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(54) **SYSTEMS AND METHODS FOR MANAGING WEB SERVICES VIA A FRAMEWORK OF INTERFACES**

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G06F 3/048 (2006.01)

(52) **U.S. Cl.** **715/744**; 715/735

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See application file for complete search history.

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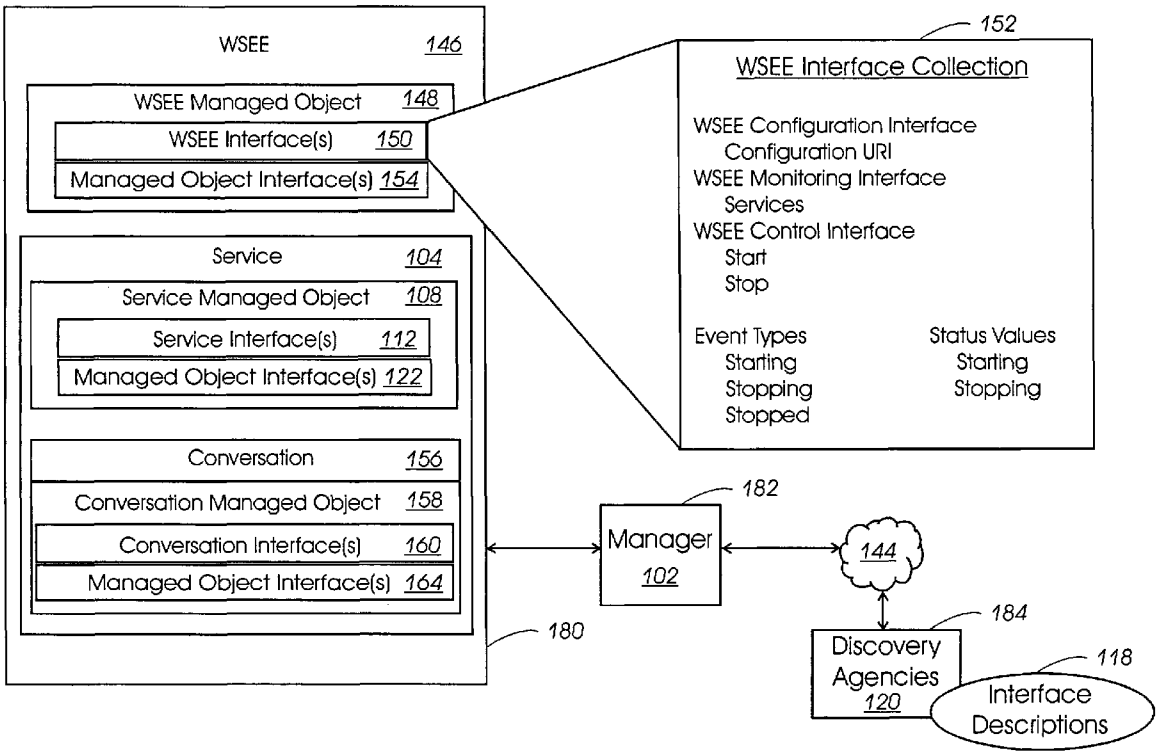
Primary Examiner — Le Luu

(57) **ABSTRACT**

A system for managing a Web service comprises a service managed object associated with the Web service. The service managed object includes an interface configured to represent management features for the service to a manager. The manager can access information regarding the Web service via the interface such as a list of conversations associated with the Web service, and the relationship of the service managed object to other managed objects.

39 Claims, 19 Drawing Sheets



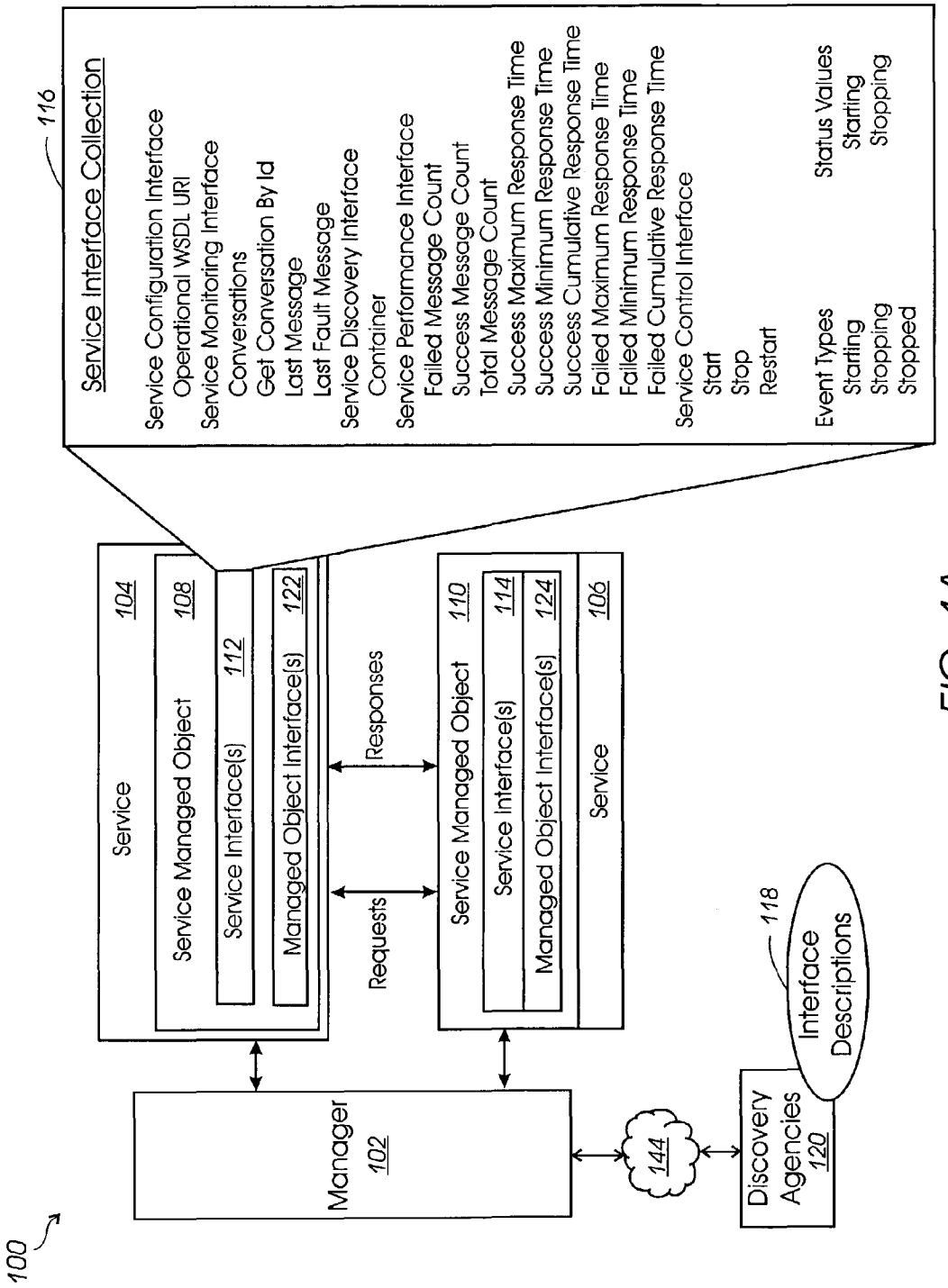

100
Manager
102
Service
104
Service Managed Object
108
Service Interface(s)
112
Managed Object Interface(s)
122
Requests
Responses
Service Managed Object
110
Service Interface(s)
114
Managed Object Interface(s)
124
Service
106
144
Discovery Agencies
120
Interface Descriptions
118
116
Service Interface Collection
Service Configuration Interface
Operational WSDL URI
Service Monitoring Interface
Conversations
Get Conversation By Id
Last Message
Last Fault Message
Service Discovery Interface
Container
Service Performance Interface
Failed Message Count
Success Message Count
Total Message Count
Success Maximum Response Time
Success Minimum Response Time
Success Cumulative Response Time
Failed Maximum Response Time
Failed Minimum Response Time
Failed Cumulative Response Time
Service Control Interface
Start
Stop
Restart
Event Types
Starting
Stopping
Stopped
Status Values
Starting
Stopping

FIG. 1A

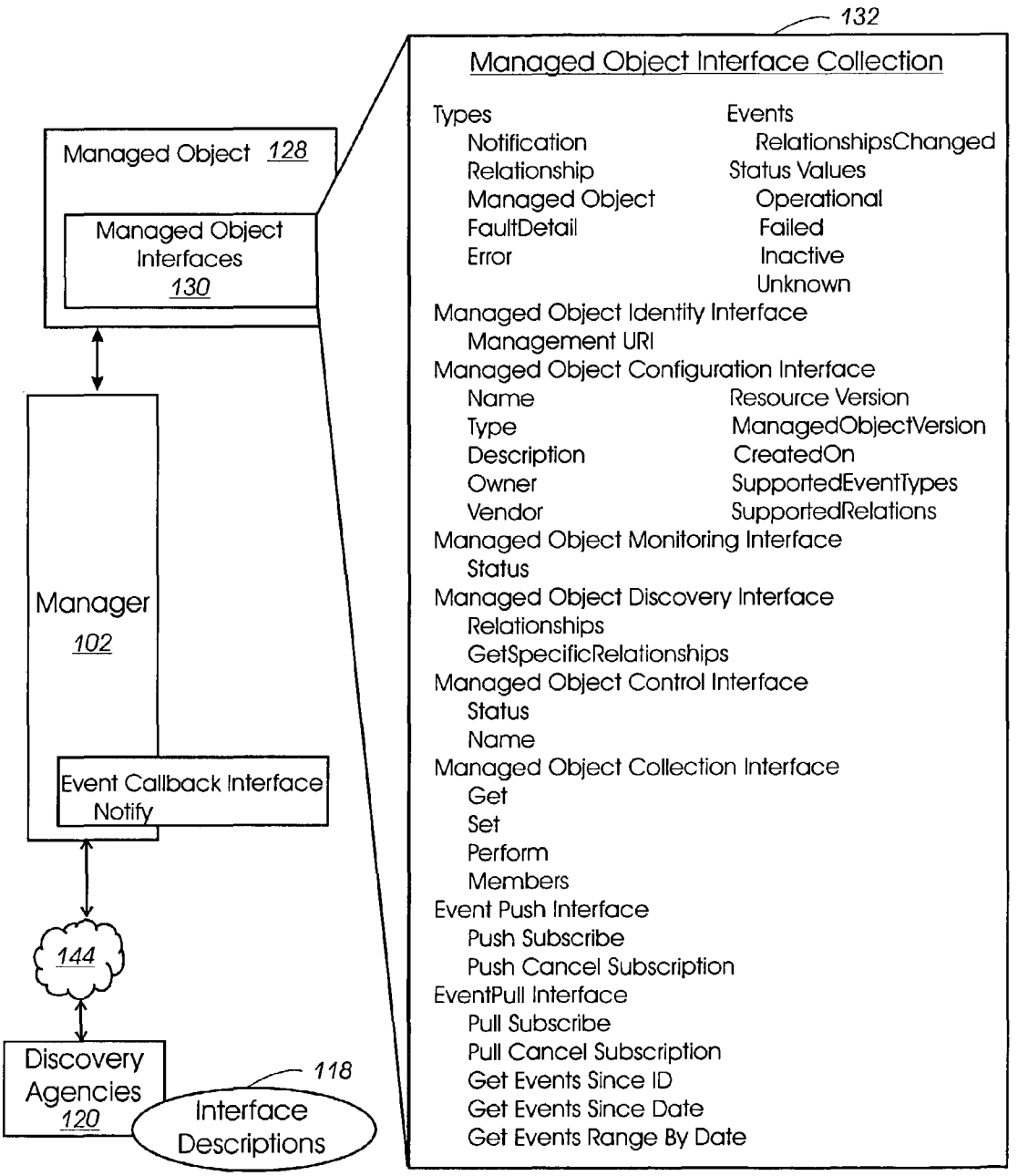

132
Managed Object Interface Collection
Types
Notification
Relationship
Managed Object
FaultDetail
Error
Events
RelationshipsChanged
Status Values
Operational
Failed
Inactive
Unknown
Managed Object Identity Interface
Management URI
Managed Object Configuration Interface
Name
Type
Description
Owner
Vendor
Resource Version
ManagedObjectVersion
CreatedOn
SupportedEventTypes
SupportedRelations
Managed Object Monitoring Interface
Status
Managed Object Discovery Interface
Relationships
GetSpecificRelationships
Managed Object Control Interface
Status
Name
Managed Object Collection Interface
Get
Set
Perform
Members
Event Push Interface
Push Subscribe
Push Cancel Subscription
EventPull Interface
Pull Subscribe
Pull Cancel Subscription
Get Events Since ID
Get Events Since Date
Get Events Range By Date
Managed Object 128
Managed Object Interfaces 130
Manager 102
Event Callback Interface
Notify
144
Discovery Agencies 120
118
Interface Descriptions

FIG. 1B

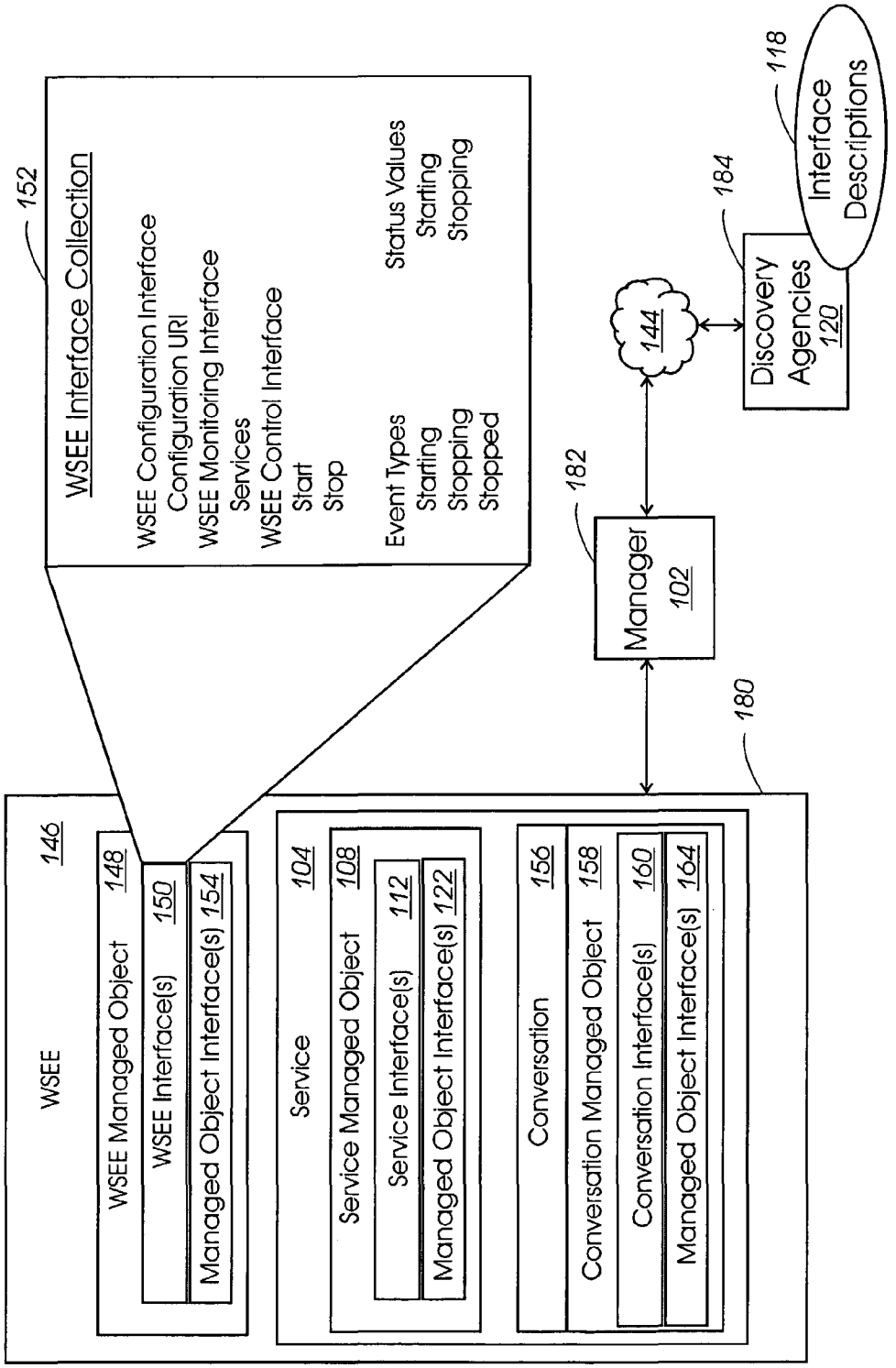

152
WSEE Interface Collection
WSEE Configuration Interface
Configuration URI
WSEE Monitoring Interface
Services
WSEE Control Interface
Start
Stop
Status Values
Starting
Stopping
Event Types
Starting
Stopping
Stopped
118
Interface Descriptions
184
Discovery Agencies 120
144
182
Manager 102
180
WSEE 146
WSEE Managed Object 148
WSEE Interface(s) 150
Managed Object Interface(s) 154
Service 104
Service Managed Object 108
Service Interface(s) 112
Managed Object Interface(s) 122
Conversation 156
Conversation Managed Object 158
Conversation Interface(s) 160
Managed Object Interface(s) 164

