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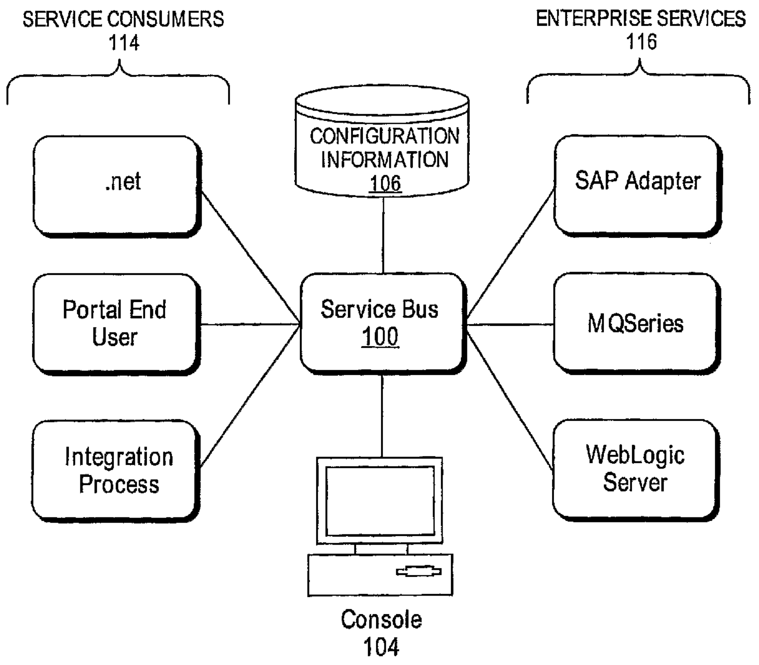

(57) Abstract: A service infrastructure that enables dynamic service composition and orchestration. This description is not intended to be a complete description of, or limit the scope of, the invention. Other features, aspects and objects of the invention can be obtained from a review of the specification, the figures and the claims.

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DYNAMIC SERVICE COMPOSITION AND ORCHESTRATION

CLAIM OF PRIORITY

This application claims priority from the following co-pending applications, which are hereby incorporated in their entirety:

U.S. Provisional Application No. 60/573,354 entitled SYSTEM AND METHOD FOR ENTERPRISE APPLICATION INTEGRATION BUS, by Matthew Mihic *et al.*, filed May 21, 2004 (Attorney Docket No. BEAS-01684US0).

U.S. Provisional Application No. 60/573,717 entitled LIQUID COMPUTING, by Alfred Chang *et al.*, filed May 21, 2004 (Attorney Docket No. BEAS-01703US0).

U.S. Patent Application No. __/___,___ entitled DYNAMIC SERVICE COMPOSITION AND ORCHESTRATION, by Paul B. Patrick *et al.*, filed May 20, 2005 (Attorney Docket No. BEAS-01825US0).

FIELD OF THE DISCLOSURE

The present disclosure relates generally to a switching fabric having message processing capabilities through which processes can communicate and, more particularly, to web service middleware.

BACKGROUND

The need for enterprise software applications to work together with web browser-based front ends lead to the development of application servers. Application servers provide a framework for integrating front-end web applications with back-end enterprise applications. Beyond simply invoking enterprise applications from applications servers, a need arose to compose pieces of different enterprise applications into composite applications. One way this can be done is to expose an enterprise application as a set of reusable services that other systems can access. However, enterprise applications are typically deployed on multiple application platforms and in heterogeneous environments. These factors make the composition effort proprietary and programming-driven, resulting in brittle and expensive integrations. What is needed is an flexible infrastructure to dynamically compose services and handle any incompatibilities that might arise between them.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1a is an illustration of a system in an embodiment.

Figure 1b is an illustration of a service bus architecture in accordance to an embodiment.

Figure 2 is an illustration metric aggregation and configuration propagation in accordance to an embodiment.

Figure 3 is an illustration of message processing pipelines in accordance to an embodiment.

Figures 4 is an illustration of a system for creating a unified information view in accordance to an embodiment.

Figure 5 is a high level schematic of a liquid data integration engine in accordance to an embodiment.

Figure 6 is an illustration of a security system to an embodiment.

Figure 7 is an illustration of an security service module in an embodiment.

Figure 8 is an illustration of system components to propagate security information in accordance to an embodiment.

Figure 9 is an illustration of a system in accordance to an embodiment.

Figure 10 is an illustration of an integrated service composition system in accordance to an embodiment.

DETAILED DESCRIPTION

The invention is illustrated by way of example and not by way of limitation in the figures of the accompanying drawings in which like references indicate similar items. References to embodiments in this disclosure are not necessarily to the same embodiment, and such references mean at least one. While specific implementations are discussed, it is understood that this is done for illustrative purposes. A person skilled in the relevant art can recognize that other components and configurations may be used without departing from the scope and spirit of the invention.

In the following description, numerous specific details are set forth to provide a thorough description of the invention. However, it can be apparent to one skilled in the art that the invention may be practiced without these specific details. In other instances, well-known features have not been described in detail so as not to obscure the invention.

Although a diagram may depict components as logically separate, such depiction is merely for illustrative purposes. It can be apparent to those skilled in the art that the components portrayed can be combined or divided into separate software, firmware and/or hardware components. For example, one or more of the embodiments described herein can be implemented in a network accessible device/appliance such as a router. Furthermore, it can also be apparent to those skilled in the art that such components, regardless of how they are combined or divided, can execute on the same computing device or can be distributed among different computing devices connected by one or more networks or other suitable communication means.

Enterprise information is typically not all stored in a single data store, such as a database, but can be instead stored in individual silos from which each enterprise application must drink. Each silo can have its own differentiating features (e.g., storage mechanism, storage format, storage access mechanism, etc.). In an attempt to bring some order to the sea of information chaos, enterprises are turning to a Service Oriented Architecture (SOA) approach to integration. Using this architectural approach, the capabilities of applications and the access mechanisms to information sources are exposed as services. Services hide underlying implementation details from application programs.

In one embodiment, information sources are exposed as services. This concept focuses on hiding the implementation and access mechanism details of a given information source behind a service based interface (or façade). While an SOA approach could be done with any number of technologies, one embodiment uses of XML and Web Services. Using this approach, it is possible to hide whether the information source requires a SQL query, for example, to access the information within. Application development becomes focused on making service requests and handling service responses. In one embodiment, an information source can be turned into a service through use of a service proxy or a service adapter.

A service proxy can serve as an external wrapper which is installed in front of an information source, an application or a service. The proxy acts as a gateway and a façade through which access to the information source is performed. By way of illustration, a service proxy for accessing files in a file system could be created to access a file anywhere in a file system or be restricted to only certain areas of the file system. By way of further illustration, service proxies can hide the details of what a requesting entity or “consumer” is required to do in order to establish a session with the information source, transform the service request into the appropriate set of interactions in order to retrieve or update the information service, and then format the information to be returned to the consumer. By way of yet another illustration, the service proxy may hide the additional steps required to determine the actual results to be returned (e.g., the retrieval of additional meta-data, such as data sensitivity labels that may be stored in yet another information store, that need to be retrieved and evaluated before particular portions of the result set are to be returned).

In one embodiment, a service adapter is an embedded or integrated form of a service proxy. A service adapter is integrated into the request/response processing logic of a process (e.g., an information source) rather than operating externally from it.

