRAM
30
FACET CONTROL MODULE
10
14
AGGREGATE OBJECT
34
36
38
32
PRIMARY FACET
FACET 1
FACET 2
PRIMARY INTERFACE
FIRST INTERFACE
SECOND INTERFACE
18
16
22
20
26
24
PRIMARY FACET OBJECT
FACET OBJECT 1
FACET OBJECT 2
28

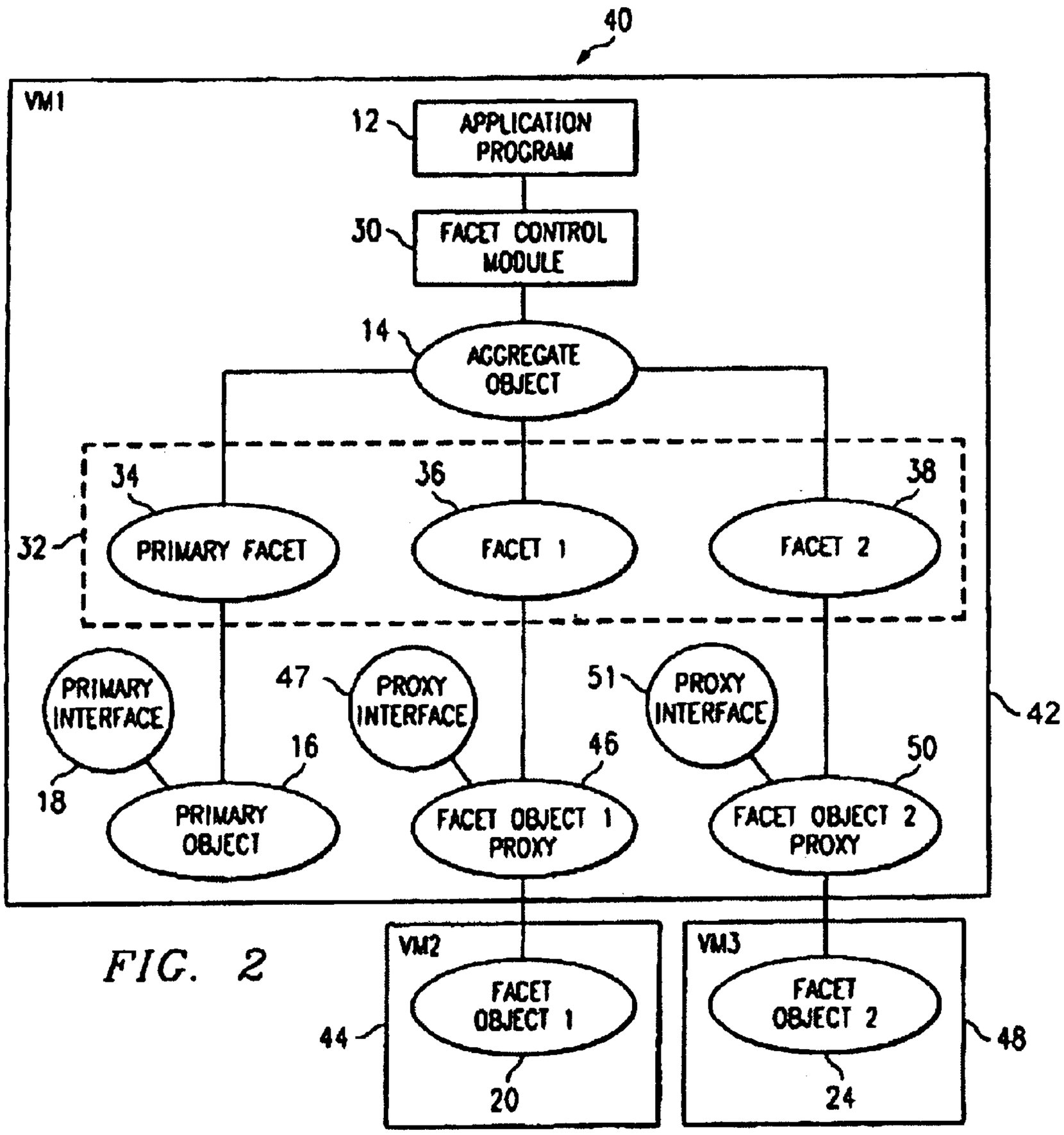

40
VM1
12
APPLICATION PROGRAM
30
FACET CONTROL MODULE
14
AGGREGATE OBJECT
34
36
38
32
PRIMARY FACET
FACET 1
FACET 2
PRIMARY INTERFACE
47
PROXY INTERFACE
51
PROXY INTERFACE
42
16
46
50
18
PRIMARY OBJECT
FACET OBJECT 1 PROXY
FACET OBJECT 2 PROXY
VM2
VM3
FACET OBJECT 1
FACET OBJECT 2
44
48
20
24

FIG. 2

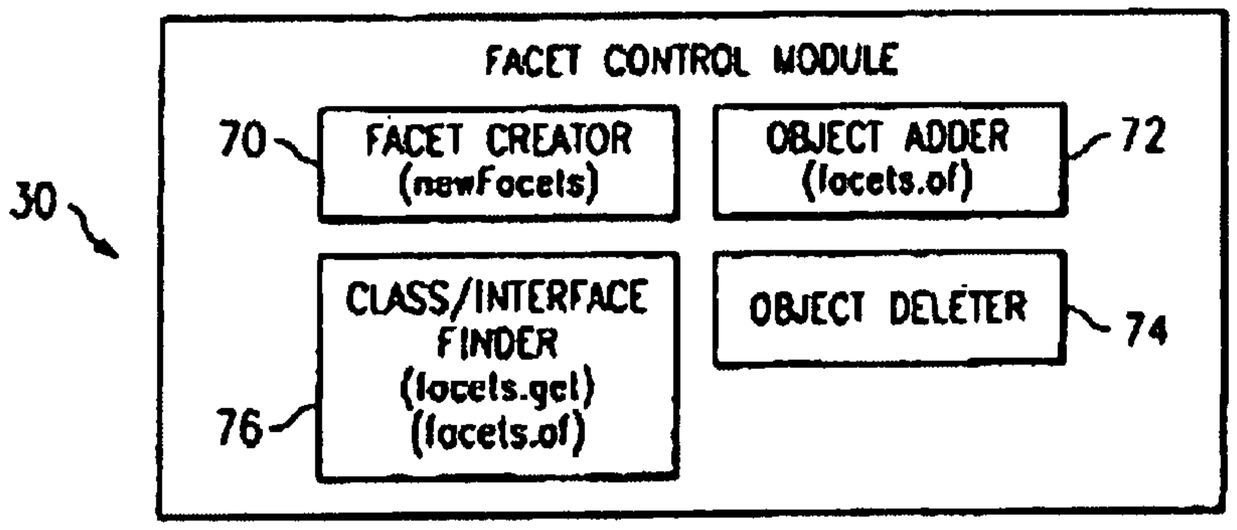

30
FACET CONTROL MODULE
70
FACET CREATOR (newFacets)
OBJECT ADDER (facets.of)
72
CLASS/INTERFACE FINDER (facets.get) (facets.of)
OBJECT DELETER
74
76

FIG. 3

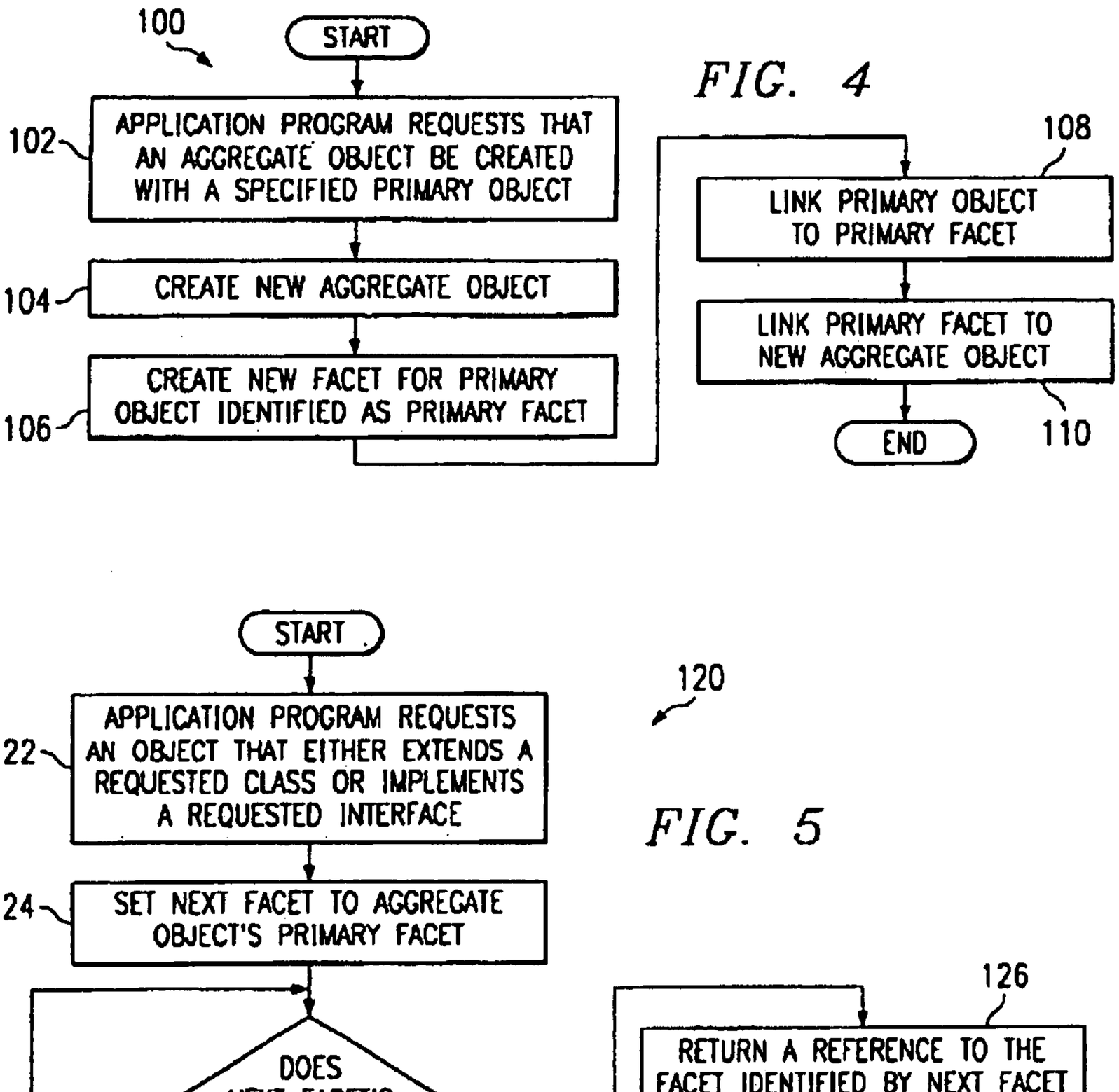

100
START
102
APPLICATION PROGRAM REQUESTS THAT AN AGGREGATE OBJECT BE CREATED WITH A SPECIFIED PRIMARY OBJECT
104
CREATE NEW AGGREGATE OBJECT
106
CREATE NEW FACET FOR PRIMARY OBJECT IDENTIFIED AS PRIMARY FACET
108
LINK PRIMARY OBJECT TO PRIMARY FACET
LINK PRIMARY FACET TO NEW AGGREGATE OBJECT
110
END

FIG. 4

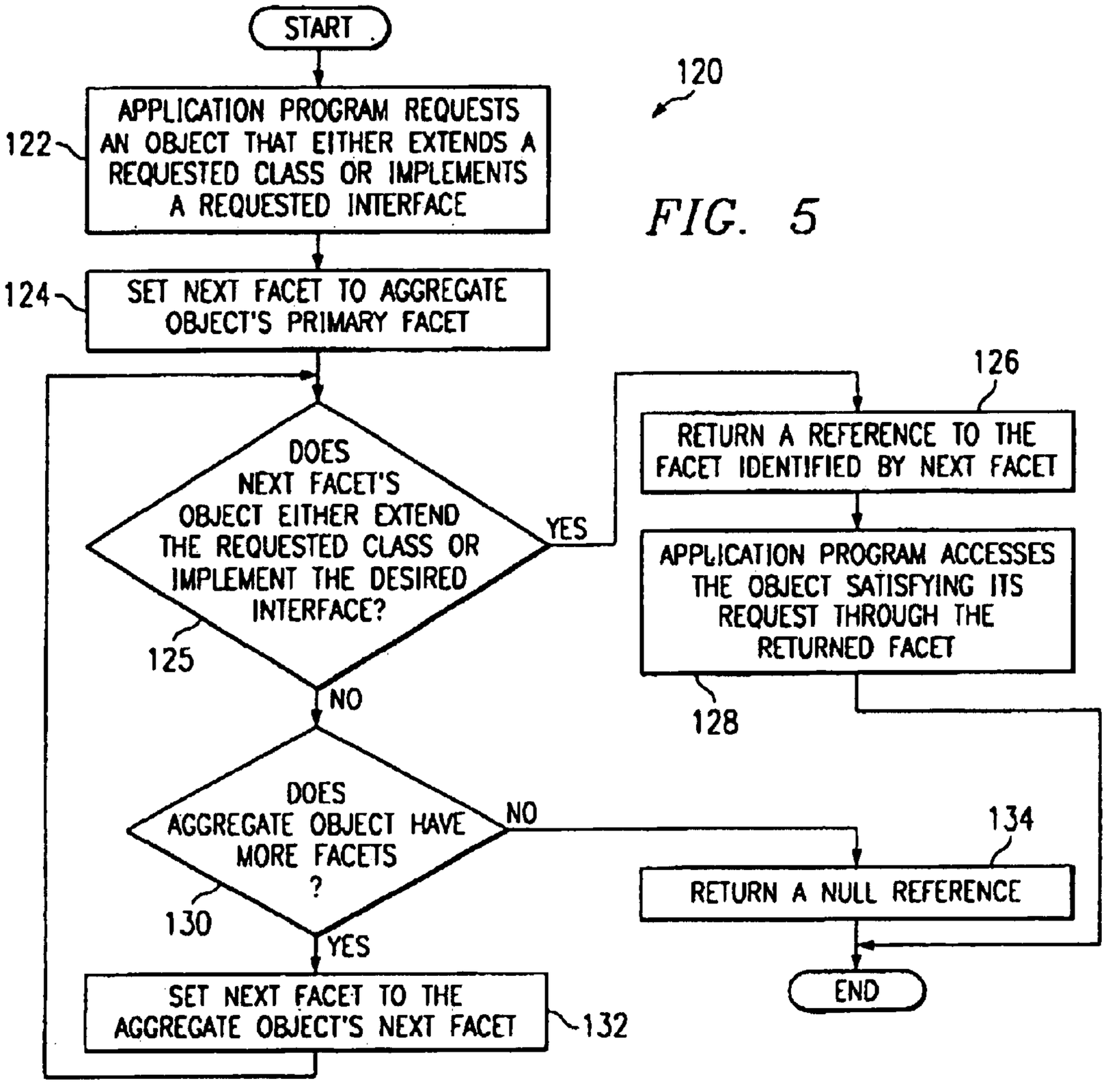

120
START
122
APPLICATION PROGRAM REQUESTS AN OBJECT THAT EITHER EXTENDS A REQUESTED CLASS OR IMPLEMENTS A REQUESTED INTERFACE
124
SET NEXT FACET TO AGGREGATE OBJECT'S PRIMARY FACET
DOES NEXT FACET'S OBJECT EITHER EXTEND THE REQUESTED CLASS OR IMPLEMENT THE DESIRED INTERFACE?
125
YES
NO
DOES AGGREGATE OBJECT HAVE MORE FACETS ?
130
YES
NO
SET NEXT FACET TO THE AGGREGATE OBJECT'S NEXT FACET
132
126
RETURN A REFERENCE TO THE FACET IDENTIFIED BY NEXT FACET
APPLICATION PROGRAM ACCESSES THE OBJECT SATISFYING ITS REQUEST THROUGH THE RETURNED FACET
128
134
RETURN A NULL REFERENCE
END