FIG. 1C

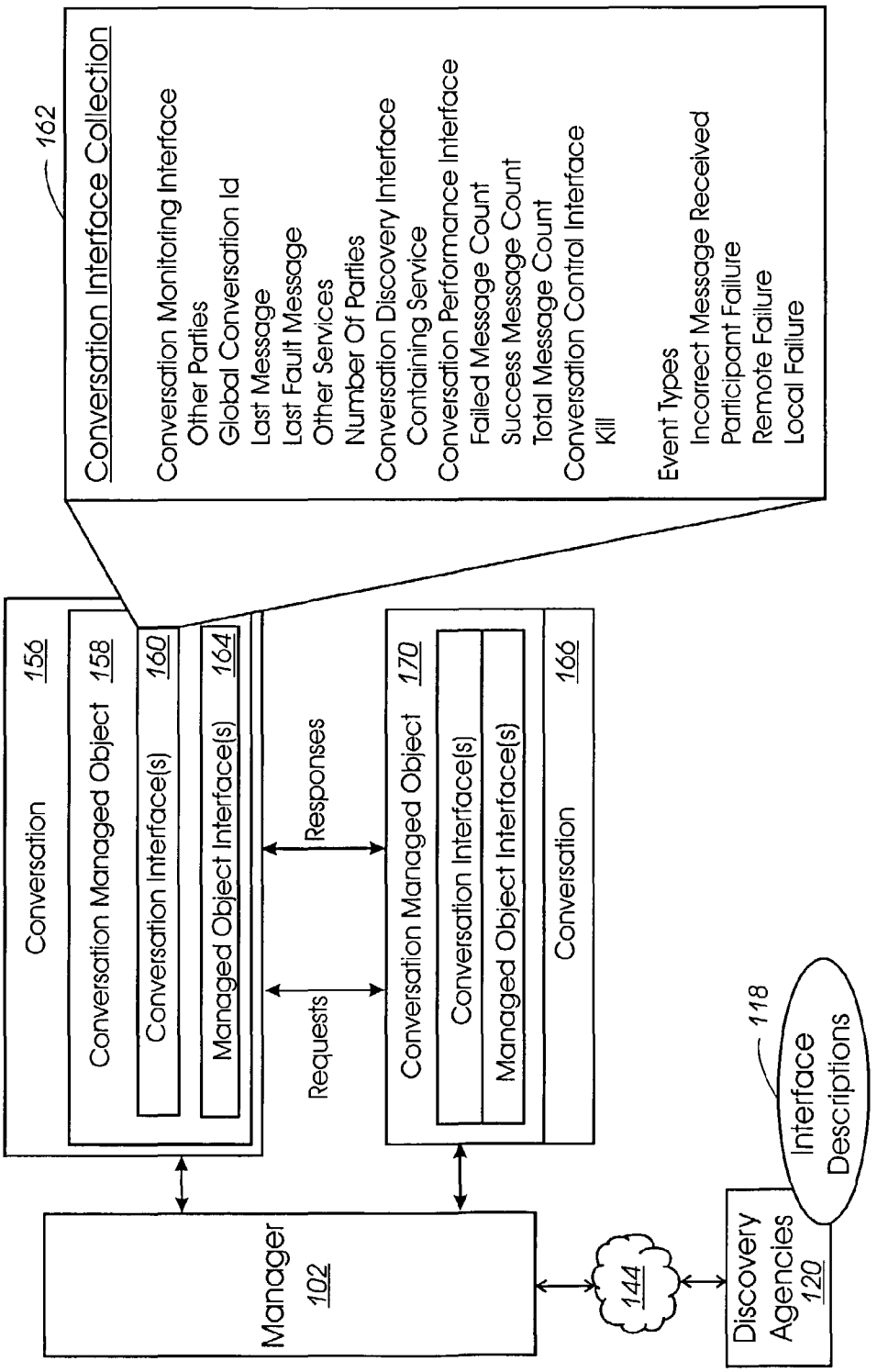

162
Conversation Interface Collection
Conversation Monitoring Interface
Other Parties
Global Conversation Id
Last Message
Last Fault Message
Other Services
Number Of Parties
Conversation Discovery Interface
Containing Service
Conversation Performance Interface
Failed Message Count
Success Message Count
Total Message Count
Conversation Control Interface
Kill
Event Types
Incorrect Message Received
Participant Failure
Remote Failure
Local Failure
Conversation 156
Conversation Managed Object 158
Conversation Interface(s) 160
Managed Object Interface(s) 164
Requests
Responses
Conversation Managed Object 170
Conversation Interface(s)
Managed Object Interface(s)
Conversation 166
Manager 102
144
Discovery Agencies 120
118
Interface Descriptions

FIG. 1D

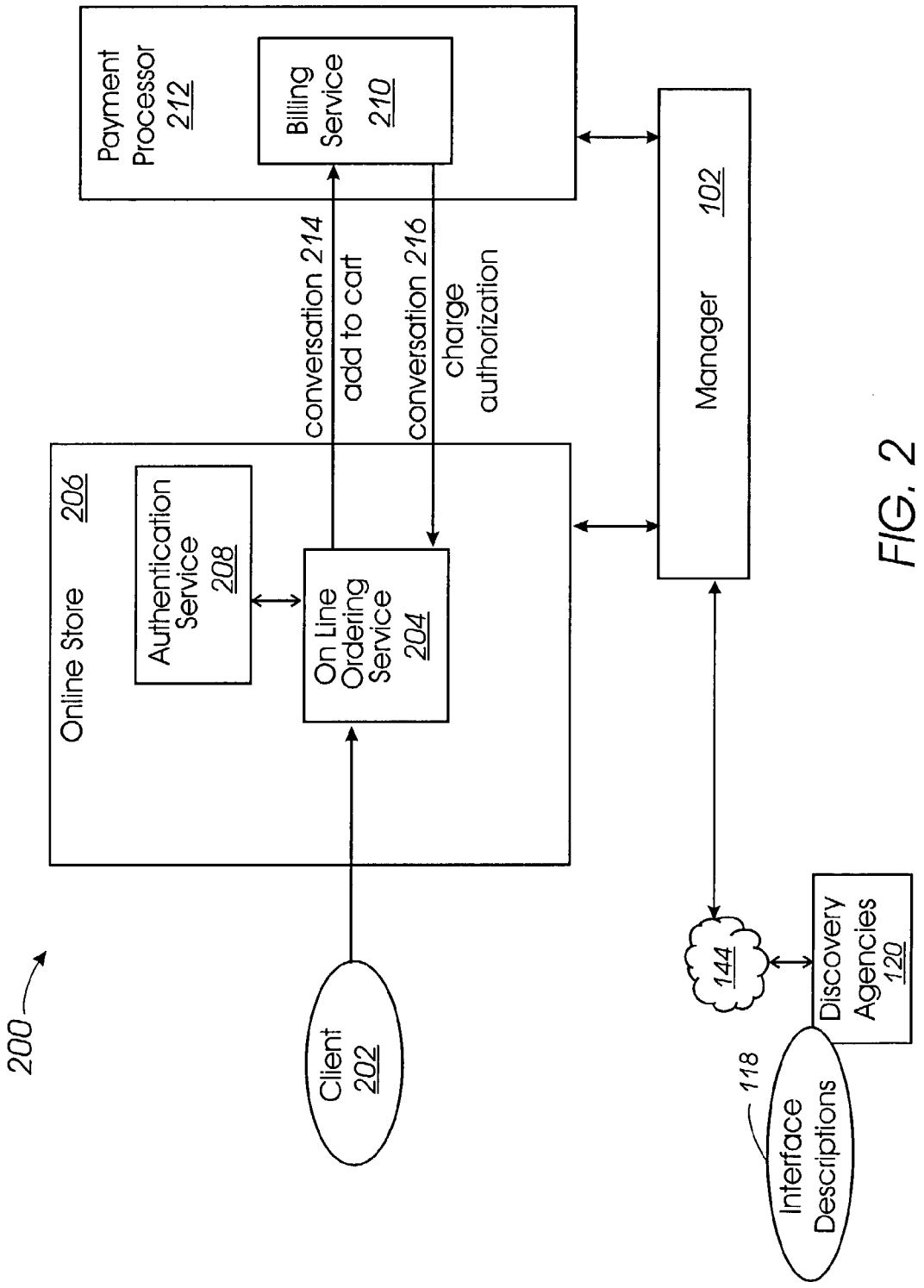

200
Payment Processor 212
Billing Service 210
Manager 102
conversation 214
add to cart
conversation 216
charge authorization
Online Store 206
Authentication Service 208
On Line Ordering Service 204
Client 202
144
Discovery Agencies 120
118
Interface Descriptions

FIG. 2

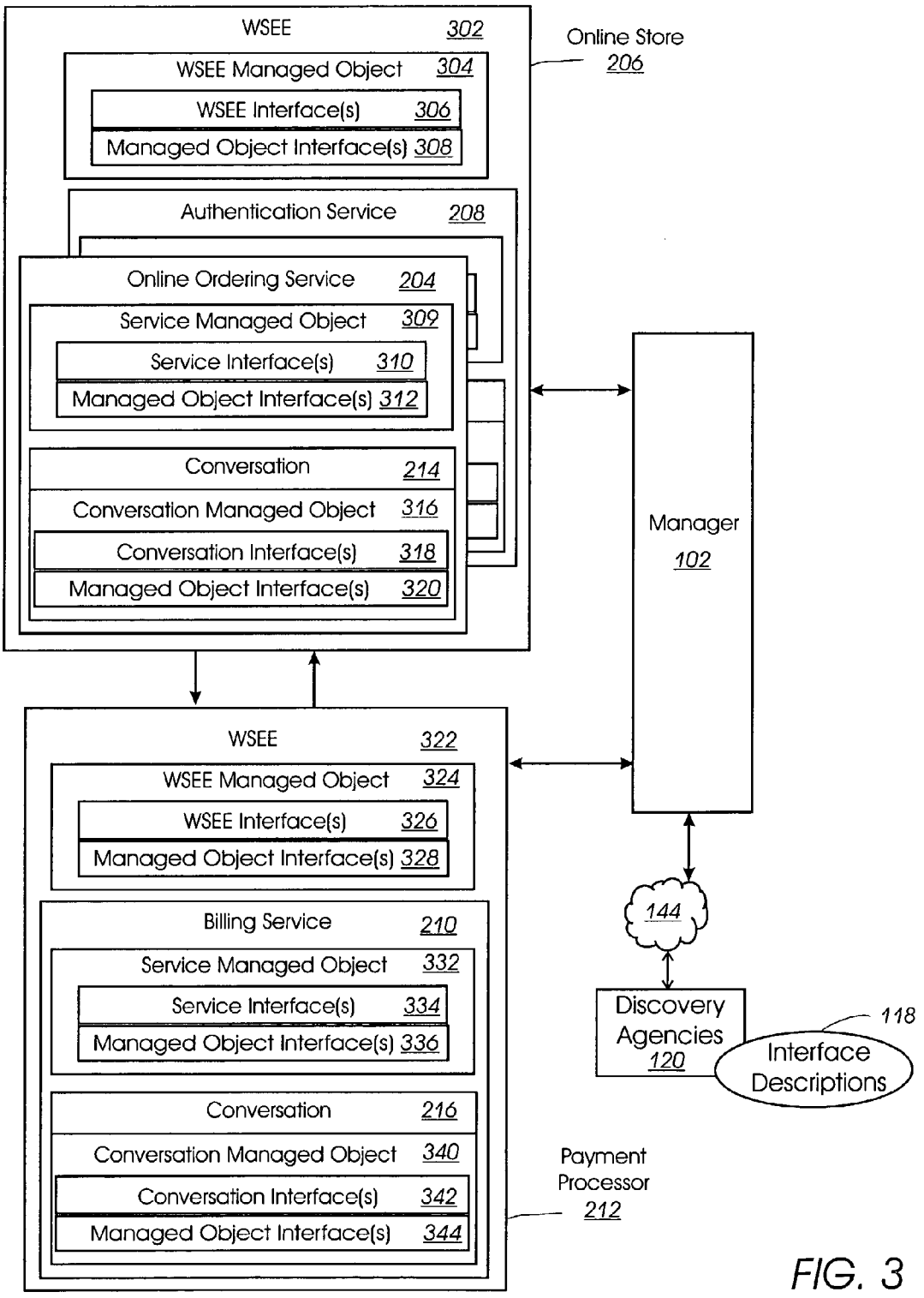

WSEE 302
WSEE Managed Object 304
WSEE Interface(s) 306
Managed Object Interface(s) 308
Online Store 206
Authentication Service 208
Online Ordering Service 204
Service Managed Object 309
Service Interface(s) 310
Managed Object Interface(s) 312
Conversation 214
Conversation Managed Object 316
Conversation Interface(s) 318
Managed Object Interface(s) 320
Manager 102
WSEE 322
WSEE Managed Object 324
WSEE Interface(s) 326
Managed Object Interface(s) 328
144
Billing Service 210
Service Managed Object 332
Service Interface(s) 334
Managed Object Interface(s) 336
Discovery Agencies 120
118
Interface Descriptions
Conversation 216
Conversation Managed Object 340
Conversation Interface(s) 342
Managed Object Interface(s) 344
Payment Processor 212

FIG. 3

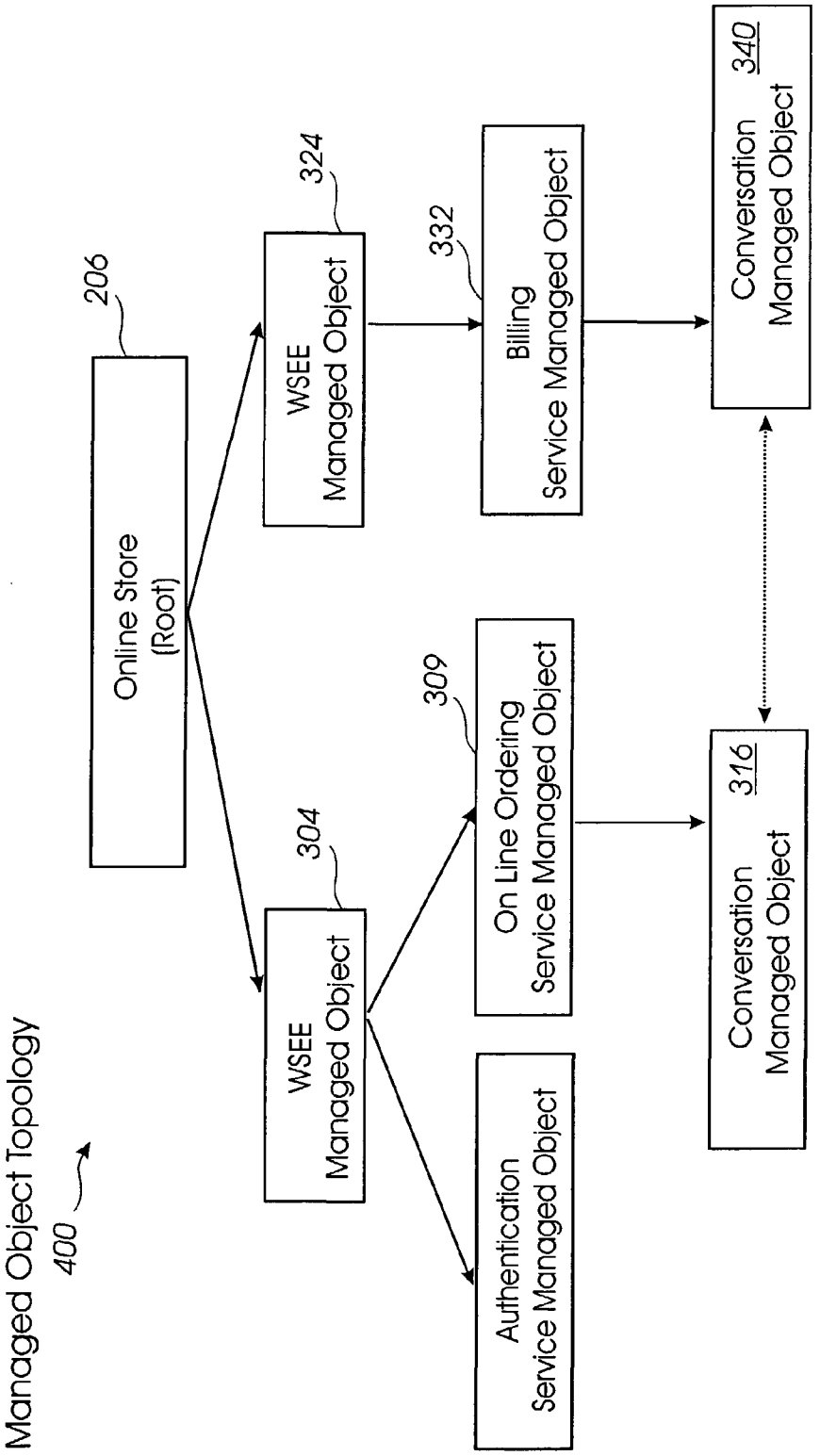

Managed Object Topology
400
206
Online Store
(Root)
304
WSEE
Managed Object
324
WSEE
Managed Object
309
On Line Ordering
Service Managed Object
Authentication
Service Managed Object
332
Billing
Service Managed Object
316
Conversation
Managed Object
340
Conversation
Managed Object