In one embodiment, the SOA approach is extended with a service bus switching fabric. The service bus can provide the flexibility to allow data transformations and other services to be "plugged" into the bus and then reused by any number of different services and application components. This removes the need to hardwire a particular processing flow of services by allowing the processing flow to be described and then dynamically assembled. In one embodiment, applications can be assembled from any of the services which are "plugged" into the bus to create new information-based applications. In addition, through the orchestration of services, using standards such as Business Process Execution Language (BPEL), it is possible to dynamically change how an information technology infrastructure utilizes information sources, performs the data transformations, and incorporates capabilities provided by and to external partners to allow an enterprise to more efficiently execute its mission.

With reference to **Figure 1a** and by way of illustration, the system includes a service bus **100** that represents a fusion of message brokering, web services, business-to-business (B2B) web services gateway and web services management concepts into a combination centered around a runtime configuration information directory/repository **106** and console **104**. The service bus is an easy to use configuration-driven intermediary that accomplishes (without limitation) the following efficiently and with high availability, scalability and reliability:

- Bridges the gap between what message sender **114** sends and what receiver **116** expects in the area of envelope protocol, transport protocol, security scheme, payload contents, one way and request/response paradigms, synchronous and asynchronous communication, point-to-point, and publish/subscribe.

• Provides additional computing capability to perform tasks such as (but not limited to) multi-destination publish, content based routing, authentication and authorization, and credential mapping.

• Provides monitoring capability with metrics collection and display, alert displays, tracking event collection and use, message archiving and Service Level Agreement (SLA) management.

Figure 1b is an illustration of a system in accordance to an embodiment. In one embodiment, the system includes a service bus **100** which can act as an intermediary between a client and a service. Note that a client may itself be a service. Messages to the service bus arrive on a transport **108** and can be processed to determine, by way of a example, a destination to route and/or publish the message to, a transformation to perform on the message, and/or security processing. The message then is sent out on transport **110** bound for a service or another service bus. In one embodiment, a response to the message can follow an inverse path through the service bus.
In one embodiment, the service bus can be implemented partially or wholly on an application server **102** such as WebLogic® Server, available from BEA Systems, Inc. The system is driven by configuration information **106** which can specified through the configuration/monitoring console **104** which provides a user interface for creating, modifying and deleting configuration information. All aspects of the system are dynamically configurable. By way of a non-limiting example, a user interface can include one or more of the following: 1) a graphical user interface (GUI) rendered on a display device or projected onto a user's retina; 2) an ability to respond to sounds and/or voice commands; 3) an ability to respond to input from a remote control device (e.g., a cellular telephone, a PDA, or other suitable remote control); 4) an ability to respond to gestures (e.g., facial and otherwise); 5) an ability to respond to commands from a process on the same or another computing device; and 6) an ability to respond to input from a computer mouse and/or keyboard. This disclosure is not limited to any particular user interface. Those of skill in the art will recognize that many other user interfaces are possible and fully within the scope and spirit of this disclosure.
In one embodiment and with reference to **Figure 2**, the configuration information is distributed throughout an enterprise by an administrative server **112** to one or more managed servers **100** hosting service buses. In aspects of these embodiments, managed servers can be deployed in clusters as is well known in the art.

Configuration information can be automatically propagated to managed servers for fast local retrieval by service buses. Likewise, monitoring metrics can be automatically collected from all managed servers for aggregation and display on the console.

In one embodiment, a service hosted by the service bus ("service proxies") and services not hosted by the service bus ("external services") but which are invoked by service proxies are both modeled as services. Service proxies act as stand-ins for, or facades of, services (i.e., external services and service proxies). By way of a non-limiting example, a service can include:

- A set of concrete interfaces called ports (also called endpoints), each with a transport address and associated configuration. In one embodiment, the set of ports constitutes load balancing and failover alternatives for the service.
- An optional abstract interface which in one embodiment is a definition of the structure of message parts in the interface possibly broken down by operations.
- A binding that defines the packaging of message parts in the abstract interface to a concrete message and the binding of that message to the transport.
- Policies for Web Services Security (WSS) and Web Services Reliable Messaging (WS-RM), authorization policies, and actions needed to be performed transparently by the binding layer (e.g., logging).

In one embodiment, a Web Services Description Language (WSDL) representation of the abstract interface, concrete interface and binding is possible for Simple Object Access Protocol (SOAP) web services based on Hypertext Transfer Protocol (Security) HTTP(S) or Java Messaging Service (JMS) transports. In aspects of this embodiment, a WSDL resource or an existing service could be used as a template for a definition of a new service's interface. Also supported are email, file, WS-RM and File Transport Protocol (FTP) transports. In one embodiment, the service bus could periodically poll a file system directory to determine if a file is ready for processing in the case of a file transport. The service bus can support request/response and one-way paradigms for HTTP and JMS asynchronous transports. It optionally supports ordered delivery of messages if the underlying transport supports it. In a further embodiment, service bus supports eXternal Markup Language (XML), non XML (structure described with MFL), binary, Multipurpose Internet Mail Extensions (MIME) with attachments (email), and SOAP packaging.

A service/service proxy can have multiple ports for the same binding. A service/service proxy can define the load balancing policy to use for its ports. In one embodiment, the policies can include round robin and random (weighted or not weighted). The ports can also service as fail-over alternatives on failure. The two concepts are coupled together for a high-availability load balancing scheme.
A service proxy can also define the retry policies on failure and (for request/response) a timeout policy and security policies that apply to messages in its interface. This can be specified at the service level (applies to all messages) or individual messages for the operations of the service. In one embodiment, services are categorized by one or more category schemes. For example, categories can be key names and category values can be values for the key name. A service can have multiple values for multiple category name. Categories are useful for discovery purposes. There are a number of well-known ontologies (or category schemes) that define the key name and allowed hierarchy of values. In aspects of this embodiment, leaf values in a category hierarchy are used to categorize services. In one embodiment, a service consumer can be categorized for searching. Service consumers can be an organization or an application and can send messages (or receive sync responses). In yet another embodiment, a service consumer is associated with credentials and is tied to a user so it can belong to roles for authorization.
In one embodiment, the implementation of a service proxy includes at least one message processing pipeline definition. For example, this can include a definition of a request pipeline definition and a response pipeline. Pipelines are message processing nodes that specify what actions are performed on request messages to the service proxy before invoking an external (or another proxy) service, and what processing is performed on responses from the service invoked by the service proxy before the service proxy returns a response to a client. Each pipeline can include a sequence of stages. A stage implements a programmatic interface and/or a protocol that is compatible with the pipeline. Messages fed into the pipelines are accompanied by a set of message context variables (that includes variables that contain the message contents) that can be accessed or modified by the pipeline stages.
By way of illustration, common pipeline stages include:
● A transformation stage allows flow control "if" structures to be nested to select a transformation to be performed that affects the context. A web services callout or database lookup can be an alternative to an XML Query (XQuery) or Extensible

Stylesheet Language Transformation (XSLT) transformation to set the output context variable.

• A routing stage allows "if" structures and "case" structures to be combined (and nested) to define a single endpoint and operation to route the message to. A set of transformations that affects context variables can be defined before the message is published to each endpoint. A web services callout or database lookup can be an alternative to an XQuery or XSLT transformation to set the context variable.

• A publish stage allows "if" structures and "case" structures to be combined (and nested) to define the set of endpoints and operations to publish the message to. A set of transformations that affects context variables can be defined before the message is published to each endpoint. A web services callout or database lookup can be an alternative to an XQuery or XSLT transformation to set the context variable. In one embodiment, the changes to the context are isolated to each published endpoint and do not affect subsequent processing by the pipeline. In one embodiment, WSS processing as well as authorization can be performed in the binding layer.

In one embodiment, the following are exemplary stages:

• A tracking stage allows writing a tracking record with user defined information so the tracking system can be used to search by a user defined criteria.

• An archiving stage writes the message to an archive for historical and record keeping purposes.