FIG. 5

FIG. 6

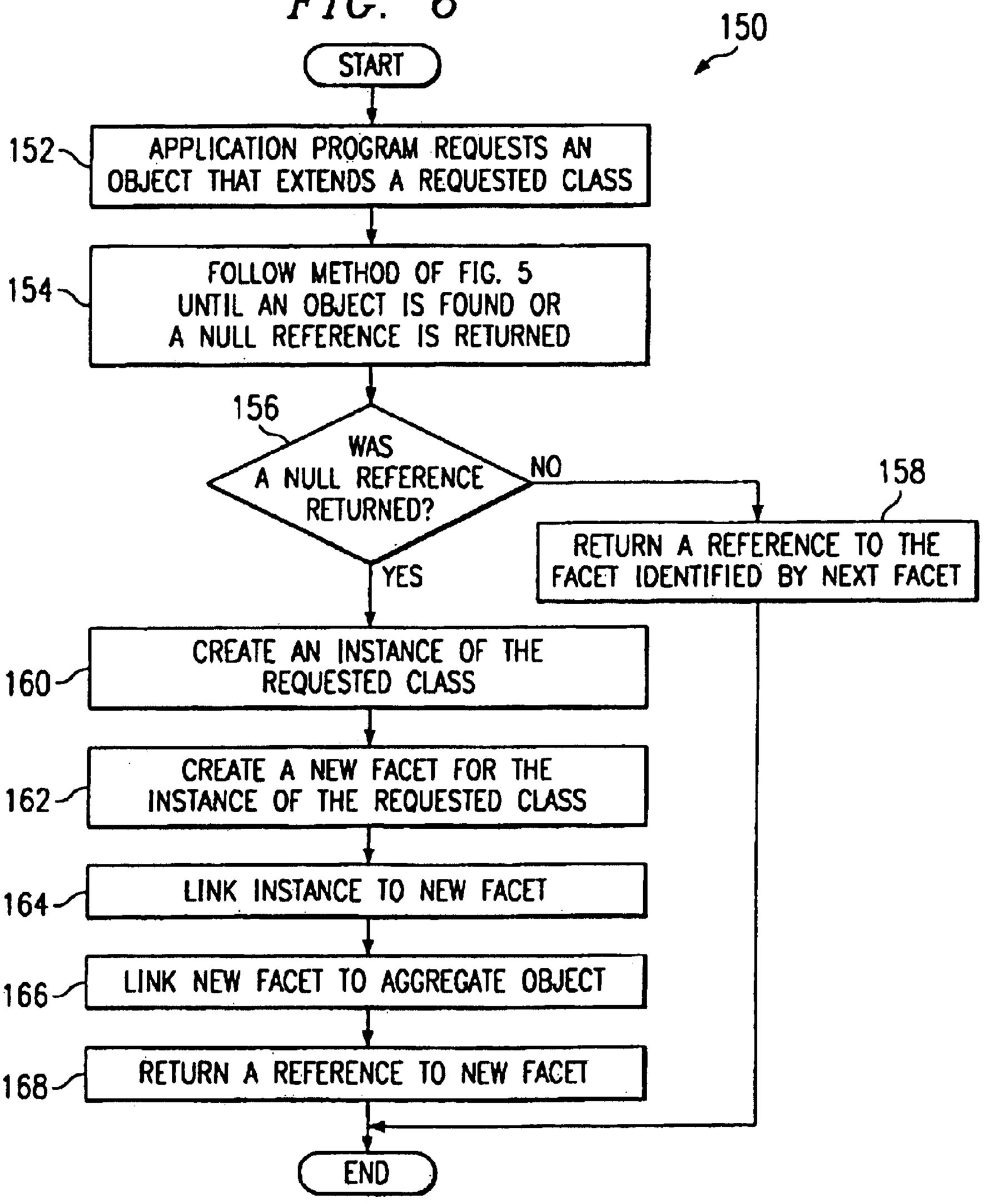

150
START
152
APPLICATION PROGRAM REQUESTS AN OBJECT THAT EXTENDS A REQUESTED CLASS
154
FOLLOW METHOD OF FIG. 5 UNTIL AN OBJECT IS FOUND OR A NULL REFERENCE IS RETURNED
156
WAS A NULL REFERENCE RETURNED?
NO
158
RETURN A REFERENCE TO THE FACET IDENTIFIED BY NEXT FACET
YES
160
CREATE AN INSTANCE OF THE REQUESTED CLASS
162
CREATE A NEW FACET FOR THE INSTANCE OF THE REQUESTED CLASS
164
LINK INSTANCE TO NEW FACET
166
LINK NEW FACET TO AGGREGATE OBJECT
168
RETURN A REFERENCE TO NEW FACET
END

FIG. 7A

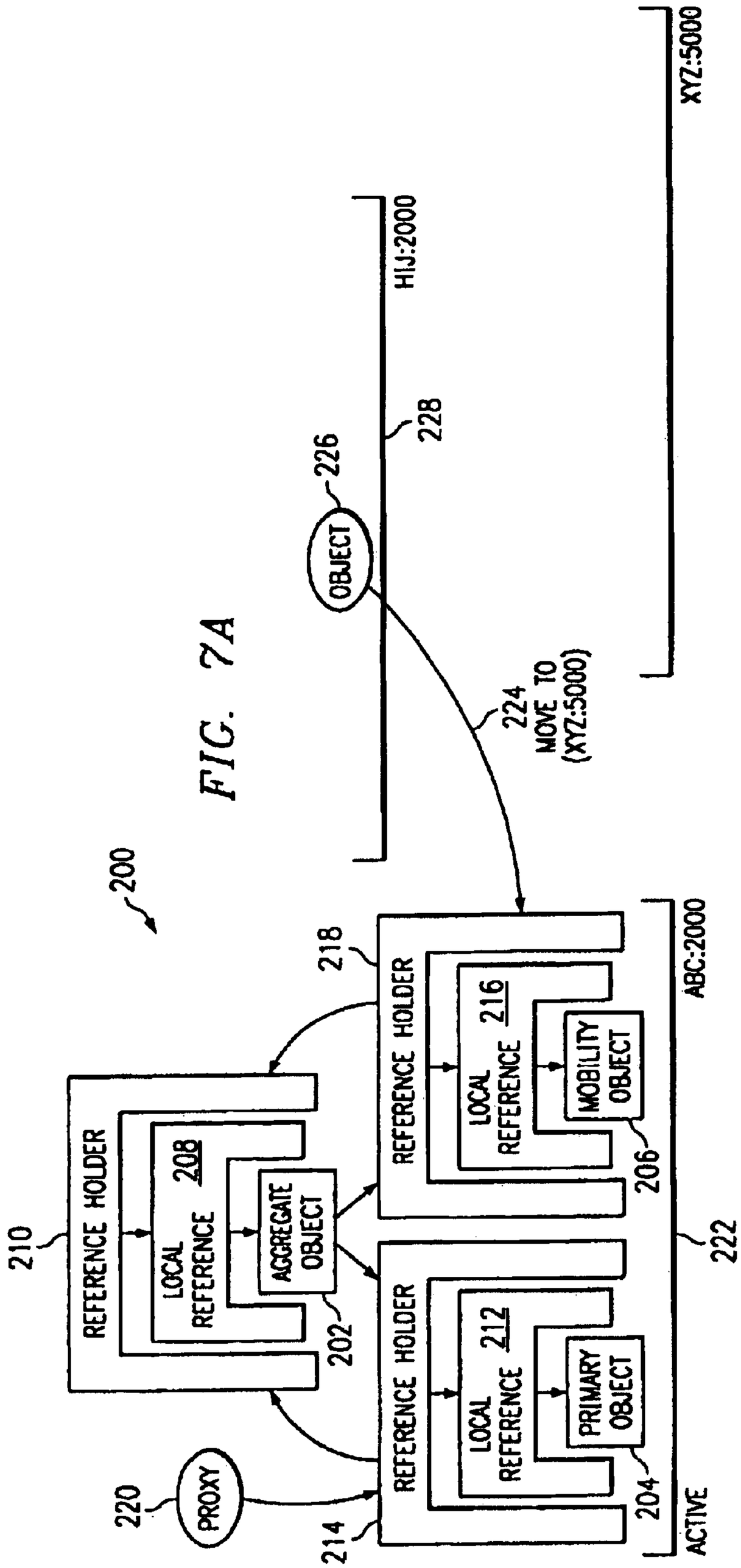
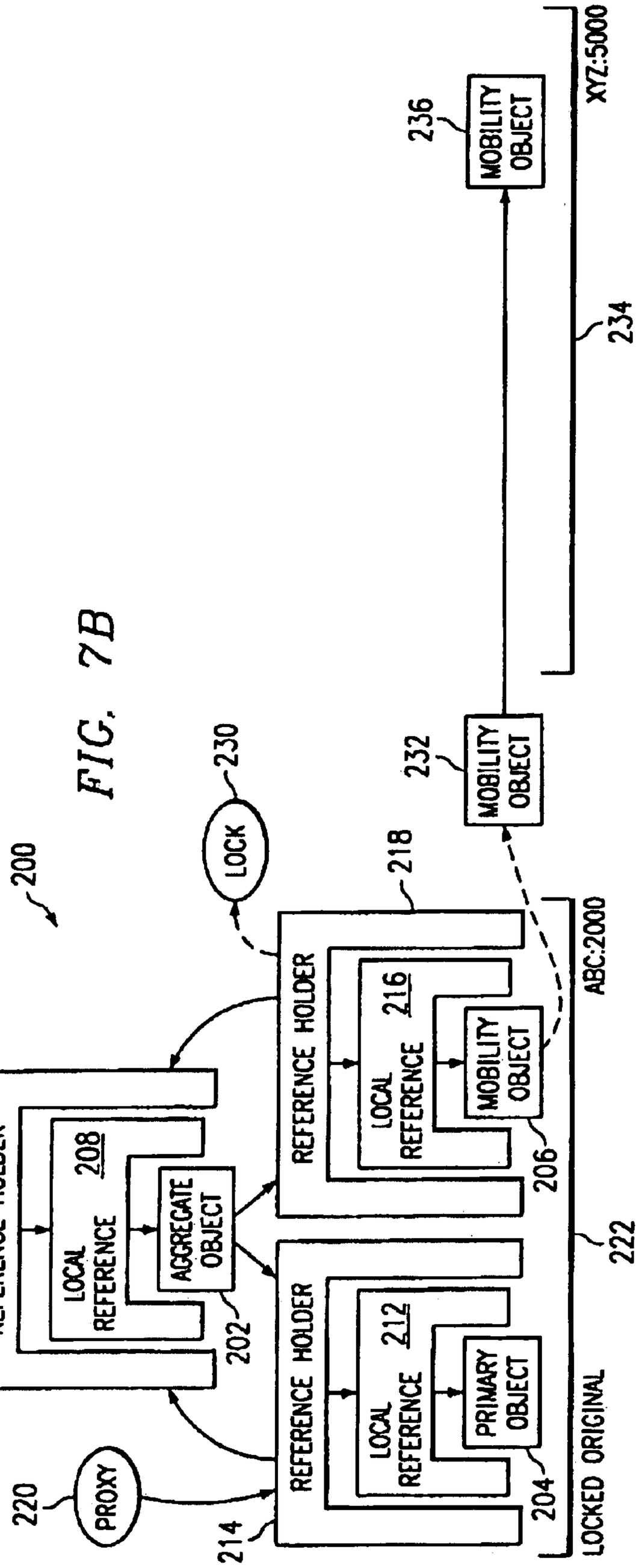

200
ACTIVE
ABC:2000
HIJ:2000
XYZ:5000
218
REFERENCE HOLDER
LOCAL REFERENCE 216
MOBILITY OBJECT
206
222
228
226
OBJECT
224
MOVE TO (XYZ:5000)
210
REFERENCE HOLDER
LOCAL REFERENCE 208
AGGREGATE OBJECT
202
REFERENCE HOLDER
LOCAL REFERENCE 212
PRIMARY OBJECT
204
214
220
PROXY

FIG. 7B


200
LOCK
230
REFERENCE HOLDER
218
LOCAL REFERENCE
208
AGGREGATE OBJECT
202
210
REFERENCE HOLDER
LOCAL REFERENCE
212
PRIMARY OBJECT
204
214
PROXY
220
REFERENCE HOLDER
216
LOCAL REFERENCE
MOBILITY OBJECT
206
MOBILITY OBJECT
232
MOBILITY OBJECT
236
XYZ:5000
234
ABC:2000
LOCKED ORIGINAL
222