FIG. 4

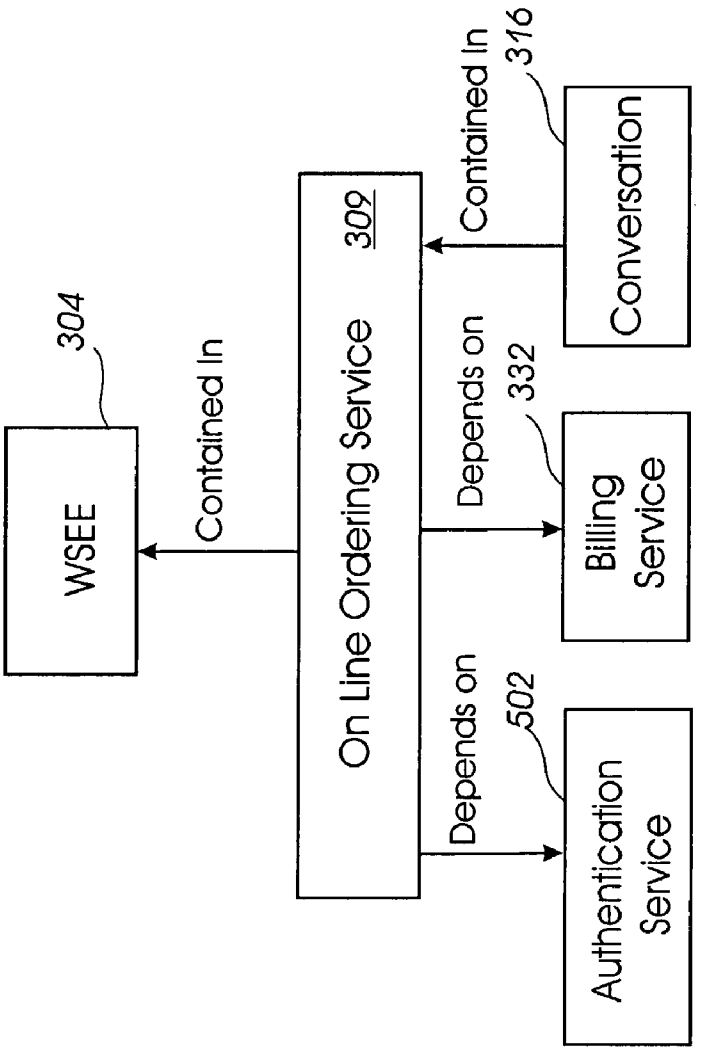

304
WSEE
Contained In
On Line Ordering Service
309
Contained In
316
Conversation
Depends on
332
Billing Service
Depends on
502
Authentication Service

FIG. 5

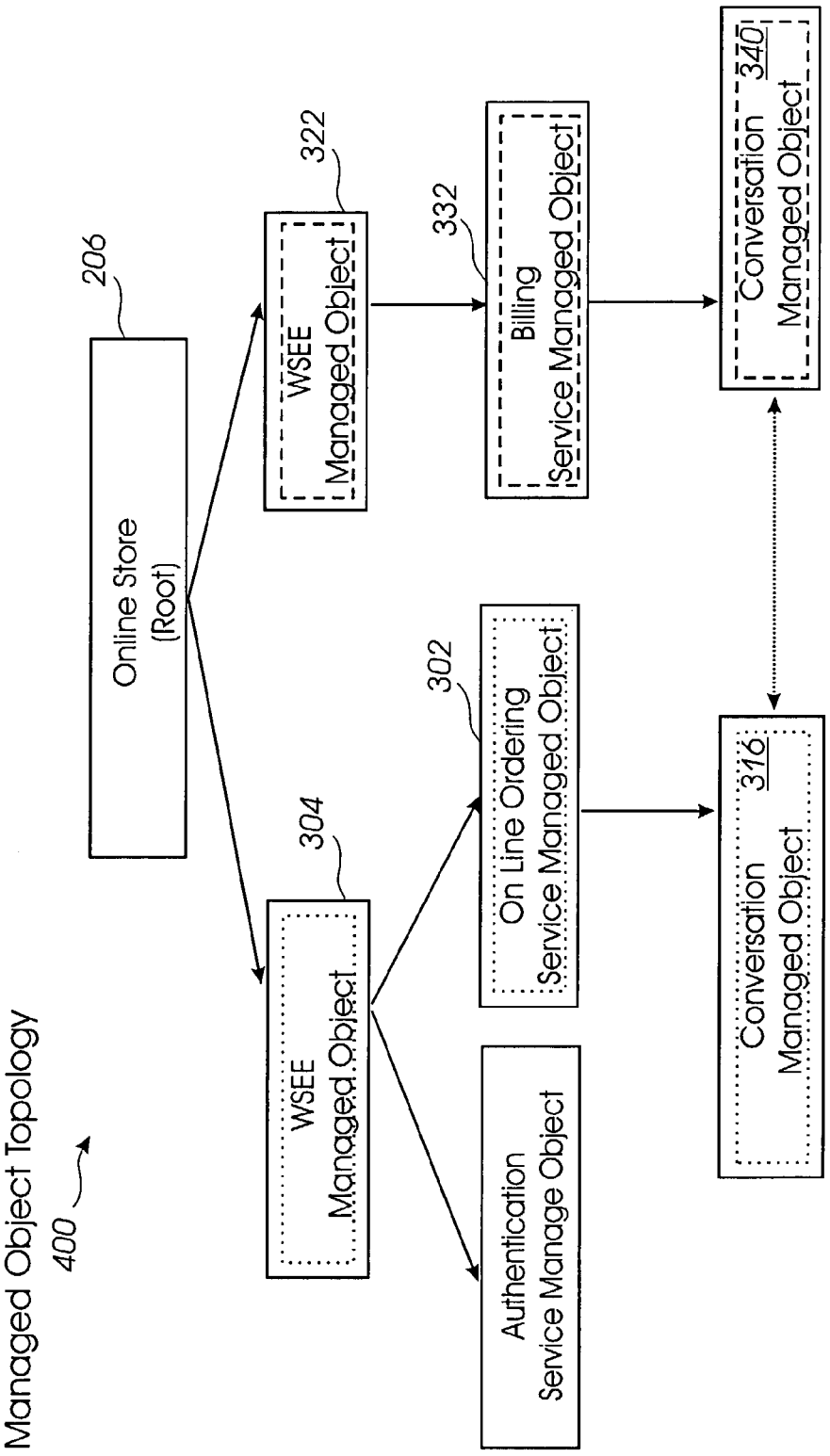

Managed Object Topology
400
206
Online Store
(Root)
304
WSEE
Managed Object
322
WSEE
Managed Object
332
Billing
Service Managed Object
302
On Line Ordering
Service Managed Object
Authentication
Service Manage Object
316
Conversation
Managed Object
340
Conversation
Managed Object

FIG. 6

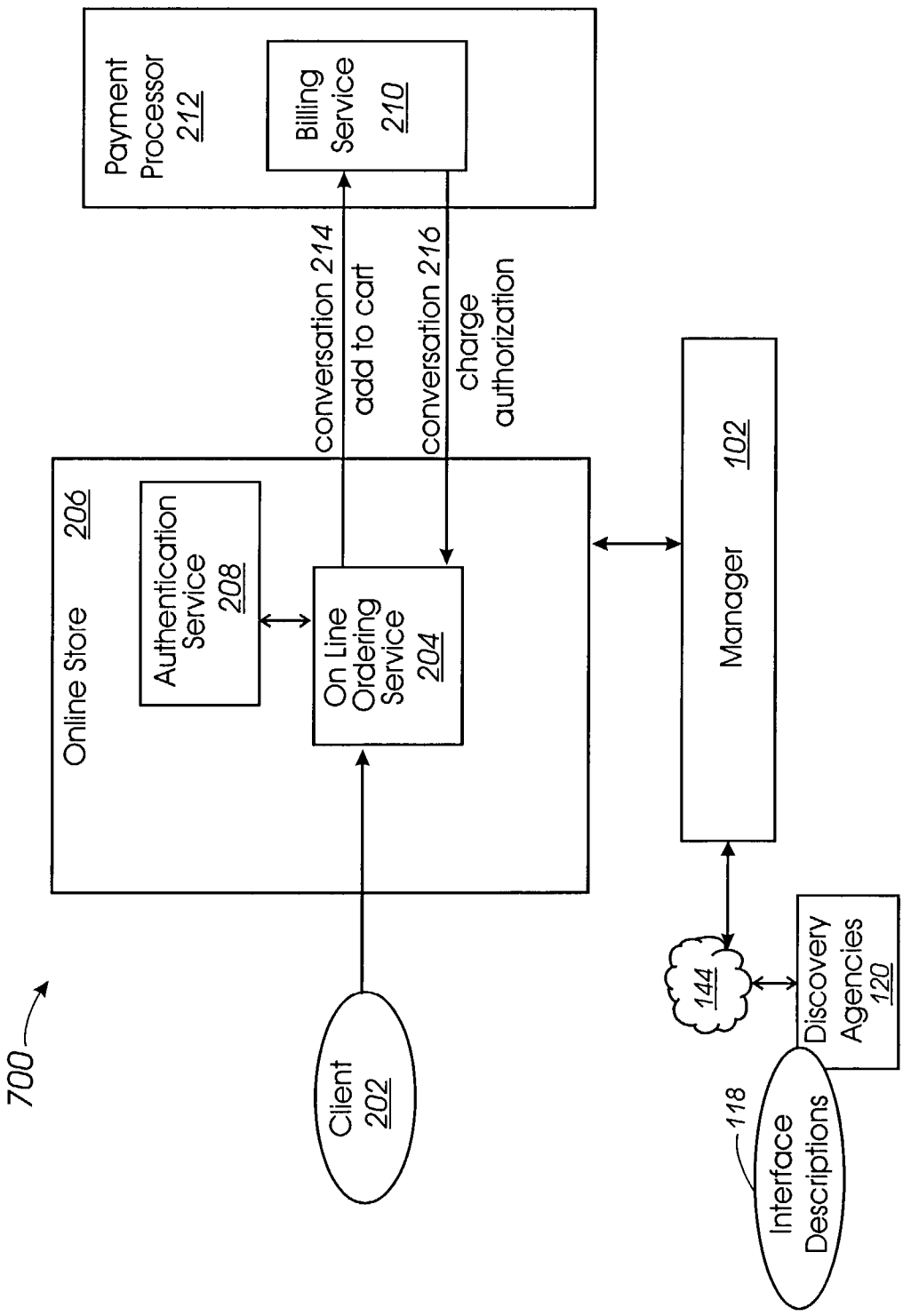

700
Client 202
Online Store 206
Authentication Service 208
On Line Ordering Service 204
Payment Processor 212
Billing Service 210
conversation 214
add to cart
conversation 216
charge authorization
Manager 102
144
Discovery Agencies 120
118
Interface Descriptions

FIG. 7

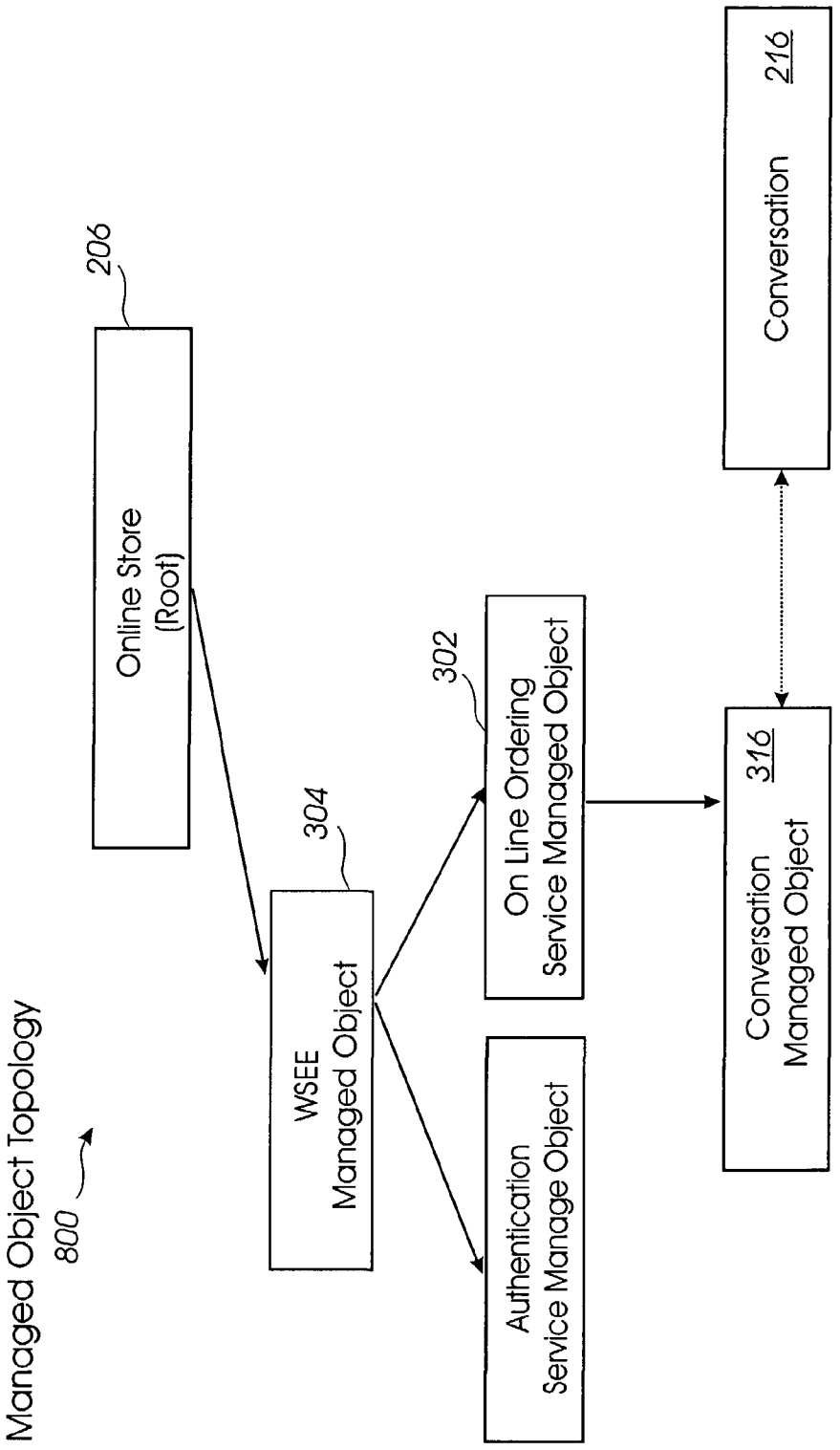

Managed Object Topology
800
Online Store
(Root)
206
WSEE
Managed Object
304
On Line Ordering
Service Managed Object
302
Authentication
Service Manage Object
Conversation
Managed Object
316
Conversation
216

FIG. 8

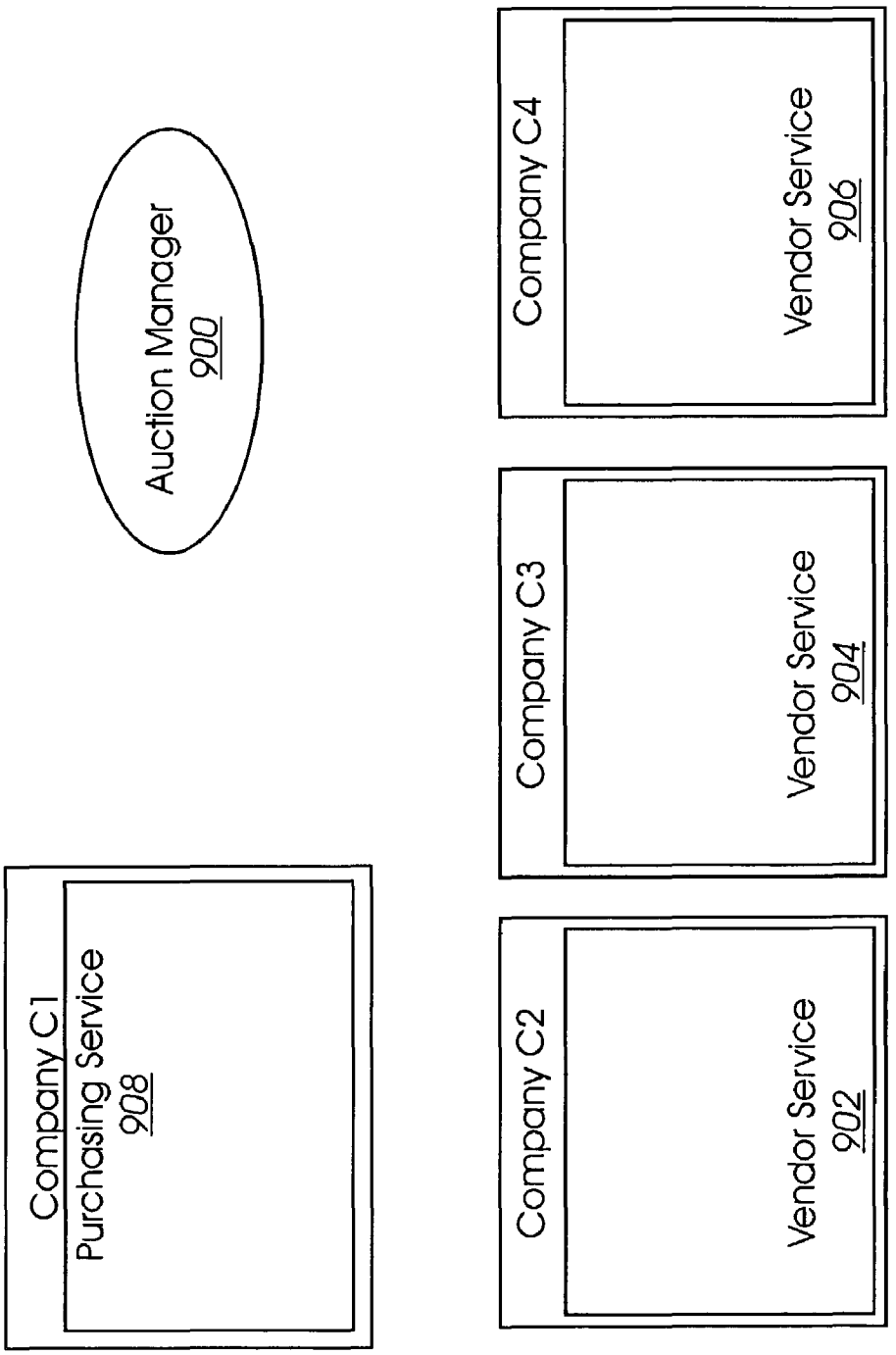

Auction Manager
900
Company C1
Purchasing Service
908
Company C2
Vendor Service
902
Company C3
Vendor Service
904
Company C4
Vendor Service
906