• A logging stage allows logging of selected context to the system log for debugging purposes.

• A validation stage validates a document against an XML of MFL schema.

• A custom stage that implements a programmatic interface and/or protocol that is compatible with pipelines.

Figure 3 is an illustration of message processing pipelines in accordance to an embodiment. An operational pipeline can process a message based on an operation indicated by the contents of the message. In one embodiment, the determination of the operation is performed through a user-selected criteria. By way of illustration, each pipeline can include one or more stages (e.g., **302**, **304**, **308**, **310**). A single service level request pipeline **300** can branch out into a plurality of operational pipelines **306** and **312**. The response processing starts with the relevant operation pipeline (**314**, **316**) which then joins into a single service level response pipeline **318**.

In one embodiment, in the case of one-way operations being invoked, the response pipeline is executed with an empty message. This permits a response to be constructed for the service proxy so bridging between request/response and one-way operations is possible (e.g., the service proxy input could be one-way while its output is request/response or vice versa). The service proxy either absorbs the response from the invoked service or generates one for the client.
In one embodiment, a context is shared across both the request pipeline and response pipeline, and other message processing nodes, and its value includes individual request/response messages. In aspects of this embodiment, the context is a set of predefined XML variables. New variables can be added and deleted to the context dynamically. The predefined context variables have by way of a non-limiting example, information about the message, the transport headers, security principals, the configuration information for the current service proxy and the configuration information for the primary routing and subscription services invoked by the service proxy. In one embodiment, the context can be read and modified by XQuery/Xupdate expressions by the stages.
By way of further illustration, the context can include the variables $header, $body and $attachments. These are wrapper variables that contain the SOAP headers, the SOAP body contents and the MIME attachments respectively. The context gives the impression that all messages are soap messages and non SOAP messages are mapped into this paradigm. In the case of binary or MFL data, the XML element that represents the document in $attachments or $body refers to the actual document with a unique identifier. In the case of SOAP RPC, the body content is itself a wrapper element that contains the typed RPC parameters.
In one embodiment, the system has a built-in type system that is available for use if desired at design time. When creating an XQuery expression in a condition or transformation at design time, the variable can be declared to be of one or more types in an editor to assist in easily creating the XQuery. In a further embodiment, the types can be specified in XML schemas, MFLs or WSDL resources. This type declaration process is aware of the nature of the variable to be typed (is a wrapper for elements of the types or the types themselves). It also provides assistance to access SOAP RPC parameters or documents in $body easily.
In one embodiment, a stage can have a sequence of steps to execute if an error occurs in that stage. This sequence of steps constitute an error pipeline or handler for

that stage. In addition an error handler can be defined for the whole pipeline or a whole service proxy. The lowest scoped error handler that exists is invoked on an error. This error handler allows the message to be published to an endpoint, formulate an error response message to be returned to the invoker of the service proxy, log the message, continue after modifying the context, or raise an exception. Raising an exception can transfer control to the next higher scoped error pipeline.

Although exposing information sources and other processes as services provides a number of benefits, it does not address a number of issues such as unified views of information and data transformations. For example, portal applications can be used as the presentation service of web-based applications by aggregating information from a number of back-end information sources (e.g., heterogeneous data sources such as relational databases, XML files, Web services, and custom applications) and assembling generated pages. The portal needs to understand each of the information sources available, what information pieces are stored in each source, the relationships between those pieces of information, and the necessary transformations required to create a single virtual view. The result of this approach is a portal that is prone to breaking when any of the underlying services on which it depends change or when the portal is migrated to a different operating environment.

In one embodiment, these problems can be overcome by creating a unified view of information on behalf of applications such as portals. In one embodiment, this capability can be provided by the Liquid Data product, available from BEA Systems, Inc. A unified information view makes the complex task of aggregating data from distributed systems easy, allowing developers to access and share business entities without having to deal with the complexities of different data structures, relationships or semantics.

Figures 4-5 are functional block diagrams illustrating a system for creating a unified information view in accordance to an embodiment. As shown in **Figure 4**, a liquid data framework **400** is used to provide a mechanism by which a set of applications, or application portals **402-410**, can integrate with, or otherwise access, a plurality of services. Such services may include a Materials Requirements and Planning (MRP) system **418**, a purchasing system **420**, a third-party relational database system **422**, a sales forecast system **424** and a variety of other data-related services **426**. Although not shown in **Figure 4** for clarity, in one embodiment, one or more of the services may interact with one or more other services through the liquid data framework **400** as well.

The liquid data framework **400** employs a liquid data integration engine **416** to process requests from the set of portals to the services. The integration engine **416** allows access to a wide variety of services, including data storage services, server-based or peer-based applications, Web services and other services capable of being delivered by one or more computational devices are contemplated in various embodiments. A services model **414** provides a structured view of the available services to the application portals. In one embodiment, the services model provides a plurality of views **412** that may be filtered, molded, or shaped views of data and/or services into a format specifically suited for each portal application. In one embodiment, data returned by services to a particular application (or other service acting as a requestor or client) is mapped to the view associated with that application (or service) by the liquid data framework. Embodiments providing multiple views of available services can enable organizations to compartmentalize or streamline access to services, thereby increasing the security of the organization's information technology infrastructure. In one embodiment, the services model may be stored in a repository **428** of service models. Embodiments providing multiple services models can enable organizations to increase the flexibility in changing or adapting the organization's information technology infrastructure by lessening dependence on service implementations.

Figure 5 is a high level schematic of a liquid data integration engine **416** in accordance to an embodiment. The liquid data integration engine includes an interface processing layer **502**, a query compilation layer **518** and a query execution layer **534**. The interface layer includes a request processor **508**, which takes a request **500** and transforms it into an XML query **516** and in one embodiment provides it to the query compilation layer. In another embodiment, the interface layer also includes access control mechanism **512**, which can determine based upon at least one policy **506** whether the client, portal application, service or other process making the request is authorized to access the resources and services required to satisfy the request. Provided that the client, application service or other process is authorized to make the request, the interface layer sends the XML query to the query compilation layer.

Within the query compilation layer, a query parsing and analysis mechanism **524** receives the query, parses it and sends the results of the parsing to a query rewrite optimizer **530**. In one embodiment, the query rewrite optimizer determines whether the query can be rewritten in order to improve performance of servicing the query based upon one or more of execution time, resource use, efficiency or other performance criteria. The query rewrite optimizer may rewrite or reformat the query based upon input from one or more of a source description **526** and a function description **528** if it is determined that performance may be enhanced by doing so. A runtime query plan generator **532** generates a query plan for the query provided by the query rewrite optimizer based upon input from one or more of the source description and the function description.

The query compilation layer passes the query plan output from the runtime query plan generator to a runtime query engine **536** in the query execution layer. The runtime query engine is coupled with one or more functions **540** that may be used in conjunction with formulating queries and fetch requests to sources **542**, which are passed on to the appropriate service(s). The service responds to the queries and fetch requests with results from sources **544**. The runtime query engine of the query execution layer translates the results into a format usable by the client or portal application, such as without limitation XML, in order to form the XML query results **520**.

In one embodiment, before responses or results are passed back to the client or portal application making the request, a query result filter **514** in the interface layer determines based upon filter parameters **522** what portion of the results will be passed back to the client or portal application, forming a filtered query response **504**. Although not shown for clarity, filter parameters may accompany the service request in one embodiment. In yet a further embodiment, the query result filter can also determine based upon access policies what portions of the filtered query response a requestor is permitted to access and may redact the filtered query response accordingly.