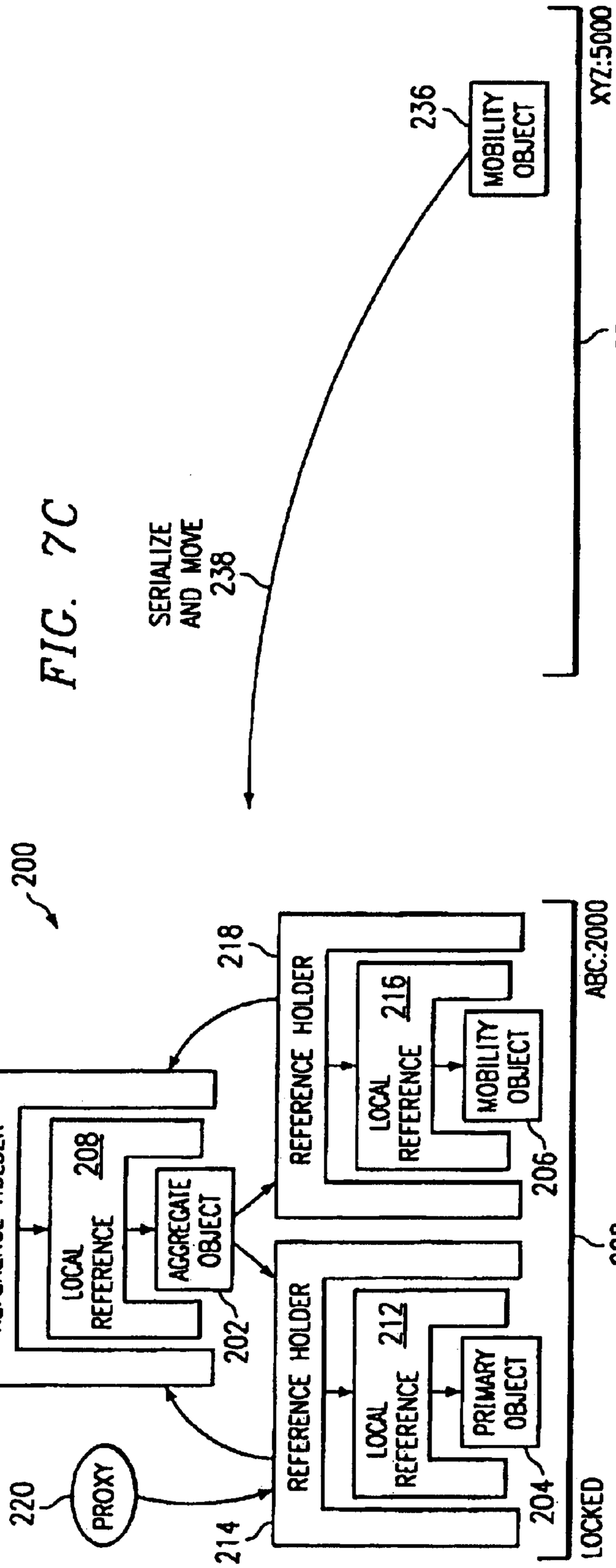

200
ABC:2000
XYZ:5000
236
MOBILITY OBJECT
234
SERIALIZE AND MOVE
238
218
REFERENCE HOLDER
216
LOCAL REFERENCE
MOBILITY OBJECT
206
210
REFERENCE HOLDER
208
LOCAL REFERENCE
AGGREGATE OBJECT
202
REFERENCE HOLDER
212
LOCAL REFERENCE
PRIMARY OBJECT
204
220
PROXY
214
222
LOCKED

FIG. 7C

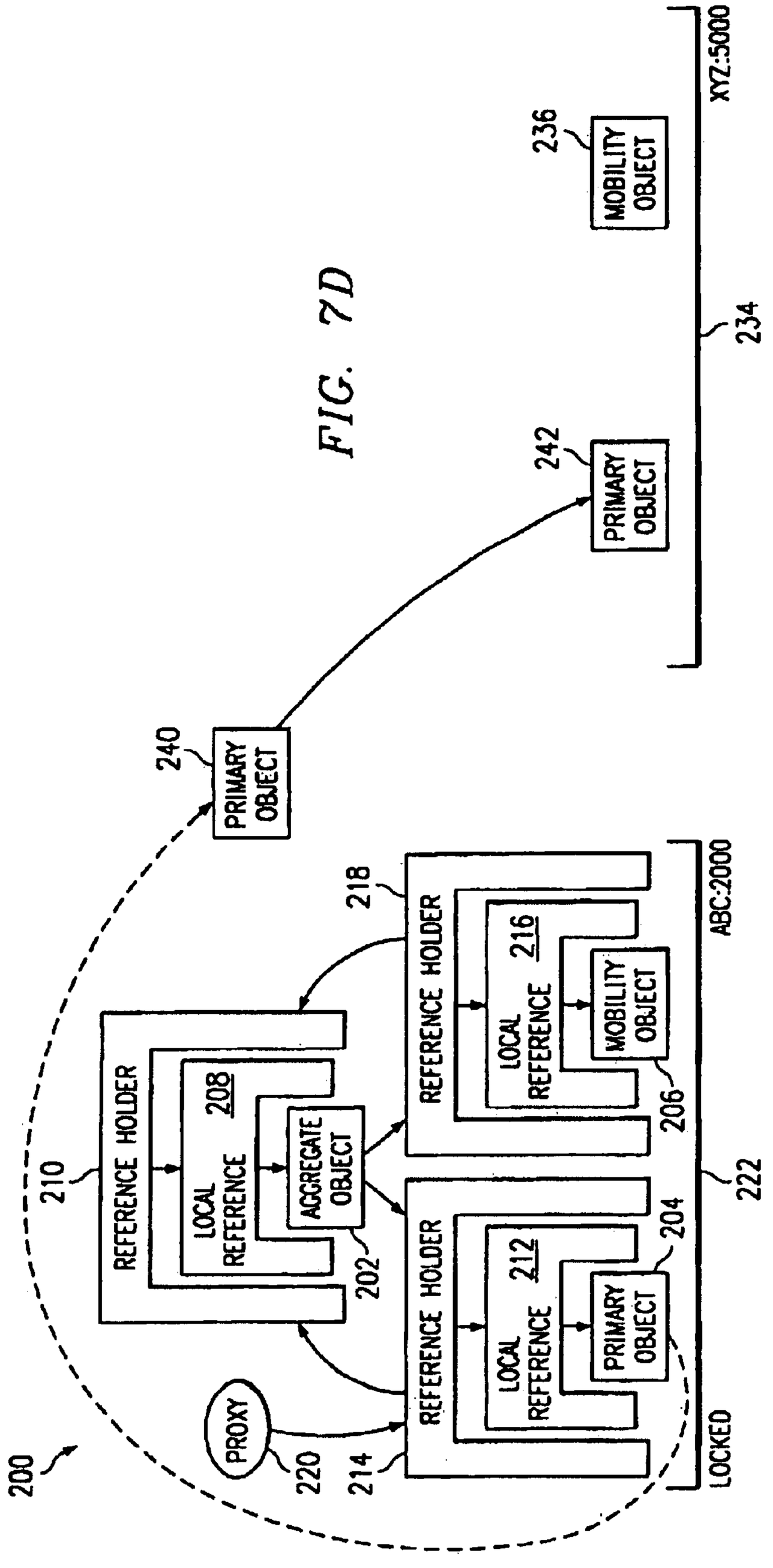


FIG. 7D
200
PROXY
220
214
REFERENCE HOLDER
218
LOCAL REFERENCE
208
AGGREGATE OBJECT
202
210
REFERENCE HOLDER
LOCAL REFERENCE
212
PRIMARY OBJECT
204
LOCKED
222
REFERENCE HOLDER
216
LOCAL REFERENCE
MOBILITY OBJECT
206
ABC:2000
PRIMARY OBJECT
240
PRIMARY OBJECT
242
MOBILITY OBJECT
236
234
XYZ:5000

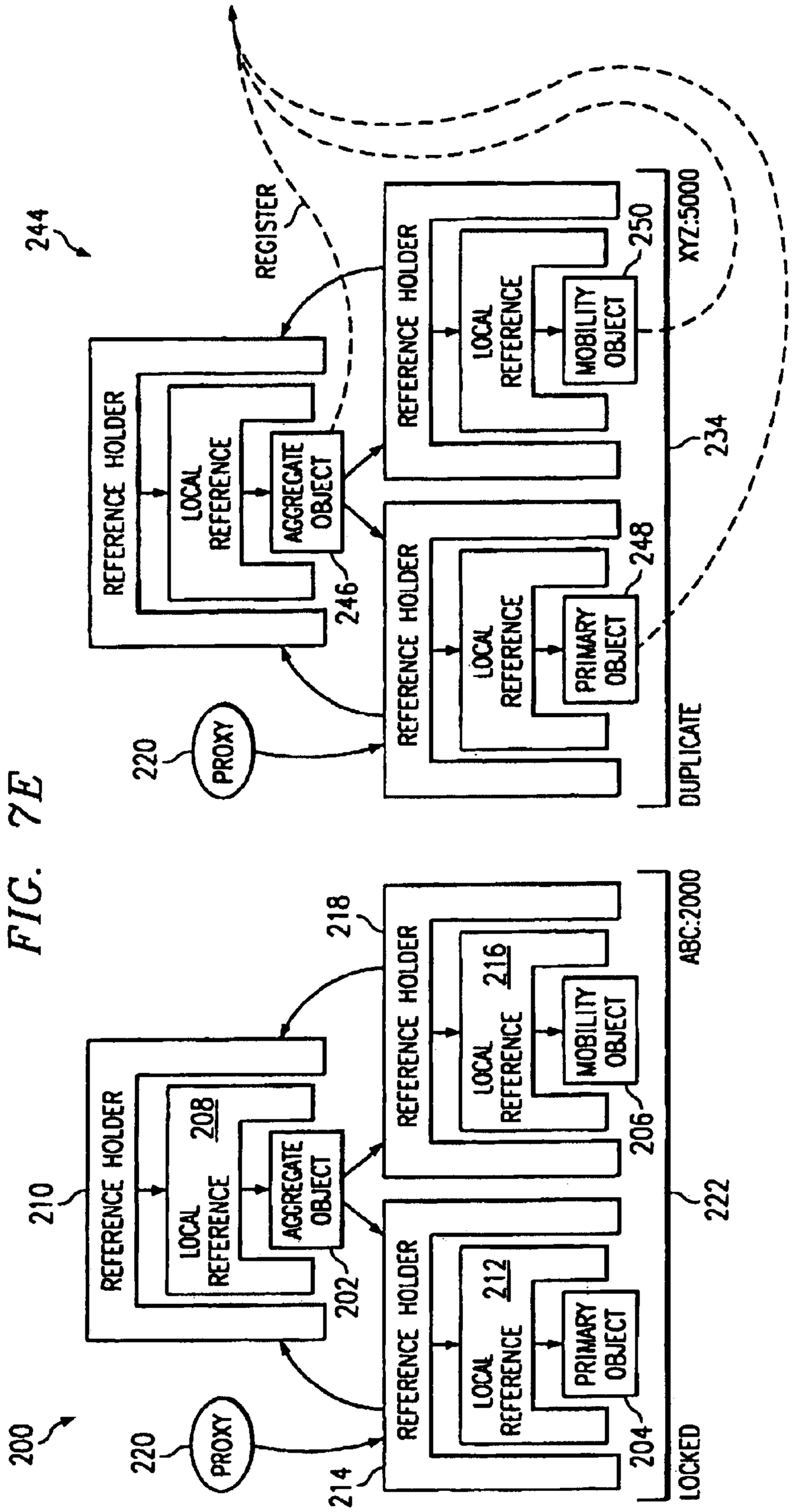

200
210
REFERENCE HOLDER
LOCAL REFERENCE
208
AGGREGATE OBJECT
202
REFERENCE HOLDER
LOCAL REFERENCE
212
PRIMARY OBJECT
204
LOCKED
206
REFERENCE HOLDER
LOCAL REFERENCE
216
MOBILITY OBJECT
218
ABC:2000
222
220
PROXY
214
244
REGISTER
REFERENCE HOLDER
LOCAL REFERENCE
246
AGGREGATE OBJECT
REFERENCE HOLDER
LOCAL REFERENCE
248
PRIMARY OBJECT
DUPLICATE
234
REFERENCE HOLDER
LOCAL REFERENCE
250
MOBILITY OBJECT
XYZ:5000

FIG. 7E

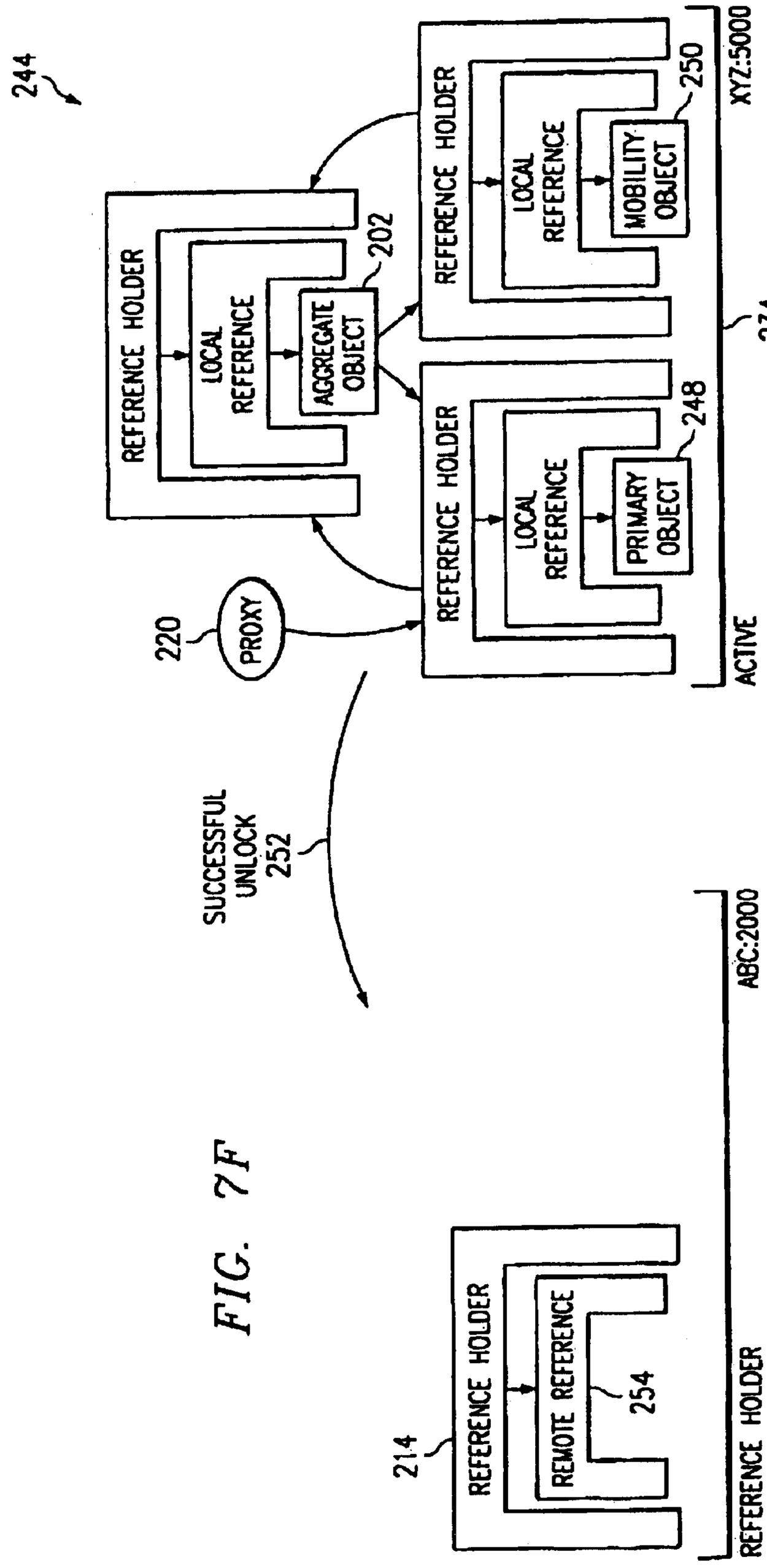

244
REFERENCE HOLDER
LOCAL REFERENCE
AGGREGATE OBJECT
202
REFERENCE HOLDER
LOCAL REFERENCE
MOBILITY OBJECT
250
XYZ:5000
234
REFERENCE HOLDER
LOCAL REFERENCE
PRIMARY OBJECT
248
ACTIVE
220
PROXY
SUCCESSFUL UNLOCK 252
ABC:2000
214
REFERENCE HOLDER
REMOTE REFERENCE
254
REFERENCE HOLDER