FIG. 9

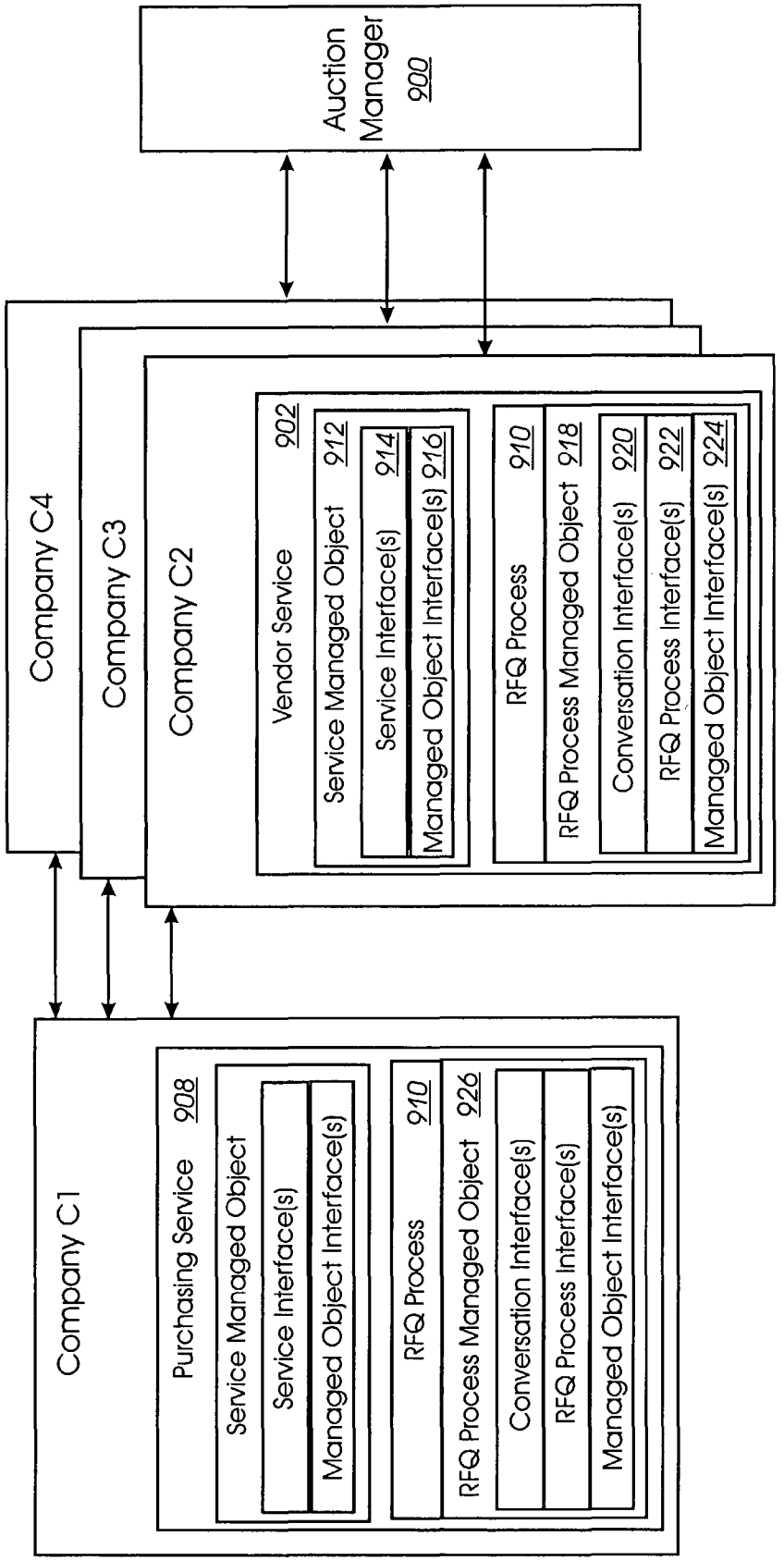

Auction Manager 900
Company C4
Company C3
Company C2
Vendor Service 902
Service Managed Object 912
Service Interface(s) 914
Managed Object Interface(s) 916
RFQ Process 910
RFQ Process Managed Object 918
Conversation Interface(s) 920
RFQ Process Interface(s) 922
Managed Object Interface(s) 924
Company C1
Purchasing Service 908
Service Managed Object
Service Interface(s)
Managed Object Interface(s)
RFQ Process 910
RFQ Process Managed Object 926
Conversation Interface(s)
RFQ Process Interface(s)
Managed Object Interface(s)

FIG. 10

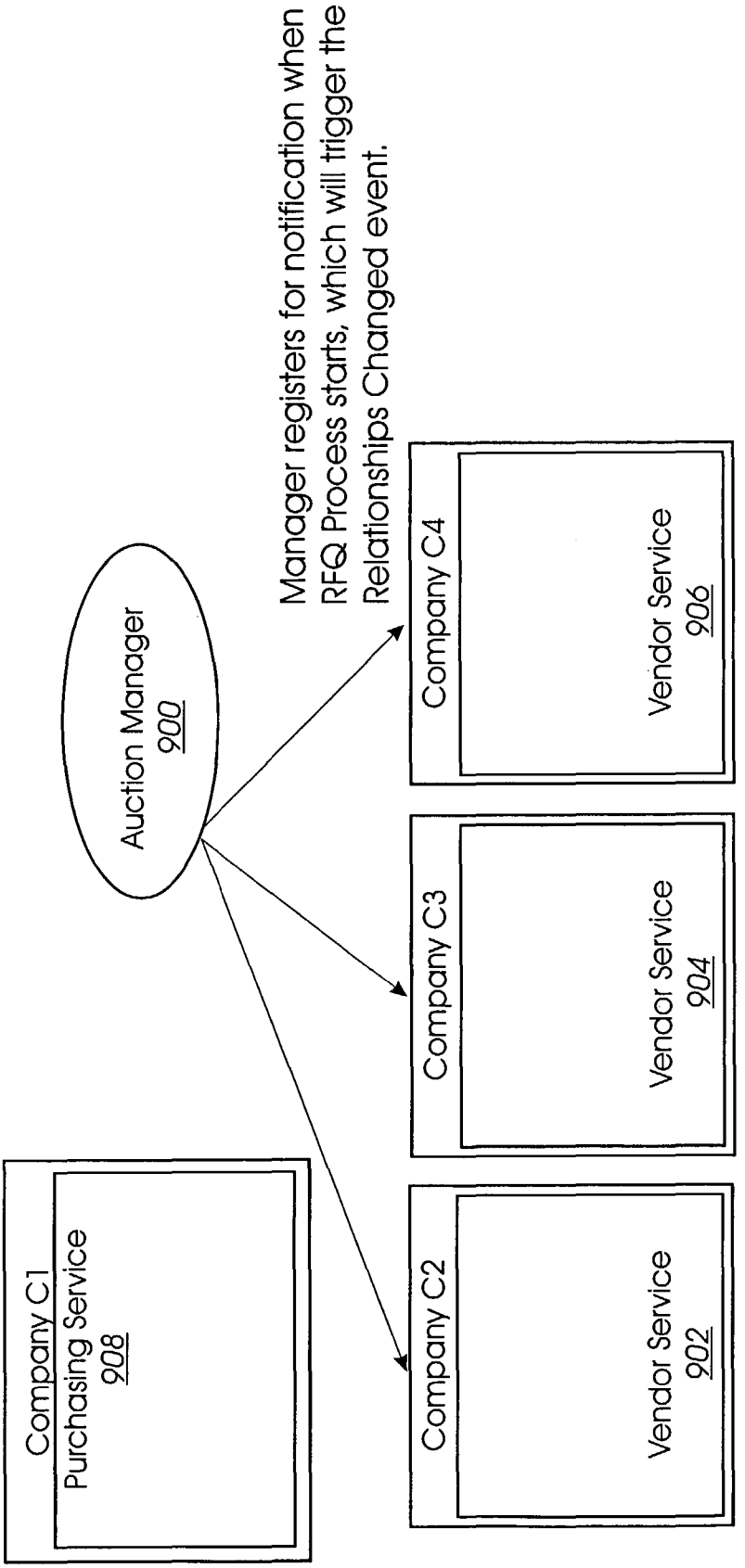

Manager registers for notification when RFQ Process starts, which will trigger the Relationships Changed event.
Auction Manager 900
Company C1 Purchasing Service 908
Company C2 Vendor Service 902
Company C3 Vendor Service 904
Company C4 Vendor Service 906

FIG. 11

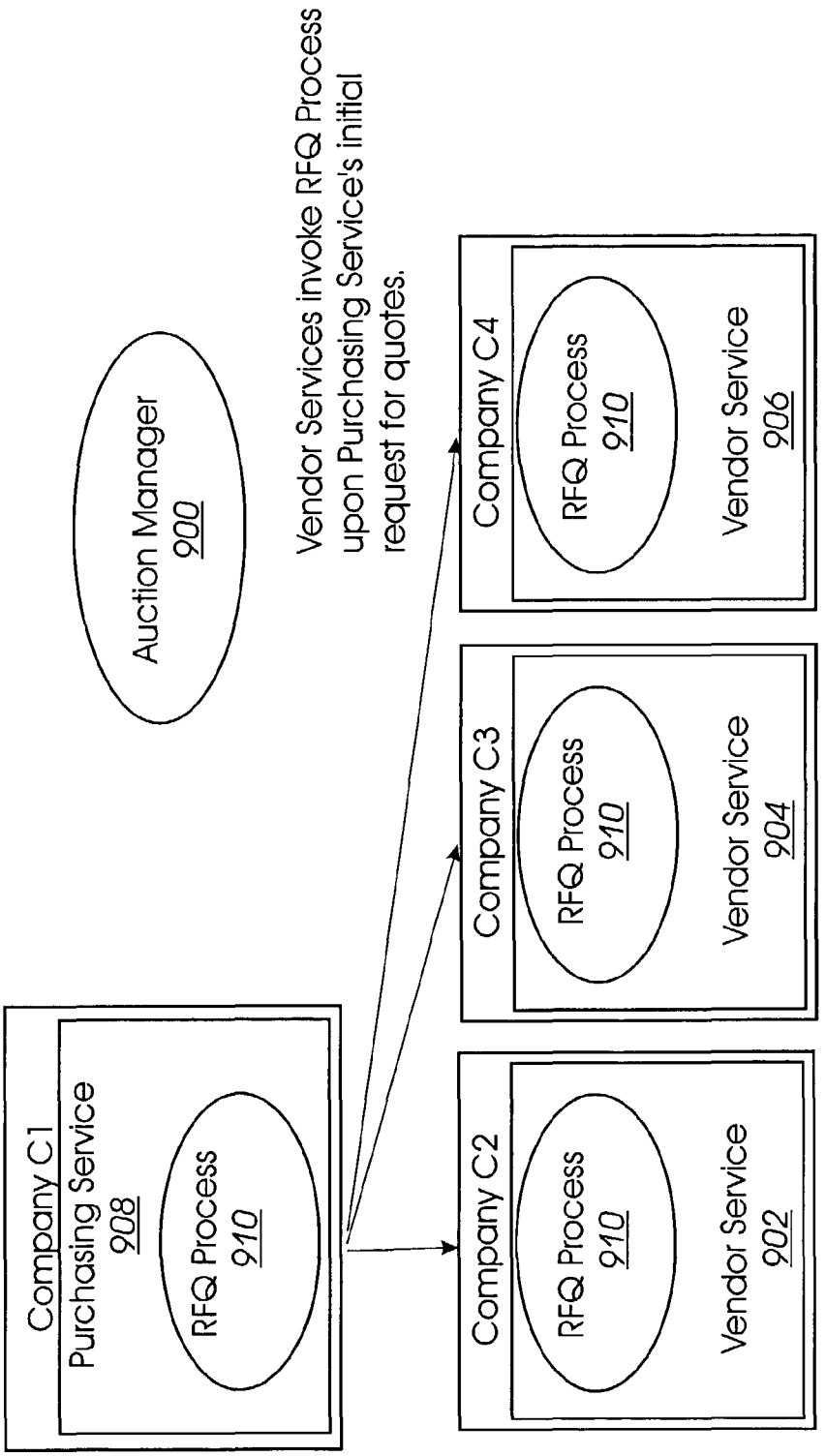

Auction Manager
900
Vendor Services invoke RFQ Process upon Purchasing Service's initial request for quotes.
Company C1
Purchasing Service
908
RFQ Process
910
Company C2
RFQ Process
910
Vendor Service
902
Company C3
RFQ Process
910
Vendor Service
904
Company C4
RFQ Process
910
Vendor Service
906

FIG. 12

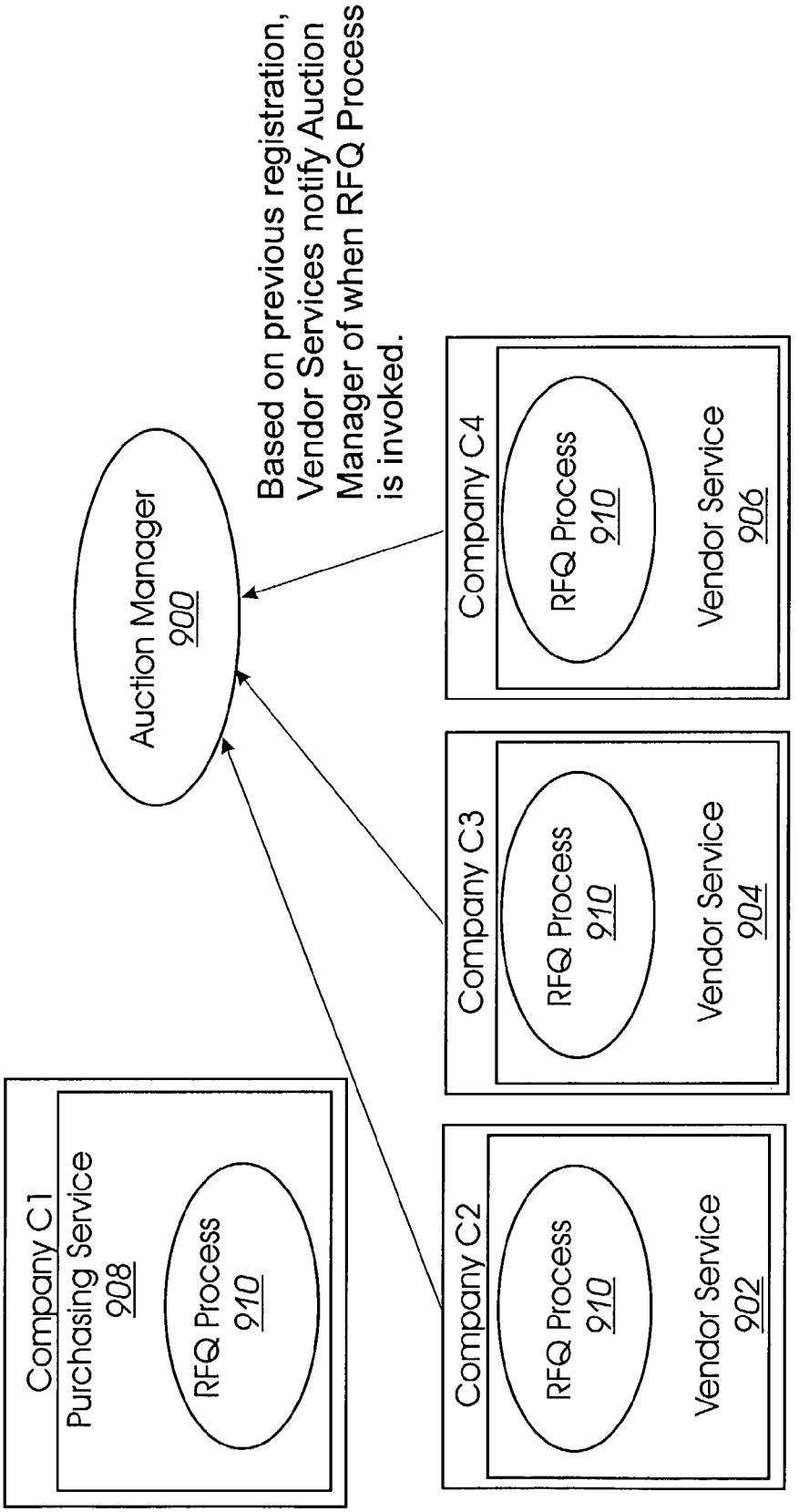

Based on previous registration, Vendor Services notify Auction Manager of when RFQ Process is invoked.
Auction Manager 900
Company C1
Purchasing Service 908
RFQ Process 910
Company C2
RFQ Process 910
Vendor Service 902
Company C3
RFQ Process 910
Vendor Service 904
Company C4
RFQ Process 910
Vendor Service 906