In one embodiment, a set of security services is provided which allow enforcement to be performed close to the resources. In a further embodiment, the implementation details of each security service are abstracted through a programmatic service interface. The security infrastructure provided through this approach can be utilized in both the service proxy and service adapter approaches, as well as within applications themselves.

Figure 6 is an illustration of a security system to an embodiment. Various client requestors **600-608** can interact with the system by generating a request **610** to access one or more resources **632-642**. Requestors can include web portals **600**, web services **602**, business processes **604**, legacy applications **606**, third party systems **608**, and/or any program/device capable of generating a request. In one embodiment, resources can include relational database management systems **632**, web services **634**, XML documents **636**, in-flight XML **638**, legacy applications **640**, third party systems **642**, and/or any program/device capable of responding to a request. In one embodiment, the request is processed by a gatekeeper called a Security Service Module (SSM) **618** before reaching a resource. In various embodiments, an SSM can be integrated with a server, application server, web server, a process or any other suitable host such as network firewalls, routers, relays, etc. In aspects of these embodiments, a container (e.g., an Enterprise JavaBean or servlet container) can intercept the request and present it to the SSM. By way of illustration, the SSM can be provided with a request context that includes subject that holds an authenticated identity (e.g., an authenticated user), a resource identifier, user/group information, and/or an object through which the SSM can obtain additional information about the context of the request.

In one embodiment, the SSM determines what roles (if any) the identity of the requestor belongs to based on predefined roles **614**. This is called role mapping. Role mapping can occur just prior to when an access decision is rendered for a resource. The SMM also determines what policies **616** (if any) apply to the request based on the mapped roles, the target resource and requested action. Access to the resource is granted or denied based on evaluation of the applicable polices.

In one embodiment, if access to the target resource is granted, the request is provided to request processor **620** which can convert the request into an XML Query ("XQuery") **622** or other suitable form. XQuery is a query language for XML that uses the structure of XML to express queries involving varied types of data either physically stored in an XML document or viewed as such. In other embodiments, the request can take the form of a Structured Query Language (SQL) expression or any other means for identifying sought after information. It will be appreciated by those of skill in the art that the present disclosure is not limited to or dependent upon the format of the request.

In one embodiment, the XQuery can then be provided to a query compiler/optimizer **626** which parses the query and determines whether the query can be rewritten in order to improve performance of servicing the query based upon one or more of execution time, resource use, efficiency or other performance criteria. A query plan can be generated and provided to distributed query processor **630** which propagates queries to one or more services (**632** – **642**) based on the query plan. Result(s) from the service(s) are assembled and transformed in the result integrator **628** into a result format **624** (e.g., an XML document or other data format) usable by the requestor. In one embodiment, BEA Liquid Data for WebLogic®, available from BEA Systems, Inc., can be used to provide the functionality of components **620**, **626**, **628** and **630**.

In one embodiment, the result **624** is intercepted by the SSM before it reaches the requestor in order to determine if any data in the result should be redacted. In aspects of this embodiment, the SSM evaluates one or more polices directed to specific parts of the result **624**. Only the parts to which the requestor is granted access are returned in the final result **612**. Alternatively, the parts to which the requestor is not granted access can be encrypted in the final result **612**. In a further embodiment, polices can be used to deny access to specific combinations of data in the result **624**. This embodiment allows data to be aggregated from disparate sources (**632-642**), each of which the requestor might be authorized to access, but when brought together might exceed the requestor's authorization.

Figure 7 is an illustration of an SSM in an embodiment. In aspects of these embodiments, the SSM includes several functional layers that can reside in one or more processes. An adaptation layer **700** ties a framework layer **704** and a services layer **710** to a run-time environment. The adaptation layer includes an Application Program Interface (API) **702** to allow exploitation of the framework layer in the run-time environment. In aspects of these embodiments, an API can comprise a programmatic interface (e.g., class, method and/or function definitions), a communication interface such as a web service or other suitable mechanism for exchanging messages, and/or any other suitable protocol for invoking functionality and exchanging information. The present disclosure is not limited to or dependent on any API implementation presently known or yet to be developed, as will be appreciated by those of skill in the art.

The adaptation layer can invoke services of the framework layer via a framework programming interface (FPI) **706**. In one embodiment, the adaptation layer invokes the FPI to process inbound requests **610** and outbound results **624**, which in turn affords each service provider module **712-720** in the services layer the opportunity to process the request/result. The framework layer can invoke services of the services layer via a service provider interface (SPI) **708**. As with the adaptation layer API, the FPI and SPI can comprise a programmatic interface (e.g., class, method and/or function definitions), a communication interface such as a web service or other suitable mechanism for exchanging messages, and/or any other suitable protocol for invoking functionality and exchanging information. The present disclosure is not limited to or dependent on any FPI/SPI implementation presently known or yet to be developed, as will be appreciated by those of skill in the art.

In aspects of these embodiments, the FPI can translate API invocations into one or more SPI invocations. The FPI also hides the SPI from the adaptation layer, thus preventing any dependency on the SPI from forming. The SPI provides the FPI access to a set of dynamically configurable security services represented as “plug in” security provider modules (“providers”) **712 - 720**. Each provider is compatible with the SPI (e.g., each provider implements the SPI). The services layer can accommodate more than one provider of the same type. In another embodiment, the adaptation layer can communicate directly with the services layer, without an intervening framework layer (e.g., the API could invoke the SPI directly).

In one embodiment and by way of illustration, authenticator **712** is used to access a credential exchange service which allows the exchange of the current requestor’s identity to be used to obtain the appropriate set of credentials with which to authenticate target resource(s). In one embodiment, role mapping provider(s) **720** dynamically determine applicable roles based on role definitions **614** before authorization provider(s) **714 - 716** are invoked to individually render a decision regarding whether or not a requestor is authorized to submit the request or receive the response. In aspects of this embodiment, an authorization provider can evaluate policies **616** based on mapped roles to determine whether or not access to a resource should be granted. In yet another embodiment, the determination of each authorization provider is used to render a final grant or deny decision by the adjudicator provider **718**. For example, the adjudicator may grant access to a resource only if all authorization providers would grant access. Other provider types are possible (not shown): authentication provider(s) can authenticate, verify, and map security tokens to an internal format and support, for example, a single sign-on capability; audit provider(s) can audit some or all security actions taken by the framework layer; and credential mapping provider(s) can map authentication credentials for a user to legacy application for single sign-on.

In one embodiment, the response **624** can have an authorization check performed against its contents prior to returning it to the requestor (as response **612**). In aspects of this embodiment, the eXtensible Access Control Markup Language (XACML), indicated as XACML Layer **726** in **Figure 7**, provides a general-purpose language for representing and evaluating access control policies in this regard. The XACML standard is maintained by the Organization for the Advancement of Structured Information Standards (OASIS), a global consortium. (An implementation of XACML for the Java® programming language is available from Sun Microsystems, Inc.) XACML supports the use of XPath expressions for addressing locations within structured data, such as an XML document, allowing the document to have policies written against its contents.

In one embodiment, an authorization provider **716** can act as a XACML Policy Enforcement Point (PEP). The PEP communicates with an XACML context handler **722** which has access to the result **624**. In order to enforce policy, the context handler can formalize attributes **736** describing the requestor at Policy Information Point (PIP) **730** and delegate the authorization decision to a Policy Decision Point (PDP) **728**. Applicable policies are located in a policy store **734** and are evaluated at the PDP, which then returns an access decision to the context handler. In one embodiment, policies **616** can be automatically translated to XACML policies **734**, and vice versa. In another embodiment, all policies in the system are represented as XACML policies and wherein an authorization provider can elect to use the policies and further elect to translate the policies to a form suitable for evaluation.