FIG. 7F

FIG. 8A

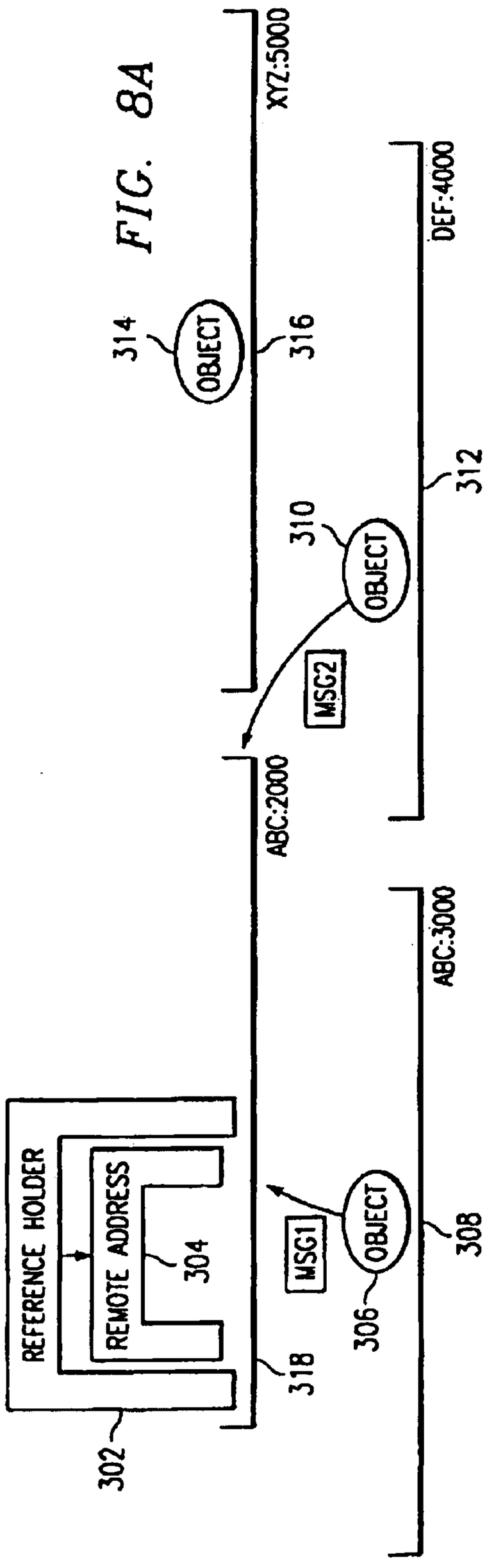
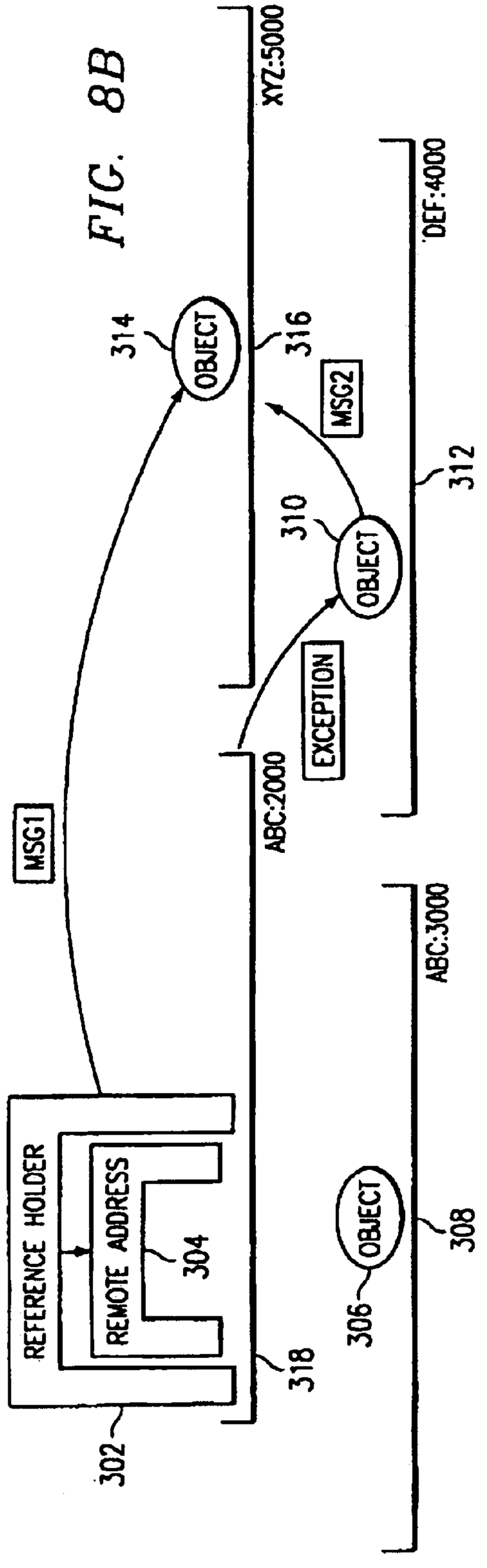

XYZ:5000
DEF:4000
314
OBJECT
316
310
OBJECT
MSG2
312
ABC:2000
ABC:3000
REFERENCE HOLDER
REMOTE ADDRESS
304
318
MSG1
OBJECT
306
308
302

FIG. 8B


XYZ:5000
DEF:4000
314
OBJECT
316
MSG2
310
OBJECT
312
MSG1
EXCEPTION
ABC:2000
ABC:3000
REFERENCE HOLDER
REMOTE ADDRESS
304
318
OBJECT
306
308
302

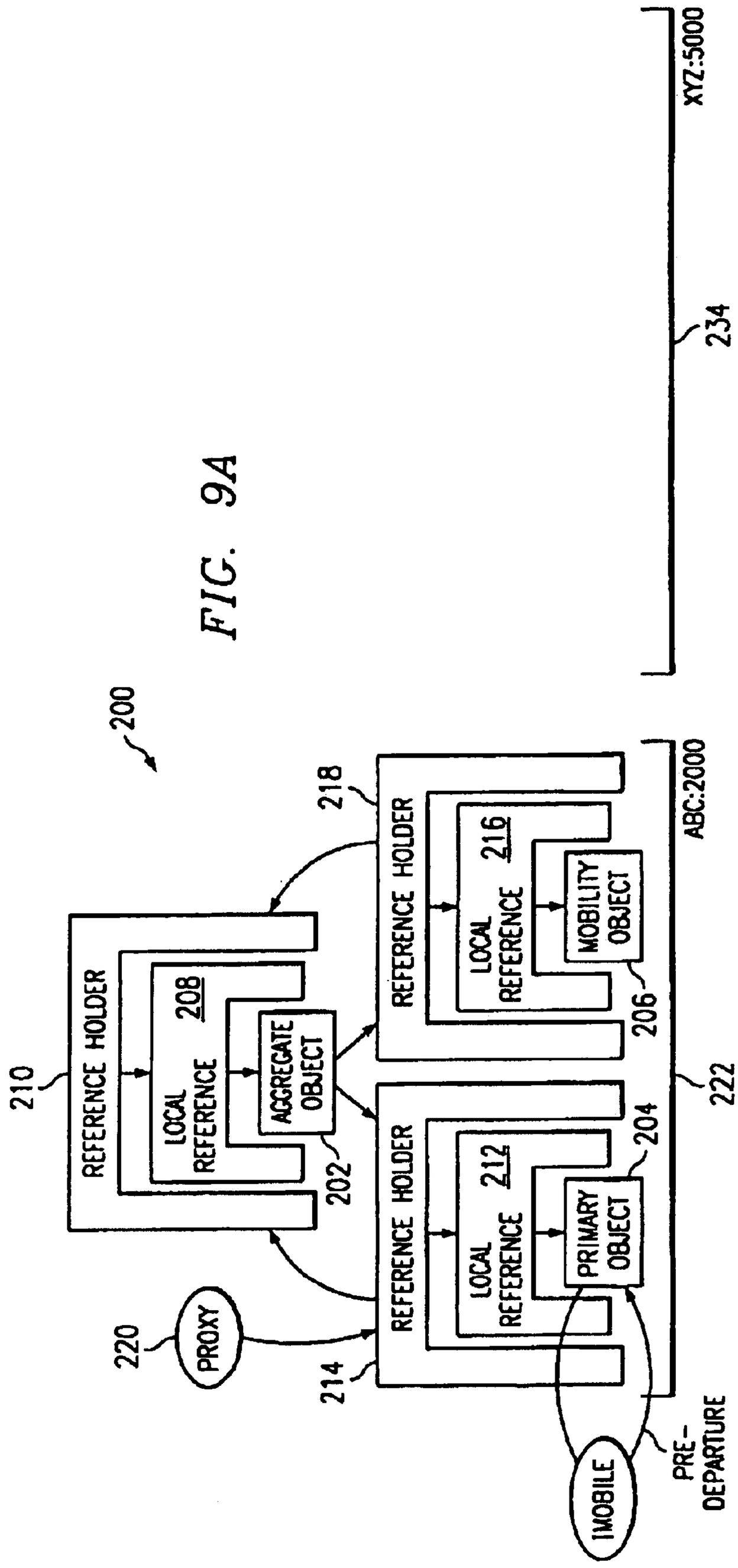

200
XYZ:5000
234
ABC:2000
222
218
REFERENCE HOLDER
LOCAL REFERENCE
216
MOBILITY OBJECT
206
208
AGGREGATE OBJECT
202
210
REFERENCE HOLDER
LOCAL REFERENCE
212
PRIMARY OBJECT
204
220
PROXY
214
IMOBILE
PRE-DEPARTURE

FIG. 9A

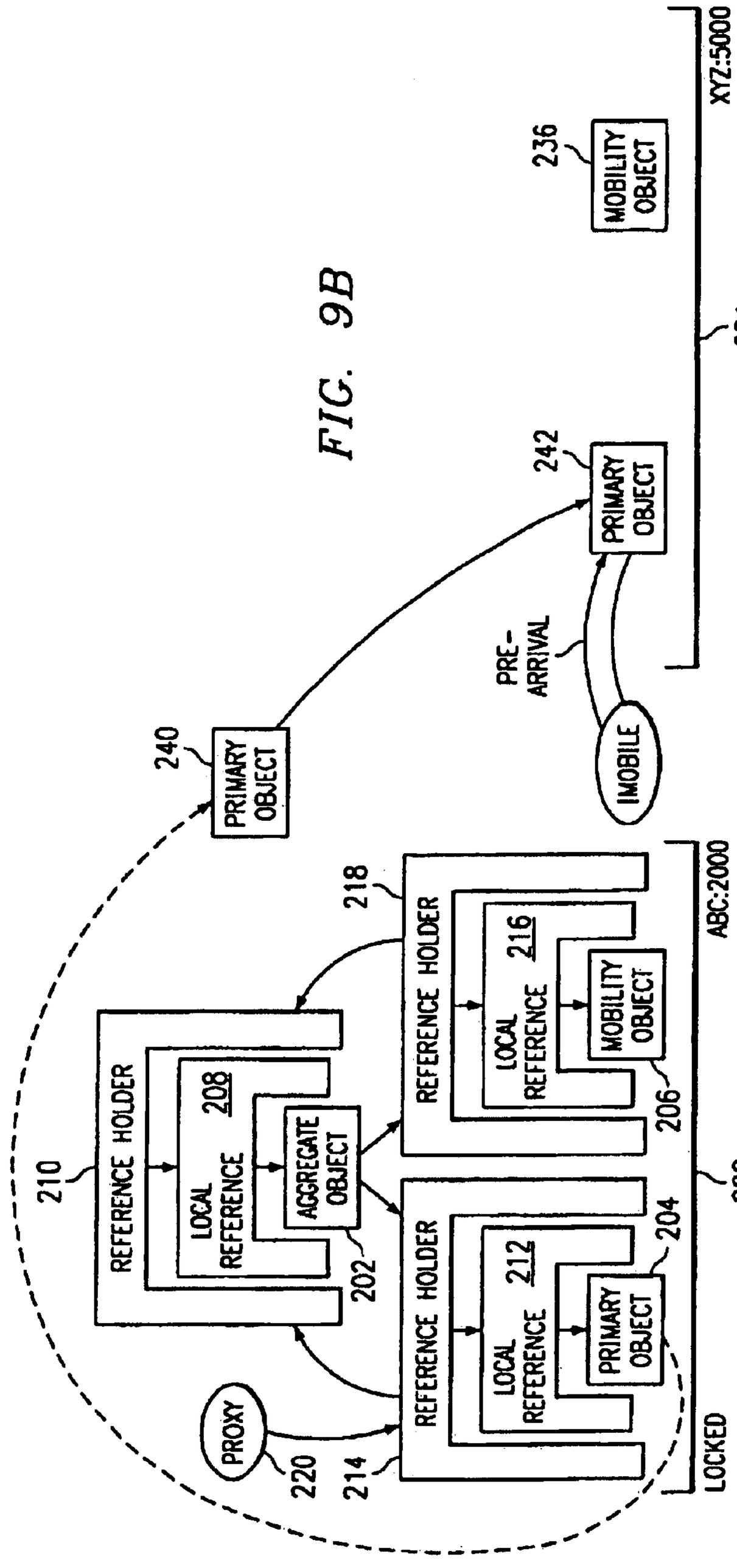

XYZ:5000
234
236
MOBILITY OBJECT
242
PRIMARY OBJECT
PRE-ARRIVAL
IMOBILE
240
PRIMARY OBJECT
218
REFERENCE HOLDER
LOCAL REFERENCE 216
MOBILITY OBJECT
206
ABC:2000
210
REFERENCE HOLDER
208
LOCAL REFERENCE
AGGREGATE OBJECT
202
222
REFERENCE HOLDER
LOCAL REFERENCE 212
PRIMARY OBJECT
204
PROXY
220
214
LOCKED