FIG. 13

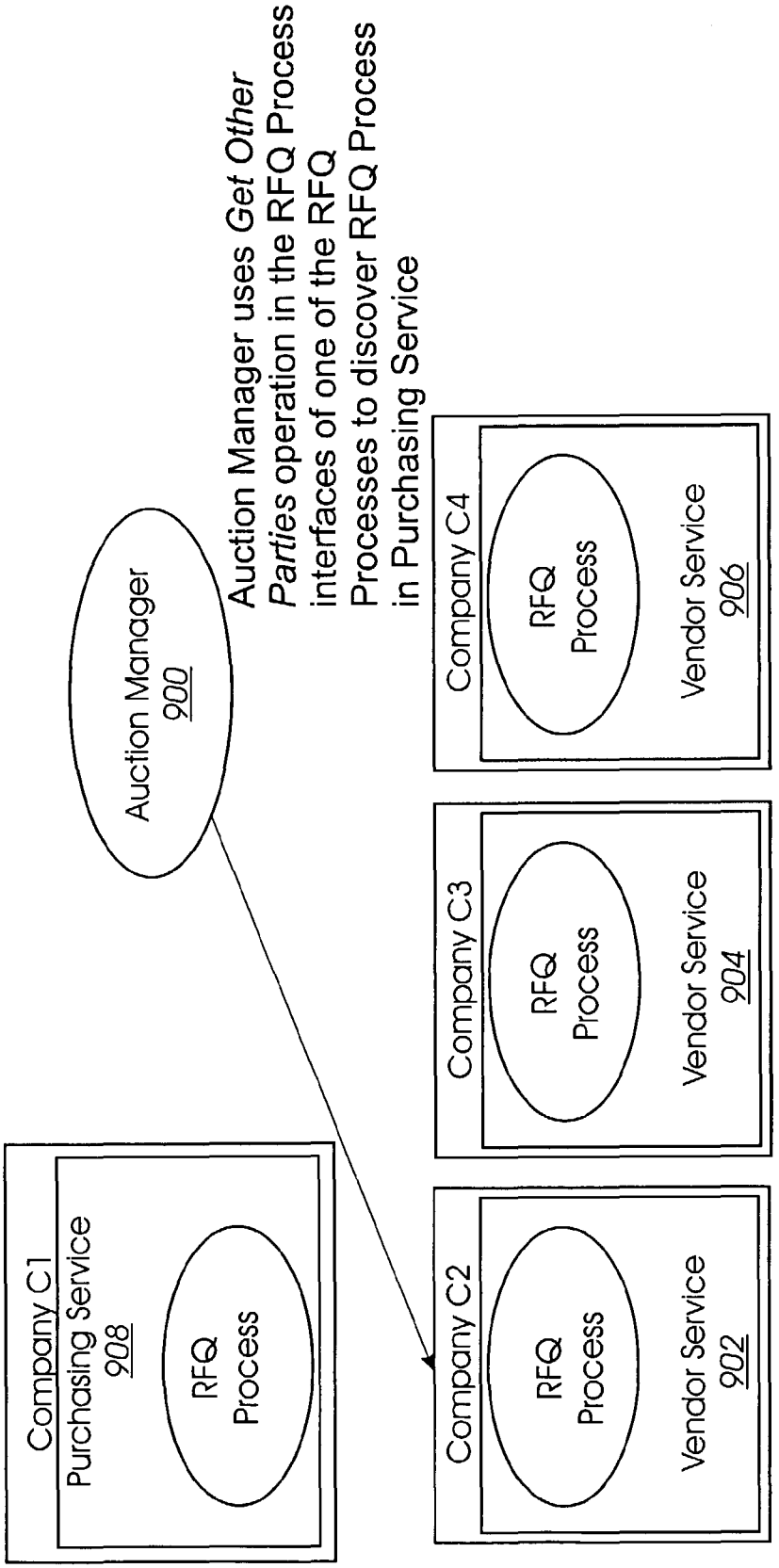

Auction Manager uses *Get Other Parties* operation in the RFQ Process interfaces of one of the RFQ Processes to discover RFQ Process in Purchasing Service
Auction Manager 900
Company C1
Purchasing Service 908
RFQ Process
Company C2
RFQ Process
Vendor Service 902
Company C3
RFQ Process
Vendor Service 904
Company C4
RFQ Process
Vendor Service 906

FIG. 14

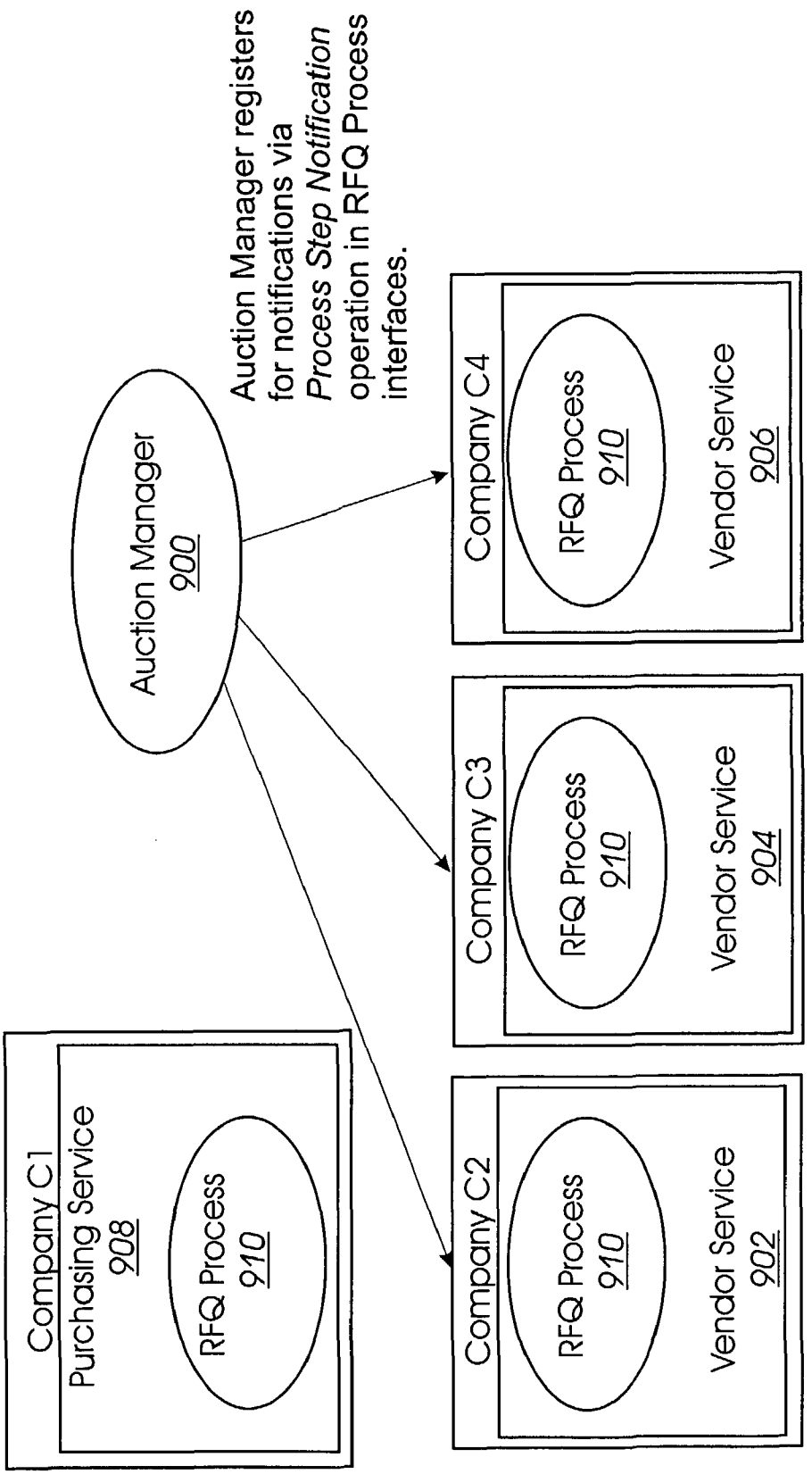

Auction Manager registers for notifications via *Process Step Notification* operation in RFQ Process interfaces.
Auction Manager 900
Company C1
Purchasing Service 908
RFQ Process 910
Company C2
RFQ Process 910
Vendor Service 902
Company C3
RFQ Process 910
Vendor Service 904
Company C4
RFQ Process 910
Vendor Service 906

FIG. 15

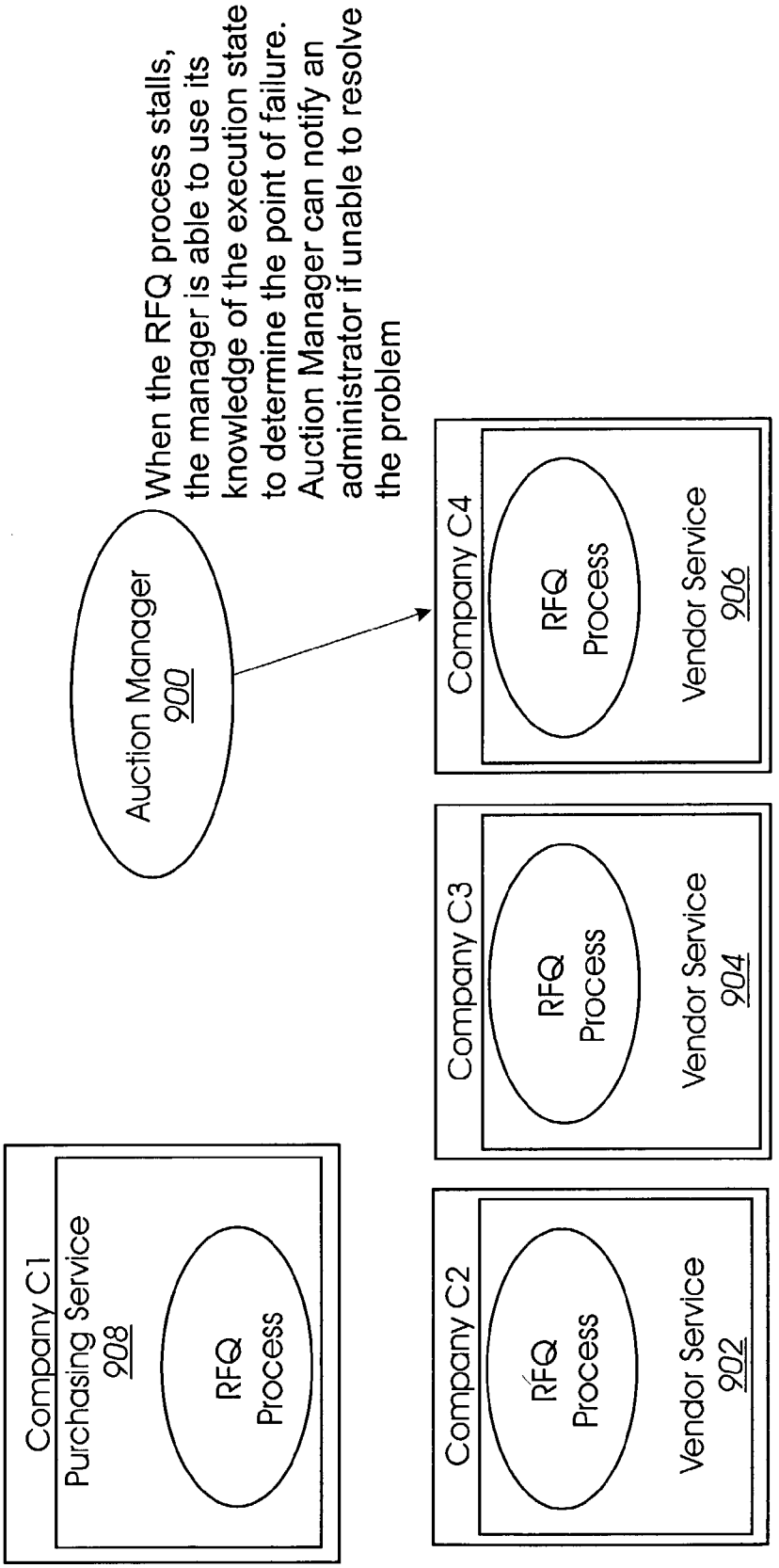

When the RFQ process stalls, the manager is able to use its knowledge of the execution state to determine the point of failure. Auction Manager can notify an administrator if unable to resolve the problem
Auction Manager 900
Company C1
Purchasing Service 908
RFQ Process
Company C2
RFQ Process
Vendor Service 902
Company C3
RFQ Process
Vendor Service 904
Company C4
RFQ Process
Vendor Service 906

FIG. 16

SYSTEMS AND METHODS FOR MANAGING WEB SERVICES VIA A FRAMEWORK OF INTERFACES

RELATED APPLICATIONS

The disclosed system and operating method are related to subject matter disclosed in U.S. Patent application no. 10/438,576, entitled "System and Method for Managing Conversations", which is assigned to the same assignee, filed on the same date as the present disclosure, and incorporated by reference herein.

COMPUTER PROGRAM LISTING APPENDIX

This specification includes Appendix A (consisting of five text files) on CD-ROM, which contains examples of interface description documents that can be used with some embodiments disclosed herein. The files on the compact discs are as follows:

1. Conversation Interfaces Description.wsdl (12 KB created May 14, 2003);
2. Event Interfaces Description.wsdl (10 KB created May 14, 2003);
3. Managed Object Interfaces Description.wsdl (22 KB created May 14, 2003);
4. Service Interfaces Description.wsdl (18 KB created May 14, 2003); and
5. WSEE Interfaces Description.wsdl (6 KB created May 14, 2003).

Appendix A is incorporated herein by reference.

BACKGROUND

Today, information technology (IT) resources are managed using a variety of incompatible and often proprietary interfaces and protocols. Requirements for management information regarding the resources need to be specifically programmed to address new resources and in many cases the specific programming is not updated as new versions of the IT resources become available.

The problem of managing disparate IT resources is becoming more acute as systems are increasingly developed using IT resources that are deployed in remote locations and accessed via information networks, such as the Internet. Generally, the resources to be managed are not readily identifiable when the resources are highly distributed and independent of one another. Further, it is difficult to obtain information regarding properties and attributes of the resources, and protocols for exchanging management information with the resources. A further difficulty lies in determining the relationships among the resources used in a system to pinpoint operational problems when one or more of the resources do not respond as expected.

The term Web services, also referred to herein as "services", describes an approach to distributed computing in which interactions are carried out through the exchange of eXtensible Markup Language (XML) messages. Web services can perform any task that can be described and contained within one or more modules of code. For example, functions such as language translation or currency conversion, performing calculations for medical claims processing, and handling certain aspects of travel planning can be implemented in a Web service. Essentially any transaction or bit of business logic can become a Web service if it can be accessed and used by another system over a network such as the Internet.

A Web service is a software system identified by a Universal Resource Identifier (URI) whose public interfaces and bindings are typically defined and described in an XML document. The description can be discovered by other software systems. These systems may then interact with the Web service in a manner prescribed by its definition, using XML based messages conveyed by Internet protocols.

The Web services architecture is based upon the interactions between three primary roles: service provider, service registry, and service requestor. These roles interact using publish, find, bind, and other operations. The service provider is the business that provides access to the Web service and publishes the service description in a service registry. The service requestor finds the service description in a service registry and uses the information in the description to bind to a service.

Web services typically send XML messages formatted in accordance with the Simple Object Access Protocol (SOAP) specification. The SOAP specification is a universally agreed-upon protocol that uses XML and optionally HTTP together to invoke functions exposed in Web services.

The XML messages can be described using the Web Services Description Language (WSDL) specification, which, along with the Universal Description Discovery and Integration (UDDI) registry, provides a definition of the interface to a Web service and identifies service providers in a network. The WSDL specification is an XML-based language used to define Web services and describe how to access them. An application trying to use a particular Web Service uses WSDL to find the location of the Web service, the function calls available, and the format that the client must follow to access the Web service. Therefore, the client first obtains a copy of the WSDL file and then uses the information in this file to format a request, often using SOAP.

The UDDI registry supports Web services by providing a place for a company to register its business and the Web services that it offers. Users that need a Web service can use this registry to find a business that provides the service.

Web services are highly extensible, interact in a loosely coupled manner, and are deployed and utilized via various standard specifications such as SOAP, WSDL, and UDDI. In particular, Web services allow businesses to create processes that span multiple enterprises and define networks based on business partnerships. Enterprises are adopting Web services technology to address their business integration needs, but currently there is no standard framework for managing Web services.

Web services have some characteristics that make them especially challenging to manage. One characteristic is that Web services work together to form a distributed application that may extend across an enterprise or even the Internet. The challenge is that there are many viewpoints from which to manage an application. The management challenges with a distributed application involve crossing boundaries of control and management domains while maintaining a unified, yet customized view for the distributed application. For instance, an IT manager may be interested in managing all of the services in a domain, which includes several computer systems. The vantage point is all Web services on a given computer system. In another instance, a process manager may be interested in all of the Web services that work together to drive a process to, completion. This may involve Web services throughout an enterprise, or possibly include Web services hosted by other companies. Still further, a business manager may be interested in all of the service agreements with the company regarding Web services hosted by other companies. The business manager will be interested in making sure the

company meets its service agreements with others. Additionally, the service providers' performance in fulfilling the service agreements will be tracked to provide information for making future business decisions.