An XACML policy comprises a set of rules, an optional set of obligations, and the identity of a rule-combining algorithm to adjudicate results from more than one policy to yield a single result. Obligations for rules evaluated by the PDP are provided by the PDP to the PEP for enforcement upon a grant or deny authorization decision by the PDP. An obligation can be used to trigger any kind of action in the PEP, including in one embodiment removing data from (or encrypting data in) the result **624** which the requestor is not authorized to see or access. The modified result **612** can then be safely provided to the requestor.

In one embodiment, SSMs are part of a distributed security network. **Figure 8** is an illustration of system components to propagate security information in accordance to an embodiment. In one embodiment, policy and/or SSM configuration information (hereinafter "security information") is distributed to SSMs via Security Control Mangers (SCMs) **802**. This is referred to as "provisioning". SCMs can reside anywhere on a computer network. In one embodiment, an SCM resides locally on systems that have one or more SSMs. An administration server **800** can provision the security information to an SCM periodically. In one embodiment, the information provisioned to an SCM is only relevant to SSMs deployed on the same system as the SCM. In aspects of these embodiments, only changes ("deltas") to this information are propagated to SCMs. This is desirable since it can reduce the amount of information that needs to be transmitted between the administration server and the SCMs. By way of illustration, this can be accomplished by associating a version number with provisioning information or subsets thereof.

SCMs can cache provisioned information in a local store **804** and further provision it to one or more SSMs. In one embodiment, an SCM provisions information to SSMs that reside on the same system as the SCM. In various embodiments, provisioned information can specify security providers, locations of directory servers, databases, XACML configuration information, and other suitable information. By way of illustration, an SSM can dynamically incorporate security providers based on configuration information supplied to it by an SCM.

The SCM has many architectural benefits for the system. Firstly, the SCM can serve as the sole external management interface for all SSM components. This can eliminate redundant management infrastructure in system components, thus allowing all system components to take advantage of improvements in future versions of the SCM management interface. Secondly, having a single management interface per computing device has security benefits. An SCM-enabled host can expose a single management communication channel rather than one per SSM. This eliminates the need for a listen port in each SSM process, drastically reducing the number of open ports that are required to be secured and monitored. Finally, the use of the SCM can greatly simplify SSM configuration. Rather than relying on instance specific configuration files, an SSM can retrieve its entire configuration from the SCM via a well-known communication port.

In one embodiment, an SCM can supply provisioned information to SSMs as needed (e.g., in response to requests by SSMs). In another embodiment, the SCM can also convey the information automatically without being requested to do so. In aspects of these embodiments, an SCM only provides provisioning information to an SSM is that relevant to that SSM and, in further aspects, only provides deltas to SSMs. In various embodiments, communication between system components can be accomplished with secure protocols. By way of illustration, mutually authenticated Transport Layer Security (TSL) connections can be utilized between components. In addition, the SCM and SSM can exchange Public-Key Infrastructure (X.509) certificates to establish identity and trust.

To facilitate the management of a potentially large number of distributed SSMs, the administration server uses a remote administration mechanism to distribute security information to each SSM. In various embodiments, the SCM is a component of this remote administration mechanism. Each SCM is responsible for storing **804** and maintaining policy and configuration information for all SSMs that it are associated with. In one embodiment, an SCM is associated with the SSMs on its local machine. When a change to an SSM's configuration or policy is made and distributed from an administration console, an SCM receives the change and updates its cached copy of the configuration. The change is then propagated to the SSM which can adapt to the configuration change dynamically or at a later time. In addition to facilitating management, the SCM enables SSMs to operate in the absence of the administration server. Since SCMs maintain a persistent copy of each configuration, new SSMs can be started and existing SSMs can continue to function, even if the Administration server goes down.

In one embodiment, the administration console can provide a graphical user interface for defining policies. For example, the user interface could provide a rendering of the XML document **624** that would allow a user to interactively select elements of the document and define the policy required to access those elements. In a further embodiment, a graphical editor or wizard that would present the user with easy-to-follow steps for defining a policy, such that the user would not require any knowledge of the underlying policy mechanism.

Although this embodiment was described with reference to a graphical user interface, a user interface is not limited to such and can include one or more of the following: an ability to respond to sounds and/or voice commands; an ability to respond to input from a remote control device (e.g., a cellular telephone, a PDA, or other suitable remote control); an ability to respond to gestures (e.g., facial and otherwise); an ability to respond to commands from a process on the same or another computing device; and an ability to respond to input from a computer mouse and/or keyboard. This disclosure is not limited to any particular user interface. Those of skill in the art will recognize that many other user interfaces presently known and yet to be developed are possible and fully within the scope and spirit of this disclosure.
When coupled with concepts such as data transformation services and Enterprise Service Bus, the system allows enterprises to dynamically assembly new applications with minimal developer involvement. **Figure 9** is an illustration of a system in accordance to an embodiment. In one embodiment, applications/services/processes **924** communicate with each other and with other applications/services/processes through a common messaging framework **926** which acts as a logical bus. Together, the messaging framework and its services (**902-912** and **922)** comprise a service infrastructure **900**. The messaging framework is made possible through messaging services **904** (e.g., service bus) which provide message management, a service registry and service management. Data services **906** (e.g., liquid data) include functionality for unified data modeling and composite data management. Security services **908** (e.g., SSM, SCM) provide distributed application security management and federated identity management. Management services **902** allow dynamic configuration of the service infrastructure.
Composition services **910** include processor orchestration mechanisms such as business process management, business rules, enterprise connectivity and business activity management. Information needed to compose services is included in the meta-data repository **912**. Services such as performance monitoring, service level agreements, data views, etc., are available to all services/applications through one or more shared services **922**. Clients **914** such as web browsers and other applications can communicate with the processes such as portals, web services and web services which are included in the presentation tier **916**. Likewise, presentation tier processes can communicate with logic components **918** such as other web services. Finally, logic components can access backend data sources **920** such as relational

databases. Each of these elements **914-920** can interact with the other through the messaging framework.

Figure 10 is an illustration of an integrated service composition system in accordance to an embodiment. The bottommost application platform services layer **1000** provides a runtime environment for a service implementation, such as J2EE or .Net. Above this layer, a message services layer **1002**, data and information services layer **1004**, and security services layer **1006** provide functionality as described above in relation to service infrastructure components **904**, **906** and **908**, respectively. A process orchestration layer **1008** is logically dependent on these underlying layers and allows the programming language independent composition of services through user interfaces which present services as entities that can be connected through the service infrastructure. User interaction components **1010** allow services and composed services to face a user through a user interface such as, but not limited to, a web portal.

Various embodiments may be implemented using a conventional general purpose or specialized digital computer(s) and/or processor(s) programmed according to the teachings of the present disclosure, as can be apparent to those skilled in the computer art. Appropriate software coding can readily be prepared by skilled programmers based on the teachings of the present disclosure, as can be apparent to those skilled in the software art. The invention may also be implemented by the preparation of integrated circuits and/or by interconnecting an appropriate network of conventional component circuits, as can be readily apparent to those skilled in the art. Various embodiments include a computer program product which is a storage medium (media) having instructions stored thereon/in which can be used to program a general purpose or specialized computing processor(s)/device(s) to perform any of the features presented herein. The storage medium can include, but is not limited to, one or more of the following: any type of physical media including floppy disks, optical discs, DVDs, CD-ROMs, microdrives, magneto-optical disks, holographic storage, ROMs, RAMs, PRAMS, EPROMs, EEPROMs, DRAMs, VRAMs, flash memory devices, magnetic or optical cards, nanosystems (including molecular memory ICs); paper or paper-based media; and any type of media or device suitable for storing instructions and/or information. Various embodiments include a computer program product that can be transmitted in whole or in parts and over one or more public and/or private networks wherein the transmission includes instructions which can be used by one or more processors to perform any of the features presented herein. In various embodiments, the transmission may include a plurality of separate transmissions.