FIG. 9B

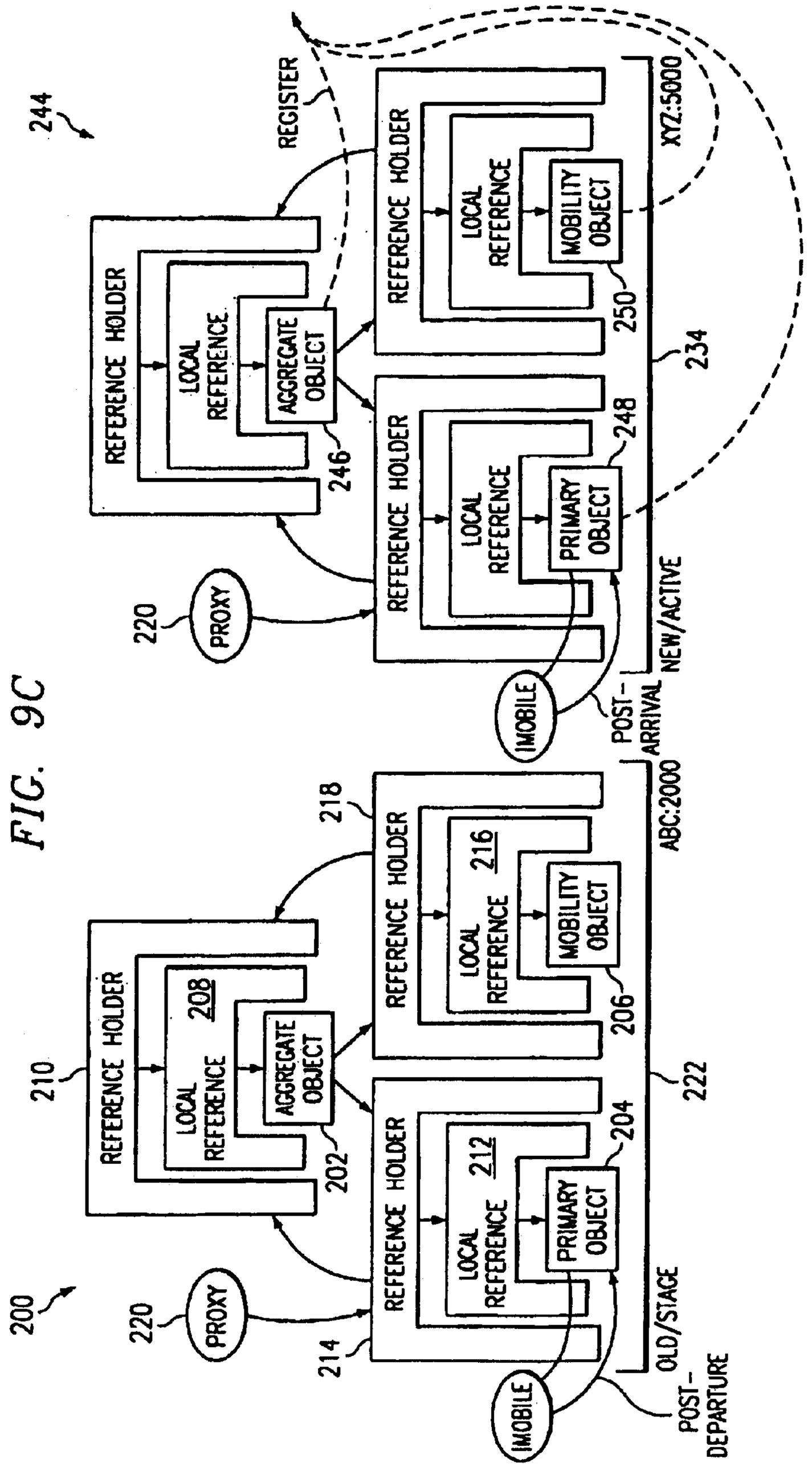

200
210
REFERENCE HOLDER
LOCAL REFERENCE
208
AGGREGATE OBJECT
202
214
REFERENCE HOLDER
LOCAL REFERENCE
212
PRIMARY OBJECT
204
222
OLD/STAGE
POST-DEPARTURE
IMOBILE
220
PROXY
218
REFERENCE HOLDER
LOCAL REFERENCE
216
MOBILITY OBJECT
206
ABC:2000
POST-ARRIVAL
NEW/ACTIVE
234
REFERENCE HOLDER
LOCAL REFERENCE
MOBILITY OBJECT
250
246
REFERENCE HOLDER
LOCAL REFERENCE
PRIMARY OBJECT
248
REGISTER
244
XYZ:5000

FIG. 9C

MOVING OBJECTS IN A DISTRIBUTED COMPUTING ENVIRONMENT

Matter enclosed in heavy brackets [ ] appears in the original patent but forms no part of this reissue specification; matter printed in italics indicates the additions made by reissue.

TECHNICAL FIELD OF THE INVENTION

The present invention relates in general to object-oriented technologies and more particularly to a method for moving objects in a distributed computing environment.

BACKGROUND OF THE INVENTION

In object oriented programming, real world objects are modeled by software objects that have encapsulated therein special procedures and data elements. In object-oriented programming terminology, procedures are referred to as methods. To avoid having to redefine the same methods and data members for each and every occurrence of an object, object-oriented programming provides the concept of classes. An inherent structure of one or more levels of increasingly more specialized classes is created to provide templates that define the methods and variables to be included in the objects of each class. The classes at the lower levels of the inheritance structure inherit the behavior, methods, and variables of the classes above. Classes above a certain class in an inheritance structure are referred to as parent classes setting up a parent-child relationship. Therefore, an object belonging to a class is a member of that class, and contains the special behavior defined by the class. In this manner, each object is an instance of a defined class or template and the need to redefine the methods and data members for each occurrence of the object is eliminated.

One example of an object-oriented programming language is Java, developed by Sun Microsystems. To define a class in Java, the programmer creates a .java file containing the source code to define the class. The .java file is compiled to create a .class file containing the executable code to define the class. Instances of the class file are instantiated to create an object containing data and methods defined by the .class file.

Object-oriented programming is a method of programming that abstracts a computer program into manageable sections. The key to object-oriented programming is the concept of encapsulation. Encapsulation is a method by which the subroutines, or methods, that manipulate data are combined with the declaration and storage of that data. This encapsulation prevents the data from arbitrarily being accessed by other programs' subroutines, or objects. When an object is invoked, the associated data is available and can be manipulated by any of the methods that are defined within an object to act upon the data.

The basic component of encapsulation is a class. A class is an abstraction for a set of objects that share the same structure and behavior. An object is a single instance of a class that retains the structure and behavior of the class. Objects also contain methods that are the processes by which an object is instructed to perform some procedure or manipulation of data that it controls. Classes may also be characterized by their interface which defines the elements necessary for proper communication between objects.

Often, a programmer needs to add functionality to an existing class of objects but either does not want to change the existing .class file or does not have access to the source code and, therefore, does not have the ability to alter the source code. In addition, the programmer may not want to alter the functionality of the existing .class file since a .class file may be used in more than one application program. Therefore, it is desirable to add functionality to an existing class of objects during the execution of an application program without altering the associated source code.

Distributed computing allows an object on one computer system to seamlessly communicate with and manipulate an object contained in a second computer system when the two computer systems are connected by a computer network. The second computer system may also be referred to as another address space. Client/server systems are an example of this type of distributed computing system. Sophisticated distributed computing systems have removed the communications burden from the computer programs, or objects in an object oriented programming environment, and placed it in a mid-level operating system that manages communications across a computer network to facilitate a client's access to and manipulation of data contained on a server system. The server system could be a computer in a different address space and remote to a user on a client system.

In distributed processing environments, objects in different address spaces may exchange a large number of messages. Using traditional distributed processing communications techniques may lead to slow response time and increased network traffic. Moving a first object to the same address space as a second object makes communications between the two objects local and, therefore, reduces network traffic. Local messages are often at least one thousand times faster than remote messages sent through the distributed computing system.

SUMMARY OF THE INVENTION

From the foregoing, it may be appreciated that a need has arisen for a method for moving objects in a distributed computing environment. In accordance with the present invention, an improved method for moving objects in a distributed computing environment is provided that substantially eliminate or reduce disadvantages and problems associated with conventional methods for moving objects in a distributed computing environment.

According to an embodiment of the present invention, there is provided a method for moving objects in a distributed computing system that includes receiving a move indication at a mobility object. The mobility object is aggregated with the primary object through an aggregate object located at a current host address and port number. The move indication instructs the mobility object to move the primary object to a new host address and port number. The aggregate object has the primary object as a primary facet object and the mobility object **[**has**]** *as* a facet object.

The method then creates a serialized version of the mobility object in response to the move indication. The method then sends the serialized version of the mobility object to the new host address and port number and creates a new version of the mobility object at the new host address and port number from the serialized version of the mobility object. The method then creates a serialized version of the primary object in response to a serialize and move message received from the new version of the mobility object. The method then sends the serialized version of the primary object to the new host address and port number and creates a new version of the primary object at the new host address and port number from the serialized version of the primary object. The method then creates a new aggregate object with the new version of the primary object as a new primary facet object

and the new version of the mobility object as a new facet object at the new host address and port number.

The present invention provides various technical advantages over conventional methods for moving objects in a distributed computing environment. For example, one technical advantage is providing a method for objects that exchange a large number of messages to move to a common computer to reduce the amount of time needed for communications and to conserve system resources. Other technical advantages may be readily apparent to one skilled in the art from the following figures, description, and claims.

BRIEF DESCRIPTION OF THE DRAWINGS

For a more complete understanding of the present invention and the advantages thereof, reference is now made to the following description taken in conjunction with the accompanying drawings, wherein like reference numbers represent like parts, in which:

FIG. **1** illustrates a block diagram of an application program utilizing aggregate objects;

FIG. **2** illustrates a block diagram of the application program utilizing aggregate objects where facet objects are distributed in different processing environments;

FIG. **3** illustrates a block diagram of a facet control module used within the application program;

FIG. **4** illustrates a flow diagram illustrating creation of aggregate objects;

FIG. **5** illustrates a flow diagram illustrating a method of locating an object that extends a requested class or implements a requested interface;

FIG. **6** illustrates a flow diagram illustrating a method for adding a class to an aggregate object;

FIGS. **7**A–**7**F illustrate an exemplary process for moving an object from one host address and port number to another host address and port number within a computer network;

FIGS. **8**A–**8**B illustrate an exemplary process for forwarding messages by a reference holder; and

FIGS. **9**A–**9**C illustrate various move notifications that may occur while moving the object from one host address and port number to another host address and port number within the computer network.

DETAILED DESCRIPTION OF THE INVENTION

Dynamic Aggregation of Objects

Referring to FIG. **1**, an application program using dynamically aggregated objects is generally indicated at **10**. An application program **12** may access one or more aggregate objects **14** through a facet control module **30**. Aggregate object **14** includes a set of facets **32** that may contain one or more facets such as a primary facet **34**, a first facet **36**, and a second facet **38**. One or more facet objects **28** are linked to the set of facets **32** in a one to one correspondence. A primary facet object **16** having a primary interface **18** is linked to primary facet **34**, a first facet object **20** having a first interface **22** is linked to first facet **36**, and a second facet object **24** having a second interface **26** is linked to second facet **38**.

Aggregate object **14** is an aggregation of one or more facet objects **28** within an object-oriented environment. Aggregate object **14** and the associated facet objects **28** function as a single logical object within the object-oriented environment. A change to one of the facet objects **28** creates a logical change in the other facet objects **28** and aggregate object **14**. For example, if one of the facet objects **28** moves to a different processing environment, or address space, the aggregate object **14** to which the particular facet object **28** is linked and any other associated facet objects **28** will move as a single logical object to the new, processing environment, or address space. Primary facet objects **16**, first facet object **20**, and second facet object **24** represent a group of one or more facet objects **28**.

Each aggregate object **14** communicates directly with its associated set of facets **32**. Each facet within a set of facets **32** is linked to a particular facet object **28**. Each facet in the set of facets **32** contains basic information related to its associated facet object **28** to facilitate use of the aggregate object **14** within application program **12**. The information contained in each facet in the set of facets **32** for its associated facet object **28** includes the class of the facet object **28** and any interfaces implemented by the facet object **28**. In one embodiment, each facet in set of facets **32** is a proxy object created from the associated facet object **28**. The proxy object is created by using Java Reflection to determine a particular facet object's **28** name, class, and interfaces. This information is then packaged into a facet in set of facets **32**. The particular facet in set of facets **32** is an object that includes the name, class, and interfaces for the associated facet object **28**. An interface in an object oriented environment defines the format and information needed to communicate with a particular object. An interface may be referred to as the public view of the object.

During application program development, the software developer may utilize aggregate objects **14** to extend the functionality of existing objects without modifying source code. The software developer extends functionality of an existing object by placing it in an aggregate object **14** as the primary facet object **16** and aggregating additional objects within aggregate object **14** as facet objects **28**. Within application program **12**, a particular object may be the primary facet object **16** of only one aggregate object **14**. Each aggregate object **14** in application program **12** will have a unique primary facet object **16**. In one embodiment, a software developer desires to extend the functionality of a specified object to add additional functions such as mobility within a distributed processing environment or the ability to function as an agent within a distributed processing environment. Another example of adding functionality to an existing object would be adding repair history to a car object or adding a bonus plan to an employee object.

The software developer dynamically creates an aggregate object **14** with the specified object as the associated primary facet object **16**. The term "dynamically" is used here to refer to using program statements during execution of application program **12** to create aggregate object **14**. The software developer then dynamically adds first facet object **20** and second facet object **24** to aggregate object **14**. First facet object **20** and second aggregate object **24** provide additional functionality for primary facet object **16**. Any method of any facet object **28** may affect all facet objects **28** within aggregate object **14**. Therefore, invoking a method on first facet object **20** will effect a change in primary facet object **16**.

Application program **12** may create and utilize one or more aggregate objects **14**. Each aggregate object **14** has one or more associated facet objects **28**. Facet objects **28** may be added and deleted as application program **12** progresses depending upon processing requirements. To access a particular facet object **28**, application program **12** may request access to the particular facet object **28** that extends the functionality of a primary facet object **16** by requesting a class or interface using commands that invoke facet control module

30. Facet control module **30** then scans the set of facets **32** associated with the aggregate object **14** identified in the facet control system command until locating the particular facet object **28** that has a class that equals or extends the requested class or implements the requested interface. Facet control module **30** returns a reference to the first facet in the set of facets **32** that has a class that equals or extends the requested class or implements the requested interface. Application program **12** can then invoke the particular facet object **28** by using the returned reference to the facet in the set of facets **32**. In another embodiment, facet control system **30** may return a list of all facets within the set of facets **32** with associated facet objects **28** that have a class that equal or extend the requested class or implement the requested interface. Application program **12** *can* then determine which facet object **28** in the returned reference list to invoke.

If no facet object **28** exists that has a class that equals or extends the requested class or implements the requested interface, a not-found condition is returned to application program **12** as a null reference. Application program **12** can then determine whether a new aggregate object **14** should be created, whether an object should be added to an existing aggregate object **14** as an additional facet object **28**, or whether appropriate error handling procedures should be performed.