Another characteristic that presents management challenges is that Web services have been designed to be extensible at all levels. The SOAP protocol standard provides a very flexible mechanism to extend the processing of messages by adding headers to the message. Additionally, the body of the message may be any XML document that is understood by the Web service. The WSDL and XML-schema description standards provide a means to define arbitrary data types, and to extend or restrict previously defined data types. An XML-schema is a document that describes the valid format of an XML data-set, such as elements that are (and are not) allowed at any point; what the attributes for any element may be; and the number of occurrences of elements.

It is also possible for a Web service to provide several interfaces into its functionality. There are also discovery standards that provide their own extensibility mechanisms. The management challenges with such an extensible system include determining the type of a managed object and how to communicate with the object.

The UDDI standard allows WSDL documents to be discovered at run time. This discovery mechanism is not limited to use only within an enterprise, but is available wherever the Web service is available, including the Internet. Furthermore, it is possible to discover not only the basic capabilities of a Web service, but also the advanced capabilities that are specified by this standard. One management challenge with such a powerful discovery mechanism is to ensure that provided services are protected with the proper type of security. Another management challenge is identifying users accessing the provided Web services. Yet another more complex management challenge is to ensure that all appropriate service agreements are not only discoverable but also enforced.

SUMMARY

In one embodiment, a system for managing a Web service comprises a computer processor and a service managed object executable on the computer processor. The service managed object is associated with the Web service and includes at least one interface configured to allow a manager to access management features for the Web service, such as a list of conversations associated with the Web service.

In another embodiment, a system capable of managing a Web service comprises a computer processor configured to communicate with the service. The computer processor includes executable instructions operable to discover a managed object interface for the service; capabilities for managing the service based on the managed object interface for the service; a service interface for the service; and additional capabilities for managing the service based on the service object interface.

In yet another embodiment, a computer program product comprises a service interface and a managed object interface associated with the service interface. The service interface is configured to include information for managing a Web service, including information indicating conversations associated with the service that are in progress.

In a further embodiment, a method for managing a service comprises creating a service object representing the service, wherein the service object includes a management interface; exposing management capabilities for the service via a description of the management interface; and allowing a manager to subscribe with the service object to receive notification of events regarding the service.

Various other features and advantages of embodiments of the invention will be more fully understood upon consideration of the detailed description below, taken together with the accompanying figures.

BRIEF DESCRIPTION OF THE FIGURES

FIG. **1**A is a diagram of components included in an embodiment of a Web service management system.

FIG. **1**B is a diagram of components included in an embodiment of a base managed object interface collection for the Web service management system of FIG. **1**A.

FIG. **1**C is a diagram of components included in an embodiment of a Web Service Execution Environment interface collection for the Web service management system of FIG. **1**A.

FIG. **1**D is a diagram of components included in an embodiment of a conversation interface collection for the Web service management system of FIG. **1**A.

FIG. **2** shows a diagram of components included in an embodiment of an online shopping service system that can utilize the service management system of FIG. **1**A.

FIG. **3** shows a block diagram of components in online ordering system of FIG. **2** configured with managed objects and corresponding management interfaces.

FIG. **4** shows a diagram of the topology of the managed objects of FIGS. **2** and **3**.

FIG. **5** shows a diagram of the relationships between the managed objects of the online shopping service system of FIGS. **2** and **3**.

FIG. **6** shows the topological diagram of FIG. **4** showing propagation of failure status among components in online shopping service system of FIG. **2**.

FIG. **7** is a diagram of another embodiment of an online shopping service system that can utilize the service management system of FIG. **1**A.

FIG. **8** shows a topological diagram of managed objects in the online ordering system of FIG. **7**.

FIGS. **9** and **10** show diagrams of four independent entities capable of coordinating distributed Web services that can be monitored by a manager.

FIGS. **11** through **16** show diagrams of the distributed processing system of FIGS. **9** and **10** with annotations of various steps performed by RFQ process and auction manager.

DETAILED DESCRIPTION OF THE FIGURES

Referring to FIG. **1**A, an embodiment of a Web service management system **100** that allows manager **102** to monitor and control one or more services **104**, **106** is shown. Service managed objects **108**, **110** represent the management features of resource(s) that perform services **104**, **106**. Interfaces in one or more categories can be included in service interfaces **112**, **114** for each service managed object **108**, **110**. Service interfaces **112**, **114** can allow manager **102** to access information regarding the state of services **104**, **106**, as well as to control the operation of services **104**, **106**.

In some embodiments, management capabilities provided via service interfaces **112**, **114** include attributes that represent information about the messages exchanged with other services; operations to support the management of services **104**, **106**; and events representing exceptions and state changes that can be reported by service managed objects **108**, **110** to manager **102**. Service managed objects **108**, **110** can be

implemented within services **104**, **106**, such as shown for service managed object **108**, or in a layer external to services **104**, **106**, as shown for service managed object **110**.

Services **104**, **106** populate data fields in service interfaces **112**, **114** that are available to manager **102**. Further, services **104**, **106** receive information and control parameters from manager **102** via service interfaces **112**, **114**.

In some embodiments, each collection of service interfaces **112**, **114** supports various categories of management capabilities including managed object identity, monitoring, discovery, control, performance, configuration, and security. Other interfaces that support additional service management capabilities can be utilized, in addition to, or instead of, service interfaces **112**, **114**.

An embodiment of service interfaces **112** is represented in FIG. **1**A as Service Interface Collection **116**, which will be described with respect to service interfaces **112** and service **104**. A similar Service Interface Collection **116** can be used to develop service interfaces **114**. Service interfaces **112**, **114** can include additional, fewer, or the same features shown in the embodiment of Service Interface Collection **116** in FIG. **1**A.

Each interface in Service Interface Collection **116** includes at least one management feature that can be used by manager **102** to monitor and/or control various aspects of service **104**. In the embodiment shown, Service Interface Collection **116** includes a Service Configuration Interface, Service Monitoring Interface, Service Discovery Interface, Service Performance Interface, and Service Control Interface. Service interfaces **112**, **114** can be configured to support any one, a group, or all of the interfaces in Service Interface Collection **116**.

Further, in some embodiments, manager **102** can discover interface descriptions **118** for service interfaces **112**, **114** via a suitable discovery agency **120**, such as UDDI, or other suitable method. Interface descriptions **118** can be configured to reveal selected management information to manager **102** by exposing only selected interfaces in service interfaces **112**, **114**. For example, an interface description **118** for service interfaces **112**, **114** may only include a description the Service Monitoring Interface that is exposed to manager **102**. Examples of interfaces descriptions **118** that are suitable for use with some embodiments disclosed herein are provided in Appendix A.

Moreover, features such as attributes in Service Interface Collection **116** can support types of access by other objects, such as read and read/write. When interface descriptions **118** are implemented in WSDL, service interfaces **112**, **114** are mapped to ports, as further described herein. Service Interface Collection **116** can also be extended to provide additional management capabilities for manager **102**, as described herein.

In the embodiment shown in FIG. **1**A, Service Configuration Interface includes OperationalUri, which can represent an attribute that can return an identifier such as an URI to the location of interface descriptions **118** for service **104**.

Service Monitoring Interface can include attributes for Conversations, Get Conversation By ID, Last Message, Last Fault message.

Conversations can represent an attribute that can return a list of conversations (not shown) involving the corresponding service managed object **108** that are in progress.

The Get Conversation By ID (identifier) can represent an attribute that can return the conversation managed object (not shown) associated with the service that has the specified identifier. An example of a suitable identifier is a Universal Resource Identifier (URI) that can be used to identify resources in a domain including documents, images, downloadable files, services, electronic mailboxes, and other resources. Other suitable identifiers can be utilized.

The Last Message can represent an attribute that can return the last request message received by service **104**.

The Last Fault Message can represent an attribute that can return the last fault message returned from service **104**.

Service Discovery Interface can include a Container read-only attribute, which returns a globally unique identifier for the Web service execution environment (WSEE) (not shown) that contains service **104**.

Service Performance Interface can include attributes such as Total Message Count, Failed Message Count, and Success Message Count. Total Message Count can return the total number of messages processed by service **104**. Failed Message Count can return the number of failed messages processed by service **104**. Success Message Count can return the number of successful messages processed by service **104**.

Service Performance Interface can include additional features as shown in FIG. **1**A. For example, Success Message Count can represent an attribute that returns the number of successful messages processed by service **104**.

Success Maximum Response Time can represent an attribute that can return the maximum amount of time that successful operational requests executed before returning a response.

Success Minimum Response Time can represent an attribute that can return the minimum amount of time that successful operational requests executed before returning a response.

Success Cumulative Response Time can represent an attribute that can return the cumulative amount of time that successful operational requests have executed since service **104** was started.

Failed Maximum Response Time can represent an attribute that can return the maximum amount of time that failed operational requests executed before returning a response.

Failed Minimum Response Time can represent an attribute that can return the minimum amount of time that failed operational requests executed before returning a response.

Failed Cumulative ResponseTime can represent an attribute that can return the cumulative amount of time that failed operational requests have executed since service **104** started.

Service Control Interface can include operations such as Start, Stop, and Restart that allow manager **102** to control the execution of service **104**. The Start operation starts service **104**. Once started, service **104** should be able to receive operational and management requests supported by service interfaces **112** and managed object interfaces **122**.

The Stop operation stops service **104**. Requests from manager **102** can be processed by service **104** once service **104** has been stopped, but any operational requests should result in a fault message or a not found status being returned to the requestor. If a particular implementation of service **104** does not support the stop capability, a fault can be returned.

Service Interface Collection **116** can also include Event types and Status values. Event types include Starting, which can indicate service **104** has just entered the Starting state; Stopping, which can indicate service **104** has just entered the Stopping state; and Stopped, which can indicate service **104** has just completed the Stopping state and is no longer able to process operational requests. Service **104** can enter the Inactive state after the Stopped event. An Event represents a change in the state of a corresponding object, for example, service **104**. Manager **102** can register to receive notification of one or more of the Event types available in Service Interface Collection **116**.

Status values in Service Interface Collection **116** can include values such as Starting and Stopping to indicate the state of the corresponding service. The Starting status value can be used when the underlying resource(s) used in service **104** are transitioning from the Inactive state to the Operational state. The Stopping status value can be used when the underlying resource(s) are transitioning from the Operational state to the Inactive state.

The preceding types, operations, status values, event types, and attributes are examples of features that can be included in Service Interface Collection **116**. Other features can be implemented for Service Interface Collection **116** in addition to, or instead of, the preceding features. Further, the names for the interfaces, attributes, events, operations and other interface features disclosed herein are provided for purposes of illustration only. The same names can be used to represent different features, and other names can be implemented to represent features disclosed herein.

Managed Objects Interfaces

FIG. **1**A also shows managed object interfaces **122** associated with service managed object **108**, and managed object interfaces **124** associated with service managed object **110**. Referring to FIG. **1**B, an embodiment of managed object **128** with managed object interfaces **130** is shown. Managed object **128** is a management representation of a resource. For example, service managed objects **108**, **110** in FIG. **1**A can be considered managed objects **128**.

Managed object **128** implements managed object interfaces **130** to provide a common set of basic management capabilities that allow manager **102** to monitor and/or control the underlying resource(s) represented by managed objects **128** through various features such as attributes, operations, and event notifications. Various implementations of managed object interfaces **130** can hide some or all of the management capabilities from managers **102** that are not authorized to access specific management capabilities.

In some embodiments, each managed object **128** inherits managed object interface **130**, which can be implemented as part of each managed object **128**, or in another layer outside of managed object **128**. Each managed object **128** can also include one or more additional interfaces based on the associated resources that expose relevant information to manager **102**. For example, service managed objects **108**, **110** implement service interfaces **112**, **114**, as well as managed object interfaces **122**, **124** (FIG. **1**A).

Interface descriptions **118** for managed object interfaces **130** can be used in some implementations to expose management capabilities available for managed object **128** to manager **102**. Interface descriptions **118** allow manager **102** to determine the objects that can be managed, and the attributes of related managed objects **128**. Managed object interfaces **130** can also allow manager **102** to access information to monitor, audit, and control various aspects of managed objects **128**, and to register to receive event notifications.

The embodiment of Managed Object Interface Collection **132** shown in FIG. **1**B includes Notification, Relationship, Managed Object, Fault Detail, and Error Types that can be implemented in managed object interfaces **130**.

Notification type can be used to send event notifications for which manager **102** has subscribed. Relationship type can describe a relationship between two or more managed objects **128**. Managed Object can be a simple type based on the XML schema anyURI type and points to interface descriptions **118** for a particular managed object. An element of FaultDetail type can be added to the fault detail element of all SOAP faults returned by managed object interfaces **130**, and other interfaces associated with particular types of managed objects **128**, such as conversations interfaces **112**, **114** associated with conversations **104**, **106**. Error type can describe an error. The Fault Detail element type can contain one or more of the Error type elements to offer more specific information about the error.

Managed Object Interface Collection **132** can also include Status values and Events. For example, the type Relationships Changed Event can indicate an update to relationships in managed object **128**. Relationships Changed Event can occur when a new relationship is added or when a previous relationship has been removed.

With regard to status values included in the embodiment of Managed Object Interface Collection **132** shown in FIG. **1**B, Operational status can indicate the underlying resource is operational and ready to process incoming messages. Failed status can indicate managed object **128** has detected a problem and the underlying resource is unable to process incoming messages. Inactive status can indicate the underlying resource has terminated normally. Unknown status can indicate the state of the resource is unknown.

Interfaces shown in the embodiment of Managed Object Interface Collection **132** of FIG. **1**B include Managed Object Identity Interface, Managed Object Configuration Interface, Managed Object Monitoring Interface, Managed Object Discovery Interface, Managed Object Control Interface, Managed Object Collection Interface, Event Push Interface, Event Pull Interface. An Event Callback Interface can be implemented by a subscriber, such as manager **102**, to receive push events.

Managed objects **128** can implement Management Object Identity Interface, which includes attribute ManagementUri. ManagementUri returns an identifier, such as a URI, for interface descriptions **118** of managed object interfaces **130**.

Managed Object Configuration Interface can include several attributes regarding the configuration of associated managed object **128**, such as Name, Type, Description, Owner, Vendor, Resource Version, Managed Object Version, Created On, Supported Event Types, and Supported Relations.

Name can represent an attribute that can return the name of managed object **128**. Name can be a read-write attribute; however, the write portion can be handled in another interface, such as the Managed Object Control Interface, as further described herein.

Type can represent an attribute that returns the type of managed object **128**.

Description can represent an attribute that returns a description of managed object **128**. Manager **102** can present the description when a user requests more information regarding a particular managed object **128**. The information is distinct from interface descriptions **118**.

Owner can represent an attribute that returns the owner of managed object **128**. The owner can be the entity that deployed the resources underlying managed object **128**. For instance, if a company has developed and deployed a resource that can be hosted on a third-party system, the company still owns the associated managed object **128**. In addition, if a company has purchased the rights to use and deploy a resource locally, the company owns the resource.

Vendor can represent an attribute that returns the vendor originating managed object **128**. In cases where a company has purchased the rights to a resource, the Vendor would be the developer of the resource and the Owner would be the company deploying the resource.

Resource Version can represent an attribute that returns the version of the underlying resource.

Managed Object Version can represent an attribute that returns the version of managed object **128**.

Created On can represent an attribute that returns the date and time managed object **128** was created.

Supported Event Types can represent an attribute that returns a list of the event types supported by managed object **128**. The events may be subscribed to in either a push or pull mode by calling the appropriate subscribe operation as further described herein.

Supported Relations can represent an attribute that returns a list of the relations supported by managed object **128**. Any of the relations in the list may be used to describe relationships between managed object **128** and other managed objects. For example, managed object **128** can support relations such as Contains, ContainedIn, Depends On, Depended Upon, and Corresponds To. Other suitable relations can be utilized.

Managed Object Monitoring Interface can include a Status attribute, which can represent an attribute that returns the status of managed object **128**. The status can be represented as a URI. Managed Object Interface Collection **132** can define basic status values supported by all managed objects **128**. Other interfaces may define additional status values that may be returned by the Status attribute. The read portion of the Status can represent an attribute that can return in the Managed Object Monitoring Interface, and the write portion of the Status can represent an attribute that can return in the Managed Object Control Interface. Handling the read and write portions of the Status attribute in different interfaces allows the owner of managed object **128** to offer read-only access to the status to one consumer, and read-write access to the status to other consumers.

Managed Object Discovery Interface can include a Relationships attribute and a Get Specific Relationships operation. Relationships can represent an attribute that returns a list of relationships that are currently active for managed object **128**. The list of relationships can be dynamic and can change as the underlying resource interacts with other resources. Get Specific Relationships (relation) can represent an operation that returns a list of URIs of managed objects having the relation specified in the argument with managed object **128**.

Managed Object Control Interface can be used to modify the state of managed object **128**, normally by having the managed resource executing a task. Access to Managed Object Control Interface can be controlled via interface descriptions **118** to allow only managers **102** with acceptable privileges use Managed Object Control Interface. The embodiment of Managed Object Control Interface shown includes Status and Name attributes, which are similar to the Status and Name attributes in the Managed Object Monitoring Interface. Managers **102** with access to Managed Object Control Interface can set the values for the Status and Name attributes, however.