Stored one or more of the computer readable medium (media), the present disclosure includes software for controlling both the hardware of general purpose/specialized computer(s) and/or processor(s), and for enabling the computer(s) and/or processor(s) to interact with a human user or other mechanism utilizing the results of the present invention. Such software may include, but is not limited to, device drivers, operating systems, execution environments/containers, user interfaces and applications.

The foregoing description of the preferred embodiments of the present invention has been provided for purposes of illustration and description. It is not intended to be exhaustive or to limit the invention to the precise forms disclosed. Many modifications and variations can be apparent to the practitioner skilled in the art. Embodiments were chosen and described in order to best explain the principles of the invention and its practical application, thereby enabling others skilled in the relevant art to understand the invention. It is intended that the scope of the invention be defined by the following claims and their equivalents.

CLAIMS

What is claimed is:

1. A method for interconnecting a plurality of processes in a switching fabric, comprising:

resolving transport protocol variances dynamically among the plurality of processes;

resolving message format variances dynamically among the plurality of processes;

conveying message traffic between the plurality of processes; and

wherein a process in the plurality of processes is one of: a client, a service, a web service, and a service proxy.

2. The method of claim 1, further comprising:

satisfying authentication and/or authorization requirements among the plurality of processes.

3. The method of claim 1 wherein the conveying includes:

routing a message to a process in the plurality of processes based on information in the message.

4. The method of claim 1 wherein the resolving message format incompatibilities includes:

converting a message to a format that is compatible with a destination process in the plurality of processes.

5. The method of claim 1 wherein the resolving transport protocol incompatibilities includes:

sending a message to a destination process in the plurality of processes via a transport protocol that is compatible with the destination process.

6. The method of claim 1 wherein:

a transport protocol is one of: File Transfer Protocol (FTP), Hypertext Transfer Protocol (HTTP), HTTP/Secure (HTTPS), Java Message Service (JMS), file and electronic mail.

7. The method of claim 1 wherein:

the switching fabric is a message processing graph that includes a plurality of interconnected message processing nodes through which the message traffic is conveyed.

8. A machine readable medium having instructions stored thereon that when used cause a system to:

resolve transport protocol variances dynamically among a plurality of processes;

resolve message format variances dynamically among the plurality of processes;

convey message traffic between the plurality of processes; and

wherein a process in the plurality of processes is one of: a client, a service, a web service, and a service proxy.

9. A service infrastructure comprising:

a message services layer configured to interconnect a plurality of processes through at least one service proxy;

a information services layer configured to provide a unified view of information obtained from a plurality of information sources;

a security services layer configured to provide distributed security to the message services layer; and

wherein a process in the plurality of processes is one of: a client, a service, a web service, and a service proxy.

10. The service infrastructure of claim 9 wherein:

the information services layer is further configured to redact a portion of the information obtained based on a security policy.

11. The service infrastructure of claim 9 wherein:

the security services layer is further configured to provision security information.

12. The service infrastructure of claim 9 wherein:
the security services layer is further configured to guard a resource.

13. The service infrastructure of claim 9, wherein the message services layer further comprises:
a plurality of message processing nodes that are each configured to perform at least one action based message traffic flowing between the plurality of processes.

14. The service infrastructure of claim 13 wherein:
an action is one of: resolving transport protocol variances dynamically among the plurality of processes; resolving message format variances dynamically among the plurality of processes; conveying message traffic between the plurality of processes; and satisfying authentication and/or authorization requirements among the plurality of processes.

15. A network accessible device configured to perform the steps of claim 1.

16. A system comprising one or more components capable of performing the following steps:
resolving transport protocol variances dynamically among a plurality of processes;
resolving message format variances dynamically among the plurality of processes;
conveying message traffic between the plurality of processes; and
wherein a process in the plurality of processes is one of: a client, a service, a web service, and a service proxy.

17. The system of claim 16, further capable of performing the following step:
satisfying authentication and/or authorization requirements among the plurality of processes.

18. The system of claim 16, further capable of performing the following step:
routing the message to a process in the plurality of processes based on information in the message.

19. The system of claim 16, further capable of performing the following step:
converting the message to a format that is compatible with a destination process in the plurality of processes.

20. The system of claim 16, further capable of performing the following step:
sending the message to a destination process in the plurality of processes via a transport protocol that is compatible with the destination process.

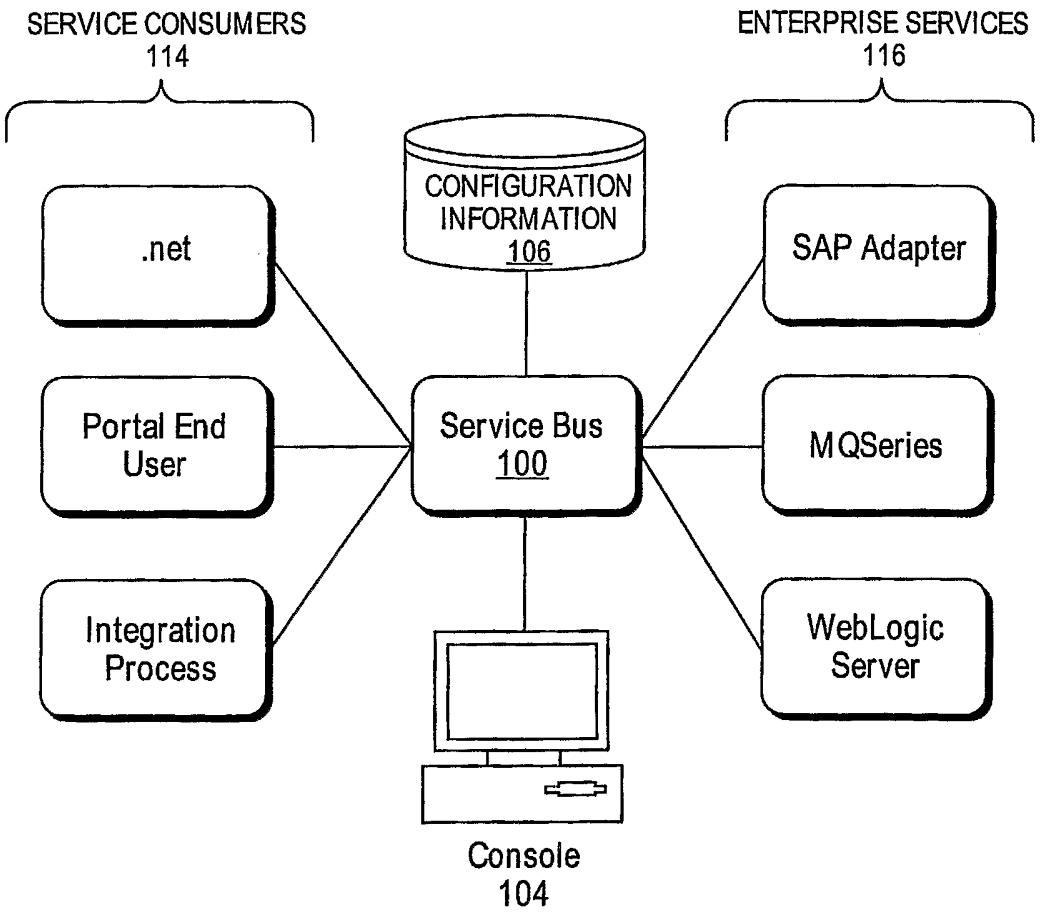
SERVICE CONSUMERS
114
ENTERPRISE SERVICES
116
CONFIGURATION INFORMATION
106
.net
Portal End User
Integration Process
Service Bus
100
SAP Adapter
MQSeries
WebLogic Server
Console
104