Referring to FIG. **2**, a system with an application program **12** using dynamically aggregated objects in a distributed processing environment is generally indicated at **40**. The structure and operation of system **40** is the same as system **10** except that facet objects **28** may exist within different address spaces in a distributed processing environment and be accessed by aggregate object **14** using proxies.

In system **40**, application program **12**, facet control module **30**, aggregate object **14**, set of facets **32** and primary facet object **16** all exist within a first environment **42**. First facet object **20** exists within a second environment **44**. Communications between aggregate object **14** and first facet object **20** are facilitated by using an appropriate distributed processing system such as an object request broker. In one embodiment, a first facet object proxy **46** resides in first environment **42** and is logically coupled to first facet object **20** in second environment **44**. First facet object proxy **46** may be a conventional proxy object created from first facet object **20**. First facet object proxy **46** has an interface **47** modeled on first interface **22**. Interface **47** has a format and needed information similar to first interface **22**. Second facet object **24** resides in a third environment **48**. Communications between aggregate object **14** and second facet object **24** are facilitated by using an appropriate distributed processing system such as an object recognition broker. In one embodiment, a second facet object proxy **50** resides in first environment **42** and provides communications between aggregate object **14** and second facet object **24**. Second facet object proxy **50** may be a conventional proxy object created from second facet object **24**. Second facet object proxy **50** has an interface modeled on second interface **26**. Interface **51** has a format and needed information similar to second interface **26**.

Referring to FIG. **3**, a facet control module is generally indicated at **30**. Facet control module **30** provides dynamic aggregation of existing objects for application program **12**. Facet control module **30** consists of several modules including a facet creator **70**, an object adder **72**, an object deleter **74**, and a class/interface finder **76**. The functionality of facet control module **30** will be discussed with reference to the flow diagrams of FIGS. **4**, **5** and **6**.

Referring to FIG. **4**, a flow diagram illustrating a method for dynamically aggregating objects is generally indicated at **100**. The method commences at step **102** where application program **12** requests that an aggregate object **14** be created with a specified primary object. The method proceeds to step **104** where facet control module **30** receives the request and forwards it to facet creator **70** to create an aggregate object **14** with a primary facet object **16** of the specified object named in the create aggregate object request. A particular object may be the primary facet object **16** of only one aggregate object **14**. The method proceeds to step **106** where a new facet **32** for the specified primary facet object **16** is created as primary facet **34**. The method proceeds to step **108** where the specified primary facet object **16** is identified and linked to primary facet **34**. The method proceeds to step **110** where primary facet **34** is linked to the new aggregate object **14**.

In one embodiment, the following syntax may be used to create an aggregate object **14**:

Facets myFacets=new Facets (myPrimary);

where myPrimary identifies an existing object which will become primary facet object **16** within the newly created aggregate object **14** identified as myFacets. Facet control module **30** creates an aggregate object **14** identified as myFacets. Next, facet control module **30** creates a primary facet **34** identified as primaryFacet. Primary facet **34** is linked to aggregate object **14**. Next, facet control module **30** creates a primary facet object **16** identified as myPrimary. Primary facet object **16** is linked to primary facet **34**. Facet control module **30** creates primary facet **34** such that primary facet **34** contains the class of primary facet object **16** and the interfaces implemented by primary facet object **16**.

Referring to FIG. **5**, a flow diagram illustrating a method for locating an object that extends a requested class or implements a requested interface within an aggregate object **14** is generally indicated at **120**. The method proceeds to step **122** where application program **12** requests that facet control module **30** locate a facet object **28** that has a class that equals or extends a requested class or implements a requested interface. Upon receiving this type of request, facet control module **30** forwards the request to class/interface finder **76**. In one embodiment, the following syntax may be used to request access to a facet object **28** that has a class that equals or extends the requested class or implements the requested interface:

myfacets.get ("class name");

where myfacets.get identifies the aggregate object **14** (myfacets) and the operation (get) for class/interface finder **76**. The class name in the above example may also identify a requested interface name. The method proceeds to step **124** where a facet reference is set to aggregate object's **14** primary facet, primary facet **34**. Primary facet **34** should be the first facet in the set of facets **32**.

The method proceeds to decisional step **125** where class/interface finder **76** determines if the facet referenced by facet-reference has a class that equals the requested class, has a class that extends the requested class, or implements the requested interface. If the facet in the set of facets **32** identified by the facet-reference meets one of the above tests, the Yes branch of decisional step **125** proceeds to step **126** where class/interface finder **76** returns a reference to the facet in the set of facets **32** identified by the facet-reference. The method proceeds to step **128** where application program **12** uses the returned reference to identify the facet object **28** through the reference to a facet in the set of facets **32**. Application program **12** then invokes the facet object **28**. After step **128**, the method terminates.

Returning to decisional step **125**, if the facet in the set of facets **32** identified by the facet-reference does not meet one

of the aforementioned tests, the No branch of decisional step **125** proceeds to decisional step **130** where class/interface finder **76** determines whether aggregate object **14** has more facets within its associated set of facets **32**. If the set of facets **32** includes more facets, the Yes branch of decisional step **130** proceeds to step **132** where the facet-reference is set to the next facet, first facet **36** in this example, in the set of facets **32** associated with aggregate object **14**. The method returns to decisional step **125** to process the next facet identified by the facet-reference.

Returning to decisional step **130**, if the set of facets **32** associated with aggregate object **14** does not include more facets, the No branch of decisional step **130** proceeds to step **134** where a null reference is returned. Application program **12** would then perform appropriate error processing upon receipt of the null reference. After step **134**, the method terminates.

Referring to FIG. **6**, a flow diagram illustrating a method for adding objects to an aggregate object **14** is generally indicated at **150**. The method commences at step **152** where application program **12** requests a facet object **28** that has a class that equals or extends a requested class. In one embodiment, the following syntax may be used to add objects to a aggregate object **14** as facet objects **28**:

myFacets.of ("class name");

where the desired aggregate object **14** is identified (myFacets) and the desired operation is also identified (.of). "Class name" refers to an existing .class file. When adding facet objects to aggregate object **14**, class names should be used so that an instance of the class may be generated and added to aggregate object **14** as a facet object **28**.

The method proceeds to step **154** where the method of FIG. **5** identified in steps **122–126** and **130–134** is performed until a facet within the set of facets **32** associated with aggregate object **14** is found that has a class that equals or extends the requested class or a null reference is returned.

The method proceeds to decisional step **156** where a determination is made regarding whether a null reference was returned. If a null reference was not returned, the No branch of decisional step **156** proceeds to step **158** where the reference received from step **126** in the method of FIG. **5** is returned. If a null reference is not received, the requested class has already been added to the set of facets **32** in aggregate object **14** and processing may continue. After step **158** the method terminates.

Returning to decisional step **156**, if a null reference is received, the Yes branch of decisional step **156** proceeds to step **160** where object adder **72** creates an instance of the requested class. The method proceeds to step **162** where object adder **72** creates a new facet for the instance of the requested class. Object adder **72** creates the new facet by adding the requested class and the interfaces implemented by that class to the new facet. The new facet is an object that summarizes available information regarding the associated facet object that in this example is the created instance of the requested class. The new facet becomes a member of the set of facets **32** associated with the aggregate object **14**.

The method proceeds to step **164** where object adder **72** links the instance of the requested class created in step **160** to the new facet created in step **162**. The method proceeds to step **166** where object adder **72** links the new facet created in step **162** to the aggregate object **14**. The method proceeds to step **168** where a reference to the new facet created in step **162** is returned. After step **168**, the method terminates.

In one embodiment, the facets.of command that is used to add objects to an existing aggregate object **14** may be used by software developers when they have determined that a requested class should be part of aggregate object **14** but they are not sure that the requested class has been added to facet objects **28** that are associated with aggregate object **14**. By using this type of command, the software developer requests a facet object **28** that has a class that equals or extends a requested class and is guaranteed that a reference to a facet object **28** will be returned.

In addition to the above-referenced sample commands, one embodiment of the present invention includes the following command to determine the primary facet object **16** of aggregate object **14**:

myFacets.getPrimary ( );

where the desired aggregate object **14** is identified as myFacets and the desired operation is identified as getPrimary. The sample command returns a reference to primary facet object **16**.

Another sample command from one embodiment of the present invention includes the following command to determine the members of set of facets **32** associated with aggregate object **14**;

myFacets.getFacets ( );

where the desired aggregate object **14** is identified as myfacets and the desired operation is identified as getfacets. The sample command returns a list of each facet object **28** associated with aggregate object **14**.

Object deleter **74** of facet control module **30** provides a software developer with the ability to delete a specified object from facet objects **28**. The software developer identifies the particular facet object **28** to be removed from aggregate object **14** and instructs facet control module **30** to remove the specified facet object from aggregate object **14**. Object deleter **74** physically deletes the associated facet in set of facets **32** and removes the link between the specified facet object and aggregate object **14**. If the specified facet object has no remaining references, an operating system of the object oriented environment may remove the specified facet object from the object oriented environment during a garbage collection procedure.

Movement

An object may be made mobile within a distributed processing environment by defining the object as a primary facet object **16** linked to an aggregate object **14** and aggregating a mobility object as a second facet object **24** as previously described. To move an object from one address space to another address space, a mobility method is invoked within aggregate object **14**. As previously described, aggregate object **14** then locates the facet without one or more facet objects **28** that provides the requested method. The mobility method may be invoked directly on the mobility facet object. In that case, the mobility facet object informs the aggregate object that the mobility method has been invoked. In another embodiment, the functionality of mobility is built into the object. To cause that object to move from one address space to another address space, a mobility method is invoked on the object.

Referring to FIGS. **7**A–**7**F, the process of moving an object from one address space to another address space within a distributed computing system is depicted. The location of an object may be generally defined as "host:portnumber/alias". For example, the location of an object may be "dallas:8000/store1", where "dallas" defines the host address, "8000" defines the port number, and "store1" defines an alias for the object. The host may be referred to by host name or an IP address. An object may be an agent which is defined as a specialized object that possesses the characteristic of autonomy. Autonomy is the abil-

ity to program an agent with one or more goals that it will attempt to satisfy, even when it has moved into a network on other platforms and has lost all contact with its creator. Agents also have the additional abilities of movement, persistence and event generation.

FIGS. **7**A–**7**F utilize a modified illustration of the structure of the aggregate object depicted in FIG. **1**. Aggregate object **202**, primary facet object **204**, and mobility facet object **206** each have a local reference and a reference holder. The reference holder and local reference are together equivalent to a member of set of facets **32**. Aggregate object **202** has a local reference **208** and a reference holder **210**. Reference holder **210** is linked to local reference **208** and receives and routes messages to aggregate object **202** through local reference **208**. Local reference **208** contains an address identifying the physical location of aggregate object **202**. Similarly, primary facet object **204** has a local reference **212** and a reference holder **214**. Mobility facet object **206** has a local reference **216** and a reference holder **218**. Aggregate object **202** is linked to both reference holder **214** for primary facet object **204** and to reference holder **218** for mobility facet object **206**. A primary object proxy **220** is linked to primary facet object **204** through reference holder **214**. Any message received by primary object proxy **220** is forwarded to reference holder **214** that further forwards the message to primary object **204**. Aggregate object **202**, primary facet object **204**, mobility facet object **206**, and their associated local references and reference holders may be generally referred to as an aggregate group **200**.

The movement process begins in FIG. **7**A where mobility facet object **206** located at a current host address and port number **222** receives a move indication **224**. Move indication **224** may be received from a requesting object **226** located at an originating host address and port number **228**. Requesting object **226** may be any object or application in the distributed computing system and may exist in any address space including an address space on the current host for aggregate group **200**. Aggregate group **200** may also be an agent that carries its own move indication **224**.

In response to move indication **224**, the move operation continues in FIG. **7**B where mobility facet object **206** accesses a lock object **230** in order to block all incoming messages to aggregate group **200** while aggregate group **200** is moving to a new host address and port number. Mobility facet object **206** creates a serialized version **232** of itself at current host address and port number **222**. The serialized version **232** is then sent to a desired new host address and port number **234**. The serialized version may be created by mobility facet object **206** sending a message containing itself as a parameter. A new version **236** of mobility facet object **206** is created at new host address and port number **234** from the serialized version **232**.

The move operation continues in FIG. **7**C where the new version **236** of mobility facet object **206** creates a serialize and move message **238** and sends it to aggregate group **200** at current host address and port number **222**. The serialize and move message **238** informs aggregate group **200** that the initial phase of moving was successful and that the other serializable parts of aggregate group **200** should be serialized and sent to new host address and port number **234**.

The move operation continues at FIG. **7**D where the aggregate group **200** receives the serialize and move message **238**. Aggregate group **200** forwards the serialize and move message **238** to primary facet object **204**. Primary facet object **204** creates a serialized version **240** of itself at current host address and port number **222**. The serialized version **240** is then sent to the new host address and port number **234**. A new version **242** of primary facet object **204** is created at new host address and port number **234** from the serialized version **240**.

The move operation continues at FIG. **7**E where a new aggregate group **244** is generated as previously described with a new aggregate object **246**, new version **242** of primary facet object **204** as a new primary facet object **248** and new version **236** of mobility facet object **206** as a new mobility facet object **250**. New aggregate group **244** and new aggregate object **246** register at new host address and port number **234** along with new version **236** of mobility facet object **206** and new version **242** of primary facet object **204**.

The move operation continues at FIG. **7**F where new aggregate group **244** sends a successful message **252** to aggregate group **200** at current host address and port number **222**. Aggregate group **200**, aggregate object **202**, primary facet object **204**, and mobility facet object **206** deregister from current host address and port number **222**. In addition, aggregate object **202** severs its links to mobility facet object **206** and primary facet object **204**. Aggregate object **202** and mobility facet object **206** are garbage collected by the system. In addition, all references to primary facet object **204** are removed such that it is garbage collected by the system. Local reference **212** of primary facet object **204** is updated with new host address and port number **234** and becomes remote reference **254**. Reference holder **214** remains a reference holder at current host address and port number **222** for new version **242** of primary facet object **204** at new host address and port number **234**. Reference holder **214** is coupled to remote reference **254** that contains the address of the physical location of new version **242** of primary facet object **204**. Reference holder **214** is used to forward messages destined for primary facet object **204** to new host address and port number **234**.

Messages that were blocked by lock object **230** are released and forwarded as necessary to new host address and port number **234** as discussed in detail with relation to FIGS. **8**A and **8**B.

Forwarding

Referring to FIGS. **8**A–**8**B, the process of forwarding messages for a moved object is illustrated. The forwarding operation begins at FIG. **8**A where message MSG**1** from an object **306** at a first host address and port number **308** and message MSG**2** from an object **310** at a second host address and port number **312** require processing by an object **314**. Object **314** has moved to a new host address and port number **316**. Object **314** may be an aggregate group such as new aggregate group **244**. Messages MSG**1** and MSG**2** may be messages that were previously sent but were blocked as a result of move indication **224** or may be messages sent from out of date objects at host address and port numbers not knowing that object **314** has moved to new host address and port number **316**. A reference holder **302** and a remote address **304** occupy an old host address and port number **318** previously occupied by object **314**. In this example, old host address and port number **318** and first host address and port number **308** exist in the same address space identified by the host address. Thus communications between object **306** and reference holder **302** are local.