Managed Object Collection Interface can include Get, Set, and Invoke operations, and Members attribute.

Get (select, interface, name) can represent an operation used to query the value of an attribute from members of a collection of managed objects **128**. The management interface and the name of the attribute can be specified by the interface and name arguments. Set (select, interface, name, XML value) can represent an operation used to modify the value of an attribute on members of a collection of managed objects **128**. The management interface and the name of the attribute are specified by the interface and name arguments. Invoke (select, interface, name, XML arguments) can represent an operation to invoke an operation on members of a collection of managed objects. In the Get, Set, and Invoke operations, the management interface and the name of the attribute can be specified by the interface and name arguments. The select argument can be an XPATH expression that identifies a subset of members of the collection. The arguments argument contains a list of arguments to pass to the operation. The return value can be a list of structures that each contain the return value from the operation or contain fault information that resulted from the invocation on a particular managed object **128**.

Members can represent an attribute that returns a list of the members of the collection.

The Event Push Interface can include Push Subscribe and Push Cancel Subscription operations. The operation Push Subscribe (EventTypes, CallbackUrl, ExpirationTime) allows manager **102** to register to receive a notification when any of a list of event types occur. The types of events available for interface collections **116**, **132** are determined by manager **102** via the Supported Event Types attribute in the Managed Object Configuration Interface. The return value from the Push Subscribe operation can be a subscription ID, for example. Manager **102** can pass the subscription ID to the Push Cancel Subscription operation to stop receiving notifications for the specified event types. The subscription will expire automatically after the expiration of a pre-specified time period. Manager **102** can invoke the Push Subscribe operation again to continue to receive event notifications.

Pull Subscribe (EventTypes, ExpirationTime) can represent an operation that allows manager **102** to subscribe to receive notifications of specified event types. Managed object **128** can cache events of the types specified for later retrieval using operations such as: GetEventsSinceId, GetEventsSinceDate, and GetEventsRangeByDate. The types of events available for interface collections **116**, **132** are determined by manager **102** via the Supported Event Types attribute in the Managed Object Configuration Interface. The return value from the Pull Subscribe operation can be a subscription ID. Manager **102** can pass the subscription ID to the Pull Cancel Subscription operation to stop receiving notifications for the specified event types. The subscription can expire automatically after a prespecified period of time expires, at which time the specified event types will no longer be cached for that subscription. In order to continue to receive events of this type, manager **102** can re-subscribe for the desired event types.

Managed object **128** can save events for all types specified in all subscriptions. If no subscription has specified some event type, all events of that type may be discarded. When a subscription is cancelled or expires, the queued event types may be discarded if no other subscriptions have expressed interest in the same event types. Each implementation can specify the time period to determine when subscriptions expire and how long events are saved before they are discarded.

Pull Cancel Subscription (SubscriptionId) can represent an operation that allows manager **102** to indicate the termination of interest in event types from previously registered subscriptions. The subscription ID passed to this operation can be an identifier such as the ID returned from a previous call to Pull Subscribe.

Get Events Since Id (SubscriptionId, EventId) can represent an operation that retrieves all events that have occurred since the event specified by the EventId. Events of the type specified by the previous subscription can be returned.

Get Events Since Date (SubscriptionId, Date) can represent an operation that retrieves all events that have occurred since the specified date and time. Events of the type specified by the previous subscription can be returned.

Get Events Range By Date (SubscriptionId, StartDate, EndDate) can represent an operation that retrieves all events that occurred in the specified date range. Events of the type specified by the previous subscription can be returned. In order to avoid missing any events, the date range can be inclusive of the endpoints.

Event Callback Interface can be implemented by a subscriber to a push event, such as manager **102**.

Event Callback Interface includes Notify (notifications) operation, which can be provided by a subscriber to push events. When managed object **128** undergoes a state change that results in one or more event to which a subscriber has registered, manager **102** can invoke the Notify operation with a corresponding list of notifications.

The preceding types, operations, and attributes are examples of features that can be included in Managed Object Interface Collection **132**. Other features can be implemented for Managed Object Interface Collection **132** in addition to, or instead of, the preceding features. Further, the names for the interfaces, attributes, events, operations and other interface features disclosed herein are provided for purposes of illustration only. The same names can be used to represent different features, and other names can be implemented to represent features disclosed herein.

WSEE Managed Objects

Referring to FIGS. **1**A, **1**B, and **1**C, services **104**, **106** are typically executed in processing systems **136** that include an execution environment, such as a Web Service Execution Environment (WSEE) **146**, to support operation of services **104**, **106**. WSEE **146** can include features such as an operating system, databases, script processors, and other components to support services **104**, **106**. WSEE managed object **148** is a managed object **128** that represents management features of WSEE **146**. WSEE managed object **148** can be implemented to notify manager **102** when WSEE **146** starts, stops, and to inform manager **102** of services **104** that can be executed in WSEE **146**, for example. WSEE interfaces **150** and managed object interfaces **154** can be configured with features that allow manager **102** to determine whether services **104**, **106** are prevented from operating due to a problem with WSEE **146**, as well as to monitor and control WSEE **146**. Interfaces in one or more categories can be included in WSEE interfaces **150** for each WSEE managed object **148**. WSEE managed objects **148** can be implemented within WSEE **146**, such as shown for WSEE managed object **148**, or in a layer external to WSEE **146**, as shown for WSEE managed object **110**.

WSEE **146** populates data fields in WSEE interfaces **150** that are available to manager **102**. Further, WSEE **146** receives information and control parameters from manager **102** via WSEE interfaces **150**. In some embodiments, each collection of WSEE interfaces **150** can support various categories of management capabilities such as monitoring, discovery, control, performance, configuration, and/or security. Other interfaces that support additional WSEE management capabilities can be utilized, in addition to, or instead of, WSEE interfaces **150**.

An embodiment of WSEE interfaces **150** is represented in FIG. **1**C as WSEE Interface Collection **152**. Each interface in WSEE Interface Collection **152** includes at least one management feature that can be used by manager **102** to monitor and/or control various aspects of WSEE **146**. Other embodiments of WSEE interfaces **150** can include additional, fewer, or the same features shown in the embodiment of WSEE Interface Collection **152** in FIG. **1**C.

In the embodiment shown, WSEE Interface Collection **152** includes a WSEE Configuration Interface, WSEE Monitoring Interface, and WSEE Control Interface. In some embodiments, manager **102** can discover interface descriptions **118** for WSEE interfaces **150** via a suitable discovery agency **120**, such as UDDI, or other suitable method. Interface descriptions **118** can be configured to reveal selected management information to manager **102** by exposing only selected interfaces in WSEE interfaces **150**. For example, an interface description **118** for WSEE interfaces **150** may only include a description the WSEE Monitoring Interface that can be exposed to manager **102**.

Moreover, attributes in WSEE Interface Collection **152** can support types of access by other objects, such as read and read/write. When interface descriptions **118** are implemented in WSDL, WSEE interfaces **150** are mapped to ports, as further described herein. WSEE Interface Collection **152** can also be extended to provide additional management capabilities for manager **102**, as described herein.

In the embodiment shown in FIG. **1**C, WSEE Configuration Interface includes ConfigurationUri, which can represent an attribute that returns an identifier, such as a URI, to the configuration information for WSEE **146**. The Managed Object Configuration interface can be included to provide the configuration information.

In the embodiment shown in FIG. **1**C, WSEE Monitoring Interface includes read-only attributes for Services, which returns a list of services **104** currently running in WSEE **146**.

WSEE Control Interface can include operations such as Start and Stop that allow Manager **102** to control the execution of WSEE **146**. The Start operation can start WSEE **146**. If WSEE **146** is already running, no additional action is required. The Stop operation can stop WSEE **146**, as well as all other objects contained in WSEE **146**, such as service **104** and conversation **156**.

WSEE Interface Collection **152** can also include Event types and Status values. Event types shown for example in FIG. **1**C include Starting, which can indicate WSEE **146** has just entered the Starting state; Stopping, which can indicate WSEE **146** has just entered the Stopping state; and Stopped, which can indicate WSEE **146** has just completed the Stopping state and is no longer able to process operational requests. Manager **102** can register to receive notification of one or more of the Event types available in WSEE Interface Collection **152**.

Status values in WSEE Interface Collection **152** can include values such as Starting and Stopping. The Starting status value can be used when the underlying resource(s) used in WSEE **146** are transitioning from an Inactive state to an Operational state. The Stopping status value can be used when the underlying resource(s) are transitioning from an Operational state to an Inactive state.

The preceding types, operations, status values, and attributes are examples of features that can be included in WSEE Interface Collection **152**. Other features can be implemented for WSEE Interface Collection **152** in addition to, or instead of, the preceding features. Further, the names for the interfaces, attributes, events, operations and other interface features disclosed herein are provided for purposes of illustration only. The same names can be used to represent different features, and other names can be implemented to represent features disclosed herein.

Referring to FIGS. **1**C and **1**D, FIG. **1**C shows service **104** containing conversation **156** layered with conversation managed object **158**, which represents the management features of resource(s) associated with conversation **156**. Similar to service managed object **108**, and WSEE managed object **148**,

conversation managed object **158** can include one or more categories of interfaces in conversation interfaces **160** shown in FIG. **1**D as Conversation Interface Collection **162**. Conversation interfaces **160** allow manager **102** to access information regarding the state of messages related to corresponding conversations **104**. Conversation managed object **158** can also include managed object interfaces **164**, which provides the common set of management features that can be implemented by any type of managed object **128**.

Service **104** can implement one or more conversations **156**, **166**. Conversations **156**, **166** can communicate with conversations in other services contained in WSEE **146**, as well as external to WSEE **146**. Conversations **156**, **166** and conversation managed object **158**, **170** can also be contained in separate WSEEs **146**. Some embodiments of Conversation managed objects **158** are further described in the disclosure entitled "System and Method for Managing Conversations", U.S. patent application Ser. No. 10/438,576.

Extending Management Capabilities for Managed Objects

Referring to FIGS. **1**B and **1**C, in some embodiments, managed object interfaces **130**, WSEE interfaces **150**, service interfaces **112**, and conversation interfaces **160** are exposed to manager **102** through interface descriptions **118**. Interface descriptions **118** provide a framework for creating management services for all managed objects **128** regardless of the resources they represent by defining the interfaces to a common format recognized by other managed objects **128** and manager **102**. In some embodiments, interface descriptions **118** define the interfaces to Web Services Description Language (WSDL). Other suitable formats can be utilized.

To simplify notation, the term "management interfaces" is used to refer collectively to managed object interfaces **130**, WSEE interfaces **150**, service interfaces **112**, and conversation interfaces **160**.

Interface descriptions **118** implemented in WSDL typically define schemas for messages and corresponding WSDL parts; port types; marker attributes; and namespaces. Port types describe a list of potential management capabilities for manager **102**. Ports that implement some or all of the port types defined in interface descriptions **118** allow managed objects **128** to expose their management capabilities and provide manager **102** with instructions for using the management capabilities. Managed objects **128** can expose different portions of the management interfaces to different managers **102**. Examples of WSDL interface descriptions **118** suitable for use with Service Interface Collection **116** and Managed Object Interface Collection **132** described herein are provided in the Appendix filed with this disclosure.

Extensions can be implemented to the management interfaces to manage additional aspects of the resources associated with respective managed objects **128**. In some embodiments, marker attributes for new management port types can be added to corresponding interface descriptions **118** to help identify the management interfaces of managed objects **128**.

In the embodiment shown in FIG. **1**C, components included in manager **102**, WSEE **146**, and discovery agencies **120** are implemented in computer processing systems **180** through **184**, respectively.

Processing systems **180** through **184** can be any suitable computer-processing device that includes memory for storing and executing logic instructions, and is capable of interfacing with other processing systems. In some embodiments, processing systems **180** through **184** can also communicate with other external components via network **144**. Various input/output devices, such as keyboard and mouse (not shown), can be included to allow a user to interact with components internal and external to processing systems **180** through **184**.

Additionally, processing systems **180** through **184** can be embodied in any suitable computing device, and so include personal data assistants (PDAs), telephones with display areas, network appliances, desktops, laptops, X-window terminals, or other such computing devices. Processing systems **180** through **184** and corresponding logic instructions can be implemented using any suitable combination of hardware, software, and/or firmware, such as microprocessors, Field Programmable Gate Arrays (FPGAs), Application Specific Integrated Circuit (ASICs), or other suitable devices.

Logic instructions executed by processing systems **180** through **184** can be stored on a computer readable medium, or accessed by processing systems **180** through **184** in the form of electronic signals. Processing systems **180** through **184** can be configured to interface with each other, and to connect to external network **144** via suitable communication links such as any one or combination of T**1** , ISDN, or cable line, a wireless connection through a cellular or satellite network, or a local data transport system such as Ethernet or token ring over a local area network.

Service Management Examples

FIG. **2** shows a diagram of components included in an embodiment of an online shopping service system **200** that can utilize service management system **100** (FIG. **1**A). A computer system associated with a purchaser, referred to as client **202**, accesses online ordering service **204** at online store **206** via a suitable interface through a network, such as a Web browser interface over the Internet. Online store **206** includes authentication service **208** and online ordering service **204**. Online ordering service **204** accesses authentication service **208** and billing service **210**.

Billing service **210** can be implemented by a third party in payment processor **212**. Information regarding transactions, such as items added to a shopping cart and credit card charge authorizations, can be exchanged via conversations **214**, **216** between online ordering service **204** and billing service **210**. Authentication service **208** authenticates user identification information and enables users to access information previously supplied to make purchases. Billing service **210** allows the purchaser to pay with a credit card, checking account, or other suitable payment means for one or more items. Payment processor **212** then sends the payment to the vendor's account. Manager **102** can be configured to manage one or more of services **204**, **208**, **210** and conversations **214**, **216**.

Referring to FIGS. **2** and **3**, FIG. **3** shows online store **206** and payment processor **212** configured with managed objects and management interfaces. Online ordering service **204** and authentication service **208** operate in WSEE **302**. WSEE **302** can be configured with WSEE managed object **304**, WSEE interfaces **306**, and managed object interfaces **308**. Online ordering service **204** includes service managed object **302** and conversation **214**. Service managed object **309** includes service interfaces **310**, and managed object interfaces **312**, while conversation managed object **316**, conversation interfaces **318**, and managed object interface **320** are associated with conversation **214**. A suitable set of managed objects and management interfaces can be configured for authentication service **208**

With regard to payment processor **212**, billing service **210** operates in WSEE **322**. WSEE **322** is configured with WSEE managed object **324**, WSEE interfaces **326**, and managed object interfaces **328**. Billing service **204** includes service

managed object **332** and conversation **216**. Service managed object **332** includes service interfaces **334** and managed object interfaces **336**, while conversation managed object **340**, conversation interfaces **342**, and managed object interface **344** are associated with conversation **216**.

Manager **102** can discover interface descriptions **118** to learn about the management capabilities available via the management interfaces. The management capabilities can include features discussed herein for the embodiments of Service Interface Collection **116** (FIG. **1**A), Managed Object Interface Collection **132** (FIG. **1**B), WSEE Interface Collection **162** (FIG. **1**C), and Conversation Interface Collection **116** (FIG. **1**D), as well as any extended resource management capabilities that can be included in an implementation.

Manager **102** can be configured to discover interface descriptions **118** for the management interfaces. In some embodiments, manager **102** includes a configuration file with a list of URIs of the locations of interface descriptions **118** for the management interfaces associated with a particular service. Manager **102** can alternatively discover interface descriptions **118** with a UDDI lookup or other suitable discovery method. Once manager **102** discovers a managed object, manager **102** can access the Relationships attribute in the corresponding managed object interface to discover other managed objects that are related to the particular managed object. Manager **102** can access the Container attribute in the service interfaces to retrieve the execution environment interfaces for WSEE managed objects.

FIG. **4** shows a topological diagram **400** of the managed objects **304**, **309**, **316**, **324**, **332**, **340** of FIG. **3**, as developed by manager **102**. Online store **206** is a root object with respect to other components in online shopping service **200** (FIGS. **2** and **3**). Managed objects included on one branch of online store **206** are shown as WSEE **304**, authentication service **402**, online ordering service **302**, and conversation **316**. The managed objects on the other branch of online store **206** include WSEE **322**, billing service **210**, and conversation **340**.

FIG. **5** shows a diagram of the logical relationships between components in online store **206**. As shown, online ordering service managed object **309** is contained in WSEE managed object **304**. Online ordering service managed object **309** depends on authentication service managed object **502** and billing service managed object **332**. Conversation managed object **316** is contained in online ordering service managed object **309**.

Manager **102** can invoke the PushSubscribe and/or PullSubscribe operations in one or more of managed object interfaces **308**, **312**, **320**, **328**, **336**, **344** to receive notifications from managed objects **304**, **309**, **316**, **324**, **332**, **340**, respectively. As an example of the notification process, assume that manager **102** receives a participant failure notification from conversation **214** via associated managed object interfaces **320**. When the error occurs, conversation managed object **316** issues a notification of the event to manager **102**. The event severity is critical, for example. When manager **102** receives the notification, a status propagation rule in manager **102** changes the status of the parent nodes to the highest status value of its children.

To illustrate propagation of the error status among related objects, FIG. **6** shows managed object topological diagram **400** of FIG. **4** with WSEE managed object **304**, online ordering service managed object **302**, and conversation managed object **316** configured with dotted boxes to indicate a status value associated with a failure. WSEE managed object **322**, billing service managed object **332**, and conversation managed object **340** are shown with dashed boxes to indicate failure status propagation from conversation managed object **340** to the parent nodes.