FIG. 1A

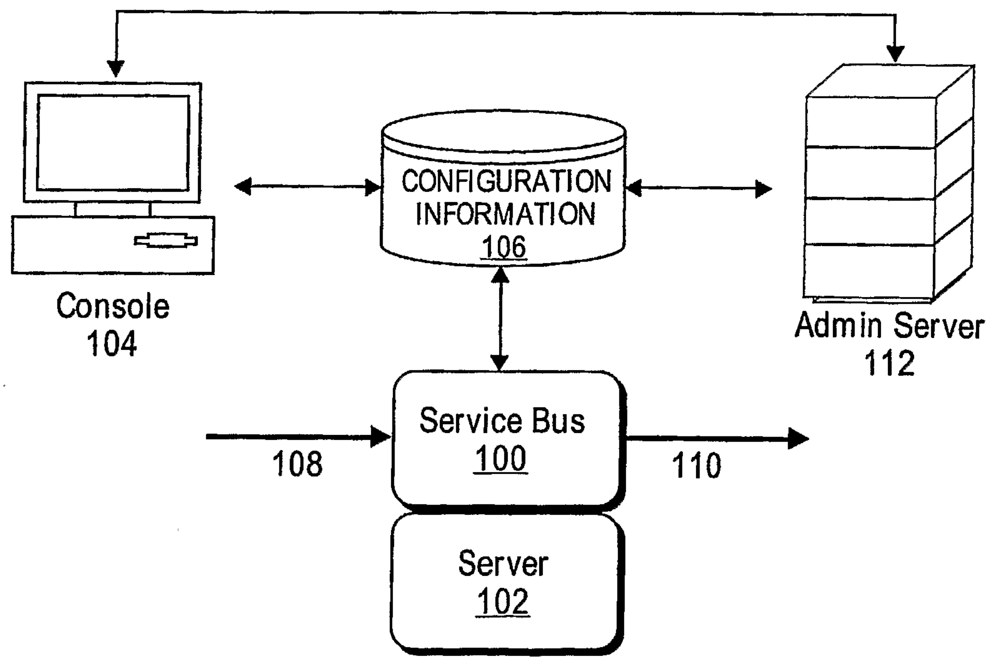
Console
104
CONFIGURATION INFORMATION
106
Admin Server
112
Service Bus
100
108
110
Server
102

FIG. 1B

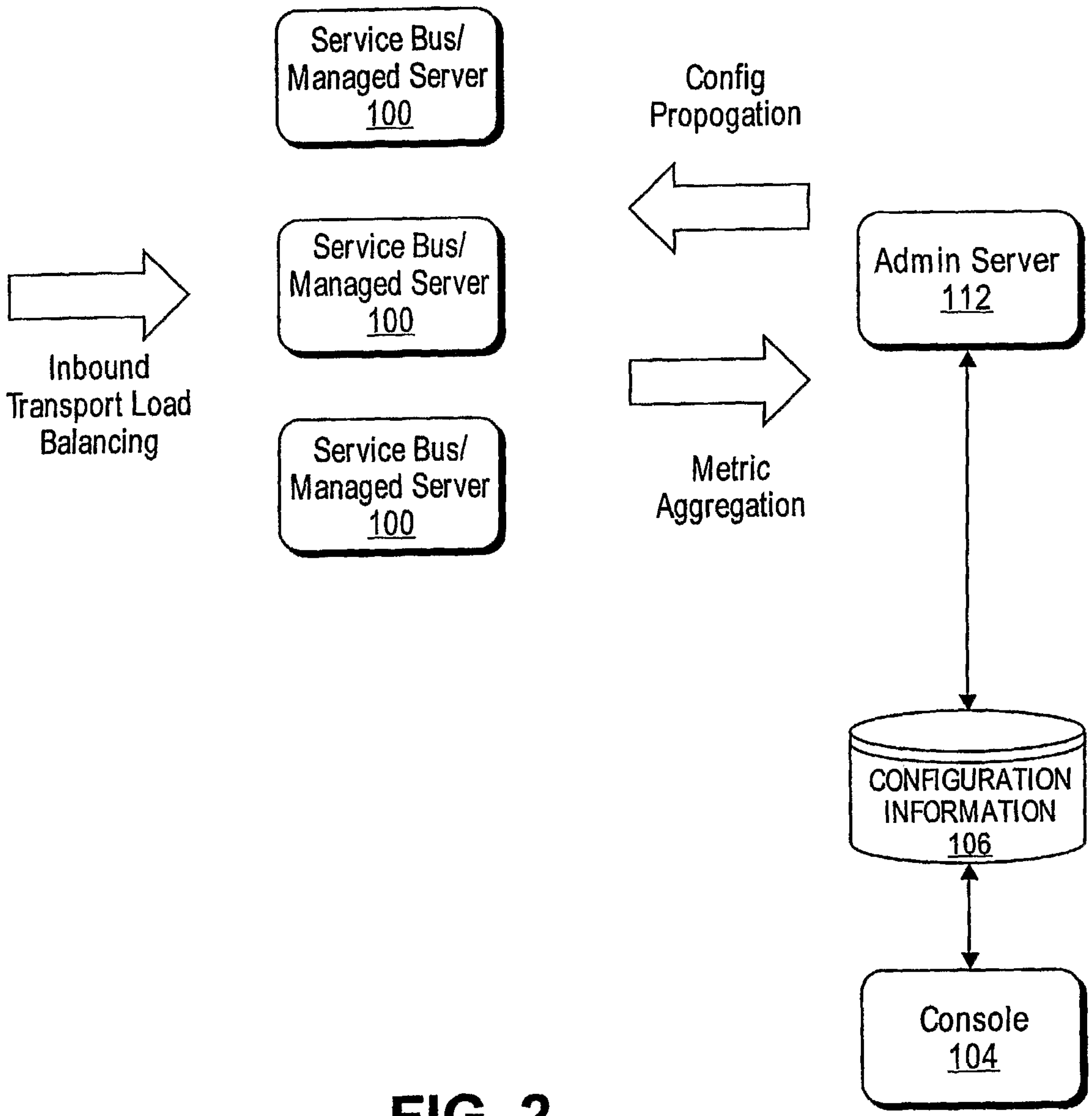
Service Bus/
Managed Server
100
Service Bus/
Managed Server
100
Service Bus/
Managed Server
100
Config
Propogation
Admin Server
112
Inbound
Transport Load
Balancing
Metric
Aggregation
CONFIGURATION
INFORMATION
106
Console
104