The forwarding operation continues at FIG. **8**B where reference holder **302**, having the new host address and port number **316** for object **314** stored in remote reference **304**, reroutes message MSG**1** to object **314** at new host address and port number **316**. Messages, such as message MSG**1**,

that are local with respect to reference holder **302** may be directly forwarded to the new location for an object referenced in the message since the message travels through only one host address on its way to a destination host address.

Reference holder **302** receives message MSG and determines that it is a remote message. In one embodiment, a remote message is determined by comparing the host address of the object originating the message with the host address of the reference holder **302**. After determining that message MSG**2** is a remote message, reference holder **302** throws an "object moved" exception to object **310**. Object **310** catches the "object moved" exception and resends message MSG**2** to new host address and port number **316** identified in the "object moved" exception. All future messages from object **310** are sent directly to object **314** at new host address and port number **316**. By using the "object moved" exception, messages destined for a target object do not pass through an intermediate host address thereby making communications between objects more efficient.

Callbacks

Referring to FIGS. **9**A–**9**C, various callback notifications that may occur during the movement of an object from current host address and port number **222** to new address and port number **234** are illustrated. Callback notifications may be sent provided that primary facet object **204** requests callback notification. In one embodiment, primary facet object **204** implements a specified Java interface to request callback notifications. However, any suitable method of requesting callback notifications may be used such as setting a callback notification flag.

FIG. **9**A illustrates a pre-departure notification for primary facet object **204** at current host address and port number **222**. Upon receipt of move notification **224**, a pre-departure notification may be generated for primary facet object **204** to determine if primary facet object **204** is available to be moved. If primary facet object **204** determines that it is not available to be moved, primary facet object **204** may throw a mobility exception causing the move to abort. The mobility exception may be thrown for any reason as determined by primary facet object **204** such as processing required to be completed at current host address and port number **222** has not been completed.

FIG. **9**B illustrates a pre-arrival notification for new version **242** of primary facet object **204** at new host address and port number **234**. The pre-arrival notification occurs immediately after new version **242** of primary facet object **204** is created from serialized version **240** at new host address and port number **234**. The pre-arrival notification may be used by new version **242** of primary facet object **204** to determine if new version **242** was successfully created. If the new version **242** was not successfully created or any other suitable error condition exists within new version **242** of primary facet object **204**, new version **242** may throw a mobility exception causing the move to abort.

FIG. **9**C illustrates post-movement callback notifications. After new aggregate group **244** registers at new host address and port number **234**, a post-arrival callback notification may be sent to new version **242** of primary facet object **204** at new host address and port number **234**. At this point, new aggregate group **244** is the active object and the move cannot be aborted. Thus, the move is deemed successful. This callback notification allows new aggregate group **244** to perform specific post-move processing that is not provided by the system.

After new aggregate group **244** registers at new host address and port number **234** but prior to aggregate group **200** disconnecting its component parts, a post-departure callback notification may be sent to primary facet object **204**. At this point, the component parts of aggregate group **200** are considered stale since a new active aggregate group **244** exists at new host address and port number **234**. The post-departure callback notification allows aggregate group **200** to perform internal final processing before its component parts are delinked and garbage collected and prior to unblocking any messages at current host address and port number **222**.

Thus, it is apparent that there has been provided in accordance with the present invention, a method for moving objects in a distributed computing environment that satisfies the advantages set forth above. Although the present invention and its advantages have been described in detail, it should be understood that various changes, substitutions, and alterations may be readily apparent to those skilled in the art and may be made herein without departing from the spirit and the scope of the present invention as defined by the following claims.

What is claimed is:

1. A method for moving objects in a distributed computing system, comprising:

receiving a move indication at a mobility object aggregated with a primary object through an aggregate object located at a current host address and port number, the primary object being unique to the aggregate object, the mobility object providing a mobility functionality for the primary object, the move indication instructing the mobility object to move the primary object to a new host address and port number, the aggregate object having the primary object as a primary facet object and the mobility object as a facet object;

creating a serialized version of the mobility object in response to the move indication;

sending the serialized version of the mobility object to the new host address and port number;

creating a new version of the mobility object at the new host address and port number from the serialized version of the mobility object;

creating a serialized version of the primary object in response to a serialize and move message from the new version of the mobility object;

sending the serialized version of the primary object to the new host address and port number;

creating a new version of the primary object at the new host address and port number from the serialized version of the primary object;

creating a new aggregate object with the new version of the primary object as a new primary facet object and the new version of the mobility object as a new facet object at the new host address and port number.

2. The method of claim **1**, further comprising:

locking the aggregate object at the current host address and port number in response to the move indication; and

unlocking the aggregate object at the current host address and port number in response to creating the new aggregate object at the new host address and port number.

3. The method of claim **1**, further **[**comprising:**]** *comprising* retaining an old version of the aggregate object, the primary object, and the mobility object at the current host address and port number.

4. The method of claim **1**, further **[**comprising:**]** *comprising* aggregating the mobility object at the current host

address and port number with the primary object at the current host address and port number, the mobility object linked to an aggregate object at the current host address and port number, the primary object linked to the aggregate object at the current host address and port number.

5. The method of claim **1**, further comprising instructing the primary object to move to the new host address and port number by invoking a method on the mobility object at the current host address and port number for moving the primary object to the new host address and port number.

6. The method of claim **1**, further comprising:

informing the primary object at the current host address and port number that the primary object is about to be moved in response to the move indication;

performing pre-departure processing by the primary object at the current host address and port number;

determining whether the object is available to move;

vetoing the move in response to determining that the object is not available to move; and

affirming the move in response to determining that the object is available to move.

7. The method of claim **1**, further comprising:

completing messages currently being processed by the primary object at the current host address and port number; and

suspending new messages arriving at the primary object at the current host address and port number.

8. The method of claim **7**, further **[**comprising:**]** *comprising* forwarding suspended messages to the new host address and port number for processing.

9. The method of claim **1**, further comprising:

storing the new host address and port number in a reference holder at the current host address and port number; and

forwarding messages received at the current host address and port number for the primary object to the new version of the primary object at the new host address and port number.

10. The method of claim **1**, further **[**comprising:**]** *comprising* registering the new aggregate object and the new version of the primary object at the new host address and port number.

11. The method of claim **1**, further comprising:

deregistering the aggregate object and the primary object at the current host address and port number; and

garbage collecting the aggregate object and the primary object at the current host address and port number.

12. The method of claim **1**, further comprising:

sending a message from a proxy to the primary object at the current host address and port number;

throwing an exception back to the proxy indicating that the primary object has moved to the new host address and port number; and

resending the message from the proxy to the new version of the primary object at the new host address and port number in response to the exception.

13. The method of claim **1**, further comprising:

sending a message from a proxy to the primary object at the current host address and port number; and

forwarding the message from the current host address and port number to the new version of the primary object at the new host address and port number.

14. The method of claim **1**, further comprising:

evaluating the sending of the serialized version of the primary object and creating of the new version of the primary object by querying the new version of the primary object to determine if the sending and creating was successful; and

aborting the method for moving objects in response to an unsuccessful sending and creating.

15. The method of claim **1**, further **[**comprising:**]** *comprising* sending a serialize and move message from the new version of the mobility object at the new host address and port number to the primary object at the current host address and port number, the serialize and move message including an indication that the new version of the mobility object has been established at the new host address and port number.

16. The method of claim **1**, further comprising:

locking the aggregate object at the current host address and port number in response to the move indication;

sending a successful move message from the new aggregate object at the new host address and port number to the aggregate object at the current host address and port number;

unlocking the aggregate object at the current host address and port number;

deregistering the aggregate object and the primary object at the current host address and port number in response to the successful move message;

storing the new host address and port number in a reference holder at the current host address and port number, the reference holder used for forwarding messages received for the primary object at the current host address and port number.

17. The method of claim **1**, further comprising:

informing the new version of the primary object at the new host address and port number that movement of the aggregate object at the current host address and port number has started;

performing pre-arrival processing by the new version of the primary object at the new host address and port number;

determining whether the new version of the primary object at the new host address and port number authorizes completion of the method for moving objects; and

aborting the method for moving objects in response to a negative authorization from the new version of the primary object at the new host address and port number.

18. The method of claim **11**, further comprising:

informing the new aggregate object at the new host address and port number that the aggregate object at the current host address and port number has been deregistered;

performing post-arrival processing by the aggregate object at the current host address and port number.

19. The method of claim **1**, further comprising:

informing the aggregate object at the current host address and port number that creation of the new aggregate object at the new host address and port number has completed;

performing post-departure processing by the aggregate object at the current host address and port number.

20. A method for moving objects in a distributed computing system, comprising:

dynamically aggregating a mobility object with a primary object to create an aggregate object located at a current host location, the primary object being unique to the aggregate object and the mobility object providing a mobility functionality for the primary object, and the

aggregate object including the primary object as a primary facet object and the mobility object as a facet object;

receiving a move indication at the mobility object, the move indication instructing the mobility object to move the primary object to a new host location;

sending a new version of the mobility object to the new host location in response to the move indication; and

sending a new version of the primary object to the new host location in response to a move message from the new version of the mobility object;

wherein a new aggregate object is created at the new host location, the new aggregate object having the new version of the primary object associated with the new version of the mobility object.

21. The method of claim 20, further comprising:

serializing the new version of the mobility object prior to sending;

wherein the new version of the mobility object is created at the new host location from the serialized version of the mobility object; and

serializing the new version of the primary object prior to sending;

wherein the new version of the primary object is created at the new host location from the serialized version of the primary object.

22. The method of claim 20, wherein the new aggregate object at the new host location comprises the new version of the primary object as a new primary facet object and the new version of the mobility object as a new facet object.

23. The method of claim 20, wherein the current host location is characterized by a current host address and port number, and the new host location is characterized by a new host address and port number.

24. The method of claim 20, further comprising:

locking the aggregate object at the current host location in response to the move indication; and

unlocking the aggregate object at the current host location in response to creating the new aggregate object at the new host location.

25. The method of claim 20, further comprising retaining an old version of the aggregate object, the primary object, and the mobility object at the current host location.

26. The method of claim 20, further comprising instructing the primary object to move to the new host location by invoking a method on the mobility object at the current host location for moving the primary object to the new host location.

27. The method of claim 20, further comprising:

informing the primary object at the current host location that the primary object is about to be moved in response to the move indication;

performing pre-departure processing by the primary object at the current host location;

determining whether the primary object is available to move;

vetoing the move in response to determining that the primary object is not available to move; and

affirming the move in response to determining that the primary object is available to move.

28. The method of claim 20, further comprising:

completing messages currently being processed by the primary object at the current host location; and

suspending new messages arriving at the primary object at the current host location.

29. The method of claim 28, further comprising forwarding suspended messages to the new host location for processing.

30. The method of claim 20, further comprising:

storing the new host location in a reference holder at the current host location; and

forwarding messages received at the current host location for the primary object to the new version of the primary object at the new host location.

31. The method of claim 20, wherein the new aggregate object and the new version of the primary object are registered at the new host location.

32. The method of claim 20, further comprising:

deregistering the aggregate object and the primary object at the current host location; and

garbage collecting the aggregate object and the primary object at the current host location.

33. The method of claim 20, further comprising:

sending a message from a proxy to the primary object at the current host location;

sending an exception back to the proxy indicating that the primary object has moved to the new host location; and

resending the message from the proxy to the new version of the primary object at the new host location in response to the exception.

34. The method of claim 20, further comprising:

sending a message from a proxy to the primary object at the current host location; and

forwarding the message from the current host location to the new version of the primary object at the new host location.

35. The method of claim 20, further comprising:

evaluating the sending of the new version of the primary object by querying the new version of the primary object to determine if the sending was successful; and

aborting the method for moving objects in response to an unsuccessful sending.

36. The method of claim 20, further comprising receiving a move message from the new version of the mobility object at the new host location at the primary object at the current host location, the move message including an indication that the new version of the mobility object has been established at the new host location.

37. The method of claim 20, further comprising:

locking the aggregate object at the current host location in response to the move indication;

receiving a successful move message from the new aggregate object at the new host location at the aggregate object at the current host location;

unlocking the aggregate object at the current host location;

deregistering the aggregate object and the primary object at the current host location in response to the successful move message; and

storing the new host location in a reference holder at the current host location, the reference holder used for forwarding messages received for the primary object at the current host location.

38. The method of claim 20, further comprising:

informing the new version of the primary object at the new host location that movement of the aggregate object at the current host location has started;

wherein pre-arrival processing is performed by the new version of the primary object at the new host location;

determining whether the new version of the primary object at the new host location authorizes completion of the method for moving objects; and

aborting the method for moving objects in response to a negative authorization from the new version of the primary object at the new host location.

39. The method of claim 32, further comprising:

informing the new aggregate object at the new host location that the aggregate object at the current host location has been deregistered; and

performing post-arrival processing by the aggregate object at the current host location.

40. The method of claim 20, further comprising:

informing the aggregate object at the current host location that creation of the new aggregate object at the new host location has completed; and

performing post-departure processing by the aggregate object at the current location.

41. One or more computer-readable storage media comprising computer-executable instructions that, when executed, direct a computer to move an object in a distributed computing environment, the computer-executable instructions configured to:

dynamically aggregate a mobility object with a primary object to create an aggregate object located at a current host location, the primary object being unique to the aggregate object and the mobility object providing a mobility functionality for the primary object, and the aggregate object including the primary object as a primary facet object and the mobility object as a facet object;

receive a move indication at the mobility object, the move indication instructing the mobility object to move the primary object to a new host location;

send a new version of the mobility object to the new host location in response to the move indication;

send a new version of the primary object to the new location in response to a move message from the new version of the mobility object; and

create a new aggregate object at the new host location, the new aggregate object having the new version of the primary object associated with the new version of the mobility object.

42. One or more computer-readable storage media as recited in claim 41, further comprising computer-executable instructions configured to:

serialize the new version of the mobility object prior to sending;

create the new version of the mobility object at the new host location from the serialized version of the mobility object;

serialize the new version of the primary object prior to sending; and

create the new version of the primary object at the new host location from the serialized version of the primary object.

43. One or more computer-readable storage media as recited in claim 41, wherein the current host location is characterized by a current host address and port number, and the new host location is characterized by a new host address and port number.

44. One or more computer-readable storage media as recited in claim 41, further comprising computer-executable instructions configured to:

lock the aggregate object at the current host location in response to the move indication; and

unlock the aggregate object at the current host location in response to creating the new aggregate object at the new host location.

45. One or more computer-readable storage media as recited in claim 41, further comprising computer-executable instructions configured to retain an old version of the aggregate object, the primary object, and the mobility object at the current host location.