To resolve the problem with conversation **214**, manager **102** reviews the status and cause of the problem/status change received through the notification. Manager **102** then inspects the notifications, the status values, and the time stamps to determine the notification that caused the status change. Once the source of the status change is determined, manager **102** determines whether it can fix the problem. If the problem cannot be solved without the assistance of a human administrator, manager **102** notifies the administrator of the problem. Once the problem is solved, manager **102** returns status values to normal in managed object interfaces **308**, **312**, **320**, **328**, **336**, **344**.

Referring now to FIG. **7**, another diagram of an embodiment of online ordering system **700** is shown with manager **102** interfacing with online store **206**, but not payment processor **212**. Such a situation can arise when payment processor **212** is in a different management domain, for example, or when components in payment processor **212** are not configured with managed objects and management interfaces.

FIG. **8** shows a topological diagram **800** of components in online ordering system **700** in FIG. **7**. In the event of a problem with payment processor **212**, manager **102** can suspend online store **206** until payment processor **212** resumes operation. Manager **102** can also direct online store **206** to other suitable payment processors to replace payment service **212**. For example, assume WSEE **322** (FIG. **3**) for billing service **210** experiences a failure. The notification from conversation managed object **316** (FIG. **3**) can indicate that conversation **216** has stopped responding. Manager **102** inspects the notifications, their status values, and their time stamps, to determine which notification caused the status change. Since conversation **216** is not responding, and payment service **212** is outside the management domain of manager **102**, manager **102** can wait until payment service **212** resumes responding, send a message to the administrator of payment service **212**, and/or re-initiate conversation **214** with a similar payment service.

Distributed Business Processes Example

As another example of the use of managed objects to manage Web services, FIGS. **9** and **10** show diagrams of distributed business processes with four independent Web services that can be monitored by auction manager **900**. Companies C**2**, C**3**, and C**4** provide vendor services **902**, **904**, **906** to bid on items specified in requests for quotes (RFQs) from purchasing service **908** at Company C**1**. The distributed process of submitting and responding to the RFQs is shown as RFQ Process **910** in FIG. **10**.

Auction manager **900** offers a management service that monitors the progress of RFQ Process **910**. The business logic and operational processes are performed through purchasing service **908** at Company C**1** and vendor service **902**, **904**, **906** from Companies C**2**, C**3**, and C**4**, respectively.

Auction manager **900** has an agreement with Companies C**1**, C**2**, C**3**, and C**4** in which auction manager **900** defines RFQ process **910** for Company C**1**'s purchasing service **908** to submit the RFQ, and for Companies C**2**, C**3**, and C**4** to respond to the RFQ. In one embodiment, RFQ process **910** is implemented in the Business Processes Execution Language (BPEL). BPEL is an XML-based language designed to enable task sharing for a distributed computing environment, even across multiple organizations, using a combination of Web services. A developer formally describes a business process

that will take place across the Web in such a way that any cooperating entity can perform one or more steps in the process the same way. In a supply chain process, for example, a BPEL program might describe a business protocol that formalizes the pieces of information in a product order, and the exceptions that may have to be handled. Other suitable specifications for implementing RFQ process **910** can be utilized, in addition to, or instead of, BPEL.

Auction manager **900** monitors RFQ process **910**, which choreographs the flow of messages for the bidding until the bidding terminates. Vendor service **902**, which is also representative of vendor services **904** and **906**, includes service managed object **912** with service interfaces **914** and managed object interfaces **916**. Vendor service **902** also includes RFQ process **910**, with RFQ process managed object **918**, conversation interfaces **920**, RFQ process interfaces **922**, and managed object interfaces **924**. Managed object interfaces **924** include information regarding RFQ process **910**, including the relationship of RFQ process managed object **918** with respect to vendor service managed object **912**. Companies C**2**, C**3**, and C**4** each provide auction manager **900** with a URI pointing to interface descriptions (not shown) for vendor services **902**, **904**, **906**.

RFQ process interfaces **922** is an extension to conversation interfaces **920**. RFQ process **910** can therefore use attributes, operations, status values, and notifications defined in conversation interfaces **920** and managed object interfaces **924**, as well as the extensions defined specifically for RFQ process **910**. For purposes of this example, assume RFQ process interfaces **922** support the following elements:

- GetGlobalProcessID operation, which returns the global process ID (URI) for an instance of RFQ process **910**. In some embodiments, the global process ID can be the URI contained in the Context/Identifier element defined by WS-Coordination, which is a known framework for coordinating distributed application programs that form Web services. Other suitable identifiers can be used.
- GetRFQProcess4ID operation, which returns the URI for a description of managed object interfaces **924** for the specific global process ID returned from the GetGlobalProcessID operation.
- ProcessStepCompleted notification, which issues an event notification to subscribing auction managers **900** when specified portions of each RFQ process **910** are completed.

FIGS. **11** through **16** show diagrams of the distributed services of FIGS. **9** and **10** with annotations of various steps performed throughout the bidding process. Referring to FIGS. **10** and **11**, auction manager **900** can use the identifiers pointing to interface descriptions (not shown) that were provided by vendor services **902**, **904**, **906** to discover interface descriptions for corresponding management interfaces. Auction manager **900** registers for notification with vendor service managed object **912** using the Relationships Changed event notification in managed object interface **916**.

Referring to FIGS. **10** and **12**, purchasing service managed object **908** knows that RFQ process **910** is available to buy selected items at a competitive price from participating vendors, such as Companies C**2**, C**3**, and C**4**. Purchasing service **908** knows that auction manager **900** is available to monitor RFQ process **910**, but does not necessarily know the identity of auction manager **900**.

Based on information in the interface descriptions of RFQ process **910**, purchasing service **908** sends a RFQ document to vendor services **902**, **904**, and **906**. Upon receiving the RFQ document, vendor services **902**, **904**, **906** invoke RFQ process **910**, as shown in FIG. **12**.

Referring to FIGS. **10** and **13**, vendor services **902**, **904**, **906** send a notification to auction manager **900** when RFQ processes **910** begin executing. The notification includes a link to RFQ Process managed object interfaces **924**. When the notification arrives, auction manager **900** retrieves interface descriptions of RFQ Process managed object interfaces **924** using information in the notification. Auction manager **900** can then invoke the management operations exposed in RFQ process interfaces **922**, as well as in managed object interfaces **924** and conversation interfaces **920**, based on information in the interface descriptions.

Auction manager **900** then calls the getGlobalProcessID operation supported by RFQ process interfaces **922** for each RFQ process **910**. The getGlobalProcessID operation returns the same global ID for RFQ process **910**, thus allowing the Auction Manager **900** to logically represent the separate instances of RFQ process **910** as the same process. In some embodiments, the global ID can be provided by the use of the WS-Coordination Context, as specified by BPEL. More specifically, the global ID can be the "Identifier" element (a URI) of the Context type defined by WS-Coordination.

Referring to FIGS. **10** and **14**, auction manager **900** invokes the GetOtherParties operation supported by conversation interfaces **920** for one of the three vendor companies. The Get Other Parties operation returns identification for managed objects in the three vendor services **902**, **904**, **906**, plus purchasing service **908**. Using this information, auction manager **900** retrieves interface descriptions of managed object interfaces **916** for vendor service managed object **912**. Auction Manager **900** then invokes the getRFQProcess4ID operation supported by RFQ process interfaces **922**, passing the global process ID provided by the vendors C**2**, C**3**, C**4**. The getRFQProcess4ID operation returns a link to RFQ process managed object **926** for purchasing service **928** to Auction Manager **900**.

In situations where the vendors are not aware of each other, auction manager **900** can call the GetOtherParties operation supported by RFQ process managed object **918**, which returns IDs for each vendor service **902**, **904**, **906**. Auction manager **900** can then call the GetRFQProcess4ID operation supported by RFQ process interfaces **922** to retrieve a link to managed object interfaces **924** for each vendor service **902**, **904**, **906**.

At this point, discovery is complete and auction manager **900** has discovered vendor service managed objects **912** and RFQ process managed objects **918** for vendor services **902**, **904**, **906**.

Auction manager **900** then uses the ProcessStepCompleted notification in RFQ process interfaces **922** to register for notification every time a new step is completed, as shown in FIG. **15**. In this manner, auction manager **900** can monitor the progress of RFQ process **910**.

The ProcessStepCompleted notification in RFQ process interfaces **922** continuously updates auction manager **900** as each step in RFQ process object **910** is completed for each vendor service **902**, **904**, **906**. Referring to FIG. **16**, if RFQ process object **910** stalls because, for example, vendor service managed object **906** is not sending a message that is expected, auction manager **900** can determine the cause of the problem using information in managed object interface **924** for vendor service managed object **912**. Auction manager **900** can send a Status request to vendor service managed object **912**. When vendor service managed object **912** does not reply within a prespecified time, the problem can be reported to a human operator at Auction Manager **900**. The operator can contact an

operator at Company C4 to solve the problem. The transaction can be completed once Company C4 fixes the technical problem.

The logic modules, processing systems, and circuitry described here may be implemented using any suitable combination of hardware, software, and/or firmware, such as Field Programmable Gate Arrays (FPGAs), Application Specific Integrated Circuit (ASICs), or other suitable devices. The logic modules can be independently implemented or included in one of the other system components. Similarly, other components have been discussed as separate and discrete components. These components may, however, be combined to form larger, smaller, or different software modules, integrated circuits, or electrical assemblies, if desired.

While the invention has been described with reference to various embodiments, it will be understood that these embodiments are illustrative and that the scope of the invention is not limited to them. Many variations, modifications, additions and improvements of the embodiments described are possible. For example, those having ordinary skill in the art will readily implement the steps necessary to provide the structures and methods disclosed herein, and will understand that the components and their arrangement are given by way of example only. The configurations can be varied to achieve the desired structure as well as modifications, which are within the scope of the invention. Variations and modifications of the embodiments disclosed herein may be made based on the description set forth herein, without departing from the scope of the invention as set forth in the following claims.

In the claims, unless otherwise indicated the article "a" is to refer to "one or more than one".

We claim:

1. A system for managing a Web service, comprising:
- a computer processor; and
- a service managed object executable on the computer processor, wherein:
  - the service managed object is associated with the Web service and includes at least one interface configured to allow a manager to access management features for the Web service; and
  - the at least one interface is configured to provide a list of conversations associated with the Web service.

2. The system of claim **1**, wherein the at least one interface is further configured to provide information regarding an interface description for the at least one interface.

3. The system of claim **1** wherein the at least one interface is further configured to provide information regarding the relationship of the service managed object to other managed objects.

4. The system of claim **1**, further comprising a conversation interface for at least one of the conversations, wherein the conversation interface provides:
- information regarding other managed objects participating in the at least one conversation;
- an identifier associated with the at least one conversation;
- information regarding messages processed by the service;
- identifiers for other services participating in the at least one conversation; and
- the number of other services participating in the at least one conversation.

5. The system of claim **4**, wherein the conversation interface further provides information regarding the service that contains the at least one conversation.

6. The system of claim **4**, wherein the conversation interface further provides notification of at least one of the following events:
- the at least one conversation received an incorrect message;
- one of the participants in the at least one conversation is missing;
- one of the remote participants in the at least one conversation sent an unexpected fault message; and
- a fault occurred while processing a message for the at least one conversation.

7. The system of claim **4**, further comprising a Web service execution environment (WSEE) interface comprising information regarding:
- the configuration of the WSEE; and
- other services that are executable in the WSEE.

8. The system of claim **1**, wherein the at least one interface is configured to provide information regarding the response time of the service.

9. The system of claim **1**, wherein the at least one interface is configured to allow a manager to control operation of the service.

10. The system of claim **1**, wherein the service managed object is configured to notify the manager of the operational status of the service.

11. The system of claim **1**, wherein the information is sent to the manager via a simple object access protocol (SOAP).

12. The system of claim **1**, further comprising an interface description that describes management capabilities available for the service via the at least one interface.

13. The system of claim **12**, wherein the interface description is formatted according to a Web services description language (WSDL).

14. A system capable of managing a Web service, comprising:
- a computer processor configured to communicate with the service, wherein the computer processor includes executable instructions operable to:
  - discover a managed object interface for the service;
  - discover capabilities for managing the service based on the managed object interface for the service;
  - discover a service interface for the service; and
  - discover additional capabilities for managing the service based on the service object interface.

15. The system of claim **14**, wherein the computer processor includes executable instructions further operable to:
- discover other managed objects related to the service based on the information in the managed object interface.

16. The system of claim **14**, wherein the computer processor includes executable instructions further operable to receive information regarding at least one of the group of:
- conversations associated with the service that are in progress;
- the last requested message received by the service;
- the last fault message returned from the service; and
- the execution environment for the service.

17. The system of claim **14**, wherein the computer processor includes executable instructions further operable to receive information regarding at least one of the group of:
- the total number of messages the service has received since its creation;
- the number of failed messages processed by the service;
- the number of successful messages processed by the Web service;
- the maximum amount of time that successful operational requests executed before returning a response;
- the minimum amount of time that successful operational requests executed before returning a response;
- the cumulative amount of time that successful operational requests have executed since the service started;

the maximum amount of time that failed operational requests executed before returning a response;

the minimum amount of time that failed operational requests executed before returning a response; and

the cumulative amount of time that failed operational requests have executed since the service started.

18. The system of claim **17**, wherein the computer processor includes executable instructions further operable to receive information regarding at least one of the group of:

an operation to start the service;

an operation to restart the service; and

an operation to stop the service.

19. The system of claim **18**, wherein the computer processor includes executable instructions further operable to receive information regarding:

a value indicating the operational status of a resource associated with the service; and

an event indicating the a change in the operational status of the resource.

20. The system of claim **19**, wherein the computer processor further comprises instructions operable to determine the management capabilities for the service based on:

a first interface description that describes the managed object interface; and

a second interface description that describes the service object interface.

21. The system of claim **20**, wherein the first interface description and the second interface description are formatted according to a Web services description language (WSDL).

22. A computer program product tangibly embodied in a computer readable storage medium, comprising:

a service interface; and

a managed object interface associated with the service interface, wherein the service interface is configured to include information for managing a Web service, including information indicating conversations associated with the service that are in progress.

23. The computer program product of claim **22**, wherein the service interface is further configured to include information regarding at least one of the group of: the last requested message received by the service; the last fault message returned from the service; and the execution environment for the service.

24. The computer program product of claim **22**, wherein the service interface is further configured to include information regarding at least one of the group of: the total number of messages the service has received since its creation; the number of failed messages processed by the service; the number of successful messages processed by the Web service; the maximum amount of time that successful operational requests executed before returning a response; the minimum amount of time that successful operational requests executed before returning a response; the cumulative amount of time that successful operational requests have executed since the service started; the maximum amount of time that failed operational requests executed before returning a response; the minimum amount of time that failed operational requests executed before returning a response; and the cumulative amount of time that failed operational requests have executed since the service started.

25. The computer program product of claim **24**, further comprising computer executable instructions operable to exchange messages via the simple object access protocol (SOAP).

26. The computer program product of claim **22**, wherein the service interface is further configured to include at least one of the group of: an operation to start the service; and an operation to stop the service.

27. The computer program product of claim **22**, wherein the service interface is further configured to include: at least one of the group of: a status value indicating the service's underlying resource is in the process of transitioning from terminated to operational status; and a status value indicating the service's underlying resource is in the process of transitioning from operational to inactive; and at least one of the group of: an event indicating the service is starting; an event indicating the service is stopping; and an event indicating the service has stopped.

28. The computer program product of claim **22**, further comprising a service interface description that describes the service interface.

29. The computer program product of claim **28**, wherein the extension to the service interface exposes management information regarding a business transaction.

30. The computer program product of claim **22**, further comprising:

an extension to the service object interface to expose additional service management capabilities for the service.

31. The computer program product of claim **30**, wherein the service interface description is formatted according to a Web services description language (WSDL).

32. The computer program product of claim **31**, wherein the extension to the service interface is implemented by including another port type in an interface description for the extension.

33. A method for managing a service, comprising:

creating a service object representing the service, wherein the service object includes a management interface;

exposing management capabilities for the service via a description of the management interface; and

allowing a manager to subscribe to receive notification of events regarding the service.

34. The method of claim **33** further comprising:

providing information regarding the service including:

information indicating conversations associated with the service;

messages processed by the service;

the execution environment for the service; and

the response time of the service.

35. The method of claim **33** further comprising:

allowing a manager to control operation of the service.

36. An apparatus for managing a service, comprising:

interface means for representing management capabilities for the service; and

description means for exposing a selection of the management capabilities for the service to a manager.

37. The apparatus of claim **36**, further comprising:

means for allowing a manager to subscribe with the service object to receive notification of events regarding the service.

38. The apparatus of claim **37** further comprising:

means for providing information indicating conversations associated with the service;

means for providing information regarding messages processed by the service; and

means for providing information indicating the response time of the service.

39. The apparatus of claim **36** further comprising:

means for allowing a manager to operate the service.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE

CERTIFICATE OF CORRECTION

PATENT NO.	: 7,925,981 B2
APPLICATION NO.	: 10/438716
DATED	: April 12, 2011
INVENTOR(S)	: M. Homayoun Pourheidari 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 21, line 19, in Claim 19, delete "the a" and insert -- the --, therefor.

Signed and Sealed this
Second Day of August, 2011

David J. Kappos

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