46. One or more computer-readable storage media as recited in claim 41, further comprising computer-executable instructions configured to instruct the primary object to move to the new host location by invoking a method on the mobility object at the current host location for moving the primary object to the new host location.

47. One or more computer-readable storage media as recited in claim 41, further comprising computer-executable instructions configured to:

inform the primary object at the current host location that the primary object is about to be moved in response to the move indication;

perform pre-departure processing by the primary object at the current host location;

determine whether the primary object is available to move;

veto the move in response to determining that the primary object is not available to move; and

computer readable program code configured to affirm the move in response to determining that the primary object is available to move.

48. One or more computer-readable storage media as recited in claim 41, further comprising computer-executable instructions configured to:

complete messages currently being processed by the primary object at the current host location; and

suspend new messages arriving at the primary object at the current host location.

49. One or more computer-readable storage media as recited in claim 41, further comprising computer-executable instructions configured to forward suspended messages to the new host location for processing.

50. One or more computer-readable storage media as recited in claim 41, further comprising computer-executable instructions configured to:

store the new host location in a reference holder at the current host location; and

forward messages received at the current host location for the primary object to the new version of the primary object at the new host location.

51. One or more computer-readable storage media as recited in claim 41, further comprising computer-executable instructions configured to register the new aggregate object and the new version of the primary object at the new host location.

52. One or more computer-readable storage media as recited in claim 41, further comprising computer-executable instructions configured to:

deregister the aggregate object and the primary object at the current host location; and

garbage collect the aggregate object and the primary object at the current host location.

53. One or more computer-readable storage media as recited in claim 41, further comprising computer-executable instructions configured to:

send a message from a proxy to the primary object at the current host location;

throw send an exception back to the proxy indicating that the primary object has moved to the new host location; and

resend the message from the proxy to the new version of the primary object at the new host location in response to the exception.

54. One or more computer-readable storage media as recited in claim 41, further comprising computer-executable instructions configured to:

send a message from a proxy to the primary object at the current host location; and

forward the message from the current host location to the new version of the primary object at the new host location.

55. One or more computer-readable storage media as recited in claim 41, further comprising computer-executable instructions configured to:

evaluate the sending of the new version of the primary object by querying the new version of the primary object to determine if the sending was successful; and

abort the method for moving objects in response to an unsuccessful sending.

56. One or more computer-readable storage media as recited in claim 41, further comprising computer-executable instructions configured to send a move message from the new version of the mobility object at the new host location to the primary object at the current host location, the move message including an indication that the new version of the mobility object has been established at the new host location.

57. One or more computer-readable storage media as recited in claim 41, further comprising computer-executable instructions configured to:

lock the aggregate object at the current host location in response to the move indication;

send a successful move message from the new aggregate object at the new host location to the aggregate object at the current host location;

unlock the aggregate object at the current host location;

deregister the aggregate object and the primary object at the current host location in response to the successful move message; and

store the new host location in a reference holder at the current host location, the reference holder used for forwarding messages received for the primary object at the current host location.

58. One or more computer-readable storage media as recited in claim 41, further comprising computer-executable instructions configured to:

inform the new version of the primary object at the new host location that movement of the aggregate object at the current host location has started;

perform pre-arrival processing by the new version of the primary object at the new host location;

determine whether the new version of the primary object at the new host location authorizes completion of the method for moving objects; and

abort the method for moving objects in response to a negative authorization from the new version of the primary object at the new host location.

59. One or more computer-readable storage media as recited in claim 41, further comprising computer-executable instructions configured to:

inform the new aggregate object at the new host location that the aggregate object at the current host location has been deregistered; and

perform post-arrival processing by the aggregate object at the current host location.

60. One or more computer-readable storage media as recited in claim 41, further comprising computer-executable instructions configured to:

inform the aggregate object at the current host location that creation of the new aggregate object at the new host location has completed; and

perform post-departure processing by the aggregate object at the current location.

61. A method for moving objects in a distributed computing system, comprising:

dynamically aggregating a mobility object with a primary object to create an aggregate object located at a current host location, the primary object being unique to the aggregate object and the mobility object providing a mobility functionality for the primary object;

receiving a move indication at the mobility object, the move indication instructing the mobility object to move the primary object to a new host location;

sending a new version of the mobility object to the new host location in response to the move indication; and

sending a new version of the primary object to the new host location in response to a move message from the new version of the mobility object;

wherein a new aggregate object is created at the new host location, the new aggregate object having the new version of the primary object associated with the new version of the mobility object, and the new aggregate object including the new version of the primary object as a new primary facet object and the new version of the mobility object as a new facet object.

62. The method of claim 61, further comprising:

serializing the new version of the mobility object prior to sending;

wherein the new version of the mobility object is created at the new host location from the serialized version of the mobility object; and

serializing the new version of the primary object prior to sending;

wherein the new version of the primary object is created at the new host location from the serialized version of the primary object.

63. The method of claim 61, wherein the current host location is characterized by a current host address and port number, and the new host location is characterized by a new host address and port number.

64. The method of claim 61, further comprising:

locking the aggregate object at the current host location in response to the move indication; and

unlocking the aggregate object at the current host location in response to creating the new aggregate object at the new host location.

65. The method of claim 61, further comprising retaining an old version of the aggregate object, the primary object, and the mobility object at the current host location.

66. The method of claim 61, further comprising instructing the primary object to move to the new host location by invoking a method on the mobility object at the current host location for moving the primary object to the new host location.

67. The method of claim 61, further comprising:

informing the primary object at the current host location that the primary object is about to be moved in response to the move indication;

performing pre-departure processing by the primary object at the current host location;

determining whether the primary object is available to move;

vetoing the move in response to determining that the primary object is not available to move; and

affirming the move in response to determining that the primary object is available to move.

68. The method of claim 61, further comprising:

completing messages currently being processed by the primary object at the current host location; and

suspending new messages arriving at the primary object at the current host location.

69. The method of claim 68, further comprising forwarding suspended messages to the new host location for processing.

70. The method of claim 61, further comprising:

storing the new host location in a reference holder at the current host location; and

forwarding messages received at the current host location for the primary object to the new version of the primary object at the new host location.

71. The method of claim 61, wherein the new aggregate object and the new version of the primary object are registered at the new host location.

72. The method of claim 61, further comprising:

deregistering the aggregate object and the primary object at the current host location; and

garbage collecting the aggregate object and the primary object at the current host location.

73. The method of claim 61, further comprising:

sending a message from a proxy to the primary object at the current host location;

sending an exception back to the proxy indicating that the primary object has moved to the new host location; and

resending the message from the proxy to the new version of the primary object at the new host location in response to the exception.

74. The method of claim 61, further comprising:

sending a message from a proxy to the primary object at the current host location; and

forwarding the message from the current host location to the new version of the primary object at the new host location.

75. The method of claim 61, further comprising:

evaluating the sending of the new version of the primary object by querying the new version of the primary object to determine if the sending was successful; and

aborting the method for moving objects in response to an unsuccessful sending.

76. The method of claim 61, further comprising receiving a move message from the new version of the mobility object at the new host location at the primary object at the current host location, the move message including an indication that the new version of the mobility object has been established at the new host location.

77. The method of claim 61, further comprising:

locking the aggregate object at the current host location in response to the move indication;

receiving a successful move message from the new aggregate object at the new host location at the aggregate object at the current host location;

unlocking the aggregate object at the current host location;

deregistering the aggregate object and the primary object at the current host location in response to the successful move message; and

storing the new host location in a reference holder at the current host location, the reference holder used for forwarding messages received for the primary object at the current host location.

78. The method of claim 61, further comprising:

informing the new version of the primary object at the new host location that movement of the aggregate object at the current host location has started;

wherein pre-arrival processing is performed by the new version of the primary object at the new host location;

determining whether the new version of the primary object at the new host location authorizes completion of the method for moving objects; and

aborting the method for moving objects in response to a negative authorization from the new version of the primary object at the new host location.

79. The method of claim 72, further comprising:

informing the new aggregate object at the new host location that the aggregate object at the current host location has been deregistered; and

performing post-arrival processing by the aggregate object at the current host location.

80. The method of claim 61, further comprising:

informing the aggregate object at the current host location that creation of the new aggregate object at the new host location has completed; and

performing post-departure processing by the aggregate object at the current location.

81. One or more computer-readable storage media comprising computer-executable instructions that, when executed, direct a computer to move an object in a distributed computing environment, the computer-executable instructions configured to:

dynamically aggregate a mobility object with a primary object to create an aggregate object located at a current host location, the primary object being unique to the aggregate object and the mobility object providing a mobility functionality for the primary object, the aggregate object including the primary object as a primary facet object and the mobility object as a facet object;

receive a move indication at the mobility object, the move indication instructing the mobility object to move the primary object to a new host location;

send a new version of the mobility object to the new host location in response to the move indication;

send a new version of the primary object to the new host location in response to a move message from the new version of the mobility object; and

create a new aggregate object at the new host location, the new aggregate object having the new version of the primary object associated with the new version of the mobility object, and the new aggregate object creates the new version of the primary object as a new primary facet object and creates the new version of the mobility object as a new facet object.

82. One or more computer-readable storage media as recited in claim 81, further comprising computer-executable instructions configured to:

serialize the new version of the mobility object prior to sending;

create the new version of the mobility object at the new host location from the serialized version of the mobility object;

serialize the new version of the primary object prior to sending; and

create the new version of the primary object at the new host location from the serialized version of the primary object.

83. One or more computer-readable storage media as recited in claim 81, wherein the current host location is characterized by a current host address and port number, and the new host location is characterized by a new host address and port number.

84. One or more computer-readable storage media as recited in claim 81, further comprising computer-executable instructions configured to:

lock the aggregate object at the current host location in response to the move indication; and

unlock the aggregate object at the current host location in response to creating the new aggregate object at the new host location.

85. One or more computer-readable storage media as recited in claim 81, further comprising computer-executable instructions configured to retain an old version of the aggregate object, the primary object, and the mobility object at the current host location.

86. One or more computer-readable storage media as recited in claim 81, further comprising computer-executable instructions configured to instruct the primary object to move to the new host location by invoking a method on the mobility object at the current host location for moving the primary object to the new host location.

87. One or more computer-readable storage media as recited in claim 81, further comprising computer-executable instructions configured to:

inform the primary object at the current host location that the primary object is about to be moved in response to the move indication;

perform pre-departure processing by the primary object at the current host location;

determine whether the primary object is available to move;

veto the move in response to determining that the primary object is not available to move; and

affirm the move in response to determining that the primary object is available to move.

88. One or more computer-readable storage media as recited in claim 81, further comprising computer-executable instructions configured to:

complete messages currently being processed by the primary object at the current host location; and

suspend new messages arriving at the primary object at the current host location.

89. One or more computer-readable storage media as recited in claim 81, further comprising computer-executable instructions configured to forward suspended messages to the new host location for processing.

90. One or more computer-readable storage media as recited in claim 81, further comprising computer-executable instructions configured to:

store the new host location in a reference holder at the current host location; and

forward messages received at the current host location for the primary object to the new version of the primary object at the new host location.

91. One or more computer-readable storage media as recited in claim 81, further comprising computer-executable instructions configured to register the new aggregate object and the new version of the primary object at the new host location.

92. One or more computer-readable storage media as recited in claim 81, further comprising computer-executable instructions configured to:

deregister the aggregate object and the primary object at the current host location; and

garbage collect the aggregate object and the primary object at the current host location.

93. One or more computer-readable storage media as recited in claim 81, further comprising computer-executable instructions configured to:

send a message from a proxy to the primary object at the current host location;

send an exception back to the proxy indicating that the primary object has moved to the new host location; and

resend the message from the proxy to the new version of the primary object at the new host location in response to the exception.

94. One or more computer-readable storage media as recited in claim 81, further comprising computer-executable instructions configured to:

send a message from a proxy to the primary object at the current host location; and

forward the message from the current host location to the new version of the primary object at the new host location.

95. One or more computer-readable storage media as recited in claim 81, further comprising computer-executable instructions configured to:

evaluate the sending of the new version of the primary object by querying the new version of the primary object to determine if the sending was successful; and

abort the method for moving objects in response to an unsuccessful sending.

96. One or more computer-readable storage media as recited in claim 81, further comprising computer-executable instructions configured to send a move message from the new version of the mobility object at the new host location to the primary object at the current host location, the move message including an indication that the new version of the mobility object has been established at the new host location.

97. One or more computer-readable storage media as recited in claim 81, further comprising computer-executable instructions configured to:

lock the aggregate object at the current host location in response to the move indication;

send a successful move message from the new aggregate object at the new host location to the aggregate object at the current host location;

unlock the aggregate object at the current host location;

deregister the aggregate object and the primary object at the current host location in response to the successful move message; and

store the new host location in a reference holder at the current host location, the reference holder used for forwarding messages received for the primary object at the current host location.

98. One or more computer-readable storage media as recited in claim 81, further comprising computer-executable instructions configured to:

inform the new version of the primary object at the new host location that movement of the aggregate object at the current host location has started;

perform pre-arrival processing by the new version of the primary object at the new host location;

determine whether the new version of the primary object at the new host location authorizes completion of the method for moving objects; and

abort the method for moving objects in response to a negative authorization from the new version of the primary object at the new host location.

99. One or more computer-readable storage media as recited in claim 81, further comprising computer-executable instructions configured to:

inform the new aggregate object at the new host location that the aggregate object at the current host location has been deregistered; and

perform post-arrival processing by the aggregate object at the current host location.

100. One or more computer-readable storage media as recited in claim 81, further comprising computer-executable instructions configured to:

inform the aggregate object at the current host location that creation of the new aggregate object at the new host location has completed; and

perform post-departure processing by the aggregate object at the current location.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

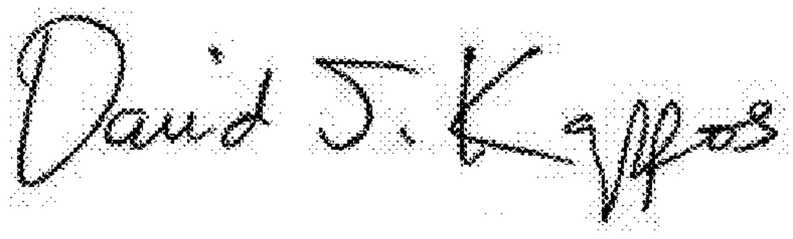
CERTIFICATE OF CORRECTION

PATENT NO. : RE41,706 E
APPLICATION NO. : 11/331418
DATED : September 14, 2010
INVENTOR(S) : Graham W. Glass et al.

It is certified that error appears in the above-identified patent and that said Letters Patent is hereby corrected as shown below:

In column 17, line 37, in Claim 41, delete "new" and insert -- new host --, therefor.

Signed and Sealed this
Eleventh Day of January, 2011



David J. Kappos
Director of the United States Patent and Trademark Office