FIG. 2

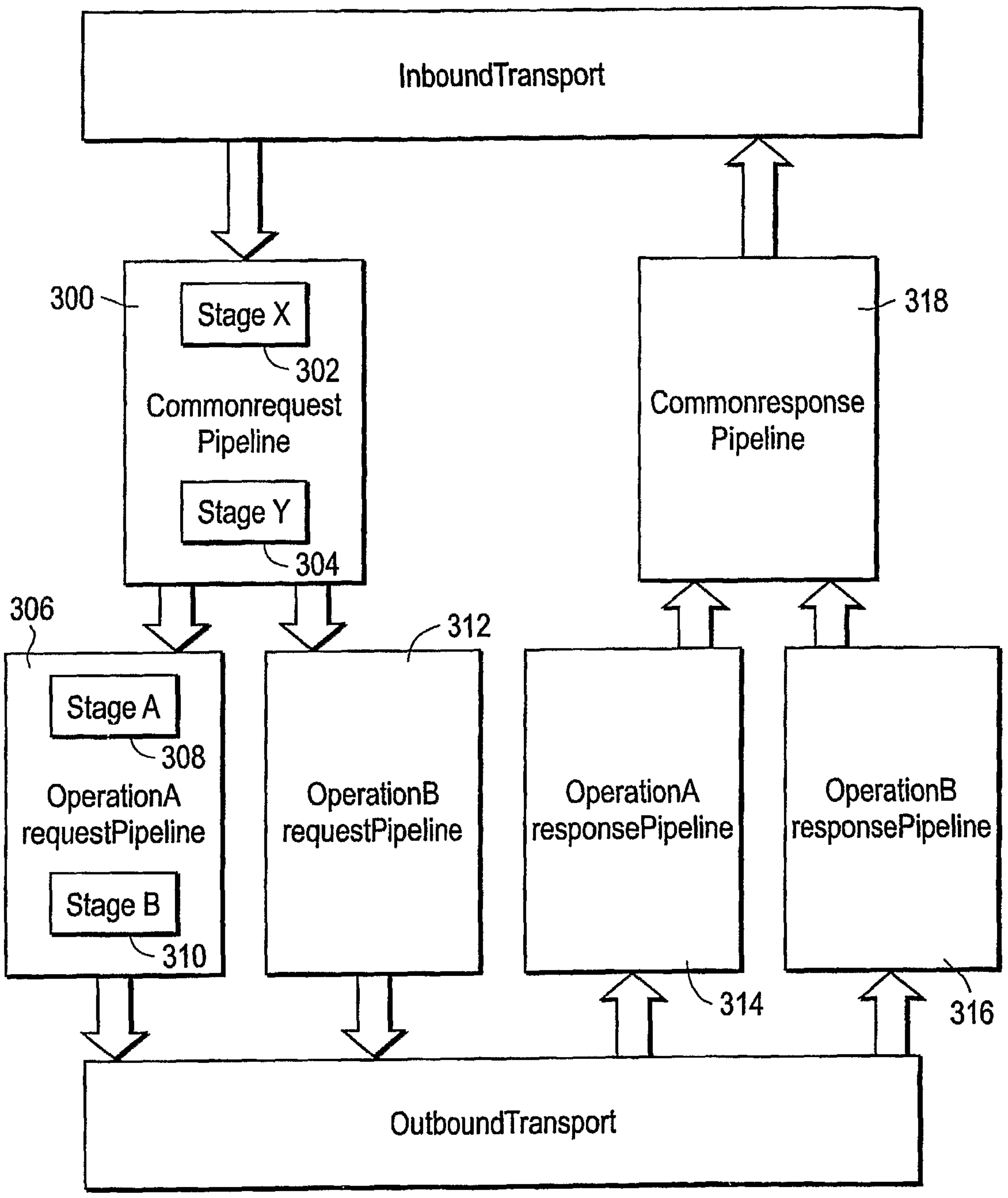
InboundTransport
300
Stage X
302
Commonrequest Pipeline
Stage Y
304
318
Commonresponse Pipeline
306
Stage A
308
OperationA requestPipeline
Stage B
310
312
OperationB requestPipeline
OperationA responsePipeline
314
OperationB responsePipeline
316
OutboundTransport

FIG. 3

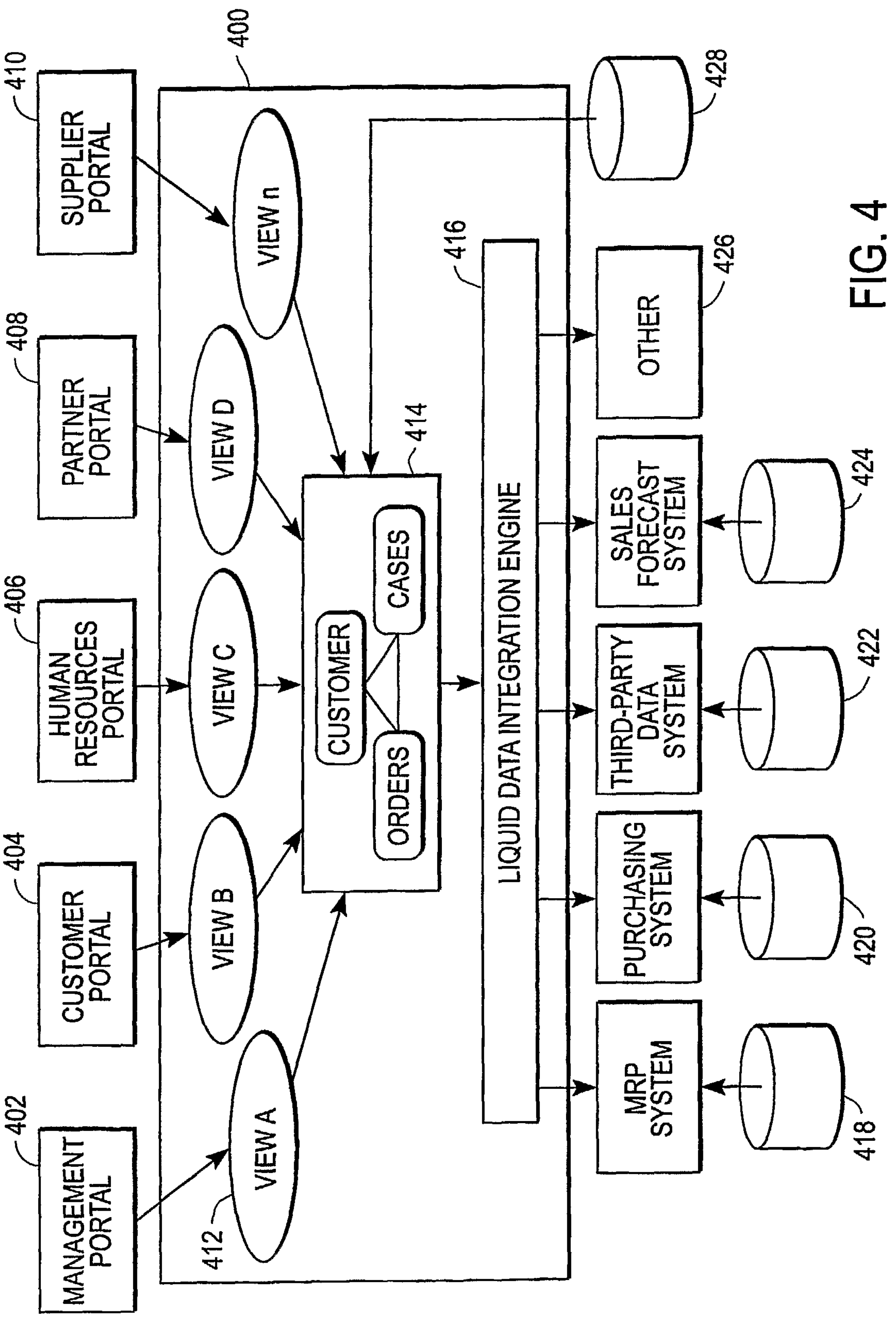
MANAGEMENT PORTAL
402
CUSTOMER PORTAL
404
HUMAN RESOURCES PORTAL
406
PARTNER PORTAL
408
SUPPLIER PORTAL
410
400
412
VIEW A
VIEW B
VIEW C
VIEW D
VIEW n
414
CUSTOMER
ORDERS
CASES
416
LIQUID DATA INTEGRATION ENGINE
MRP SYSTEM
PURCHASING SYSTEM
THIRD-PARTY DATA SYSTEM
SALES FORECAST SYSTEM
OTHER
418
420
422
424
426
428

FIG. 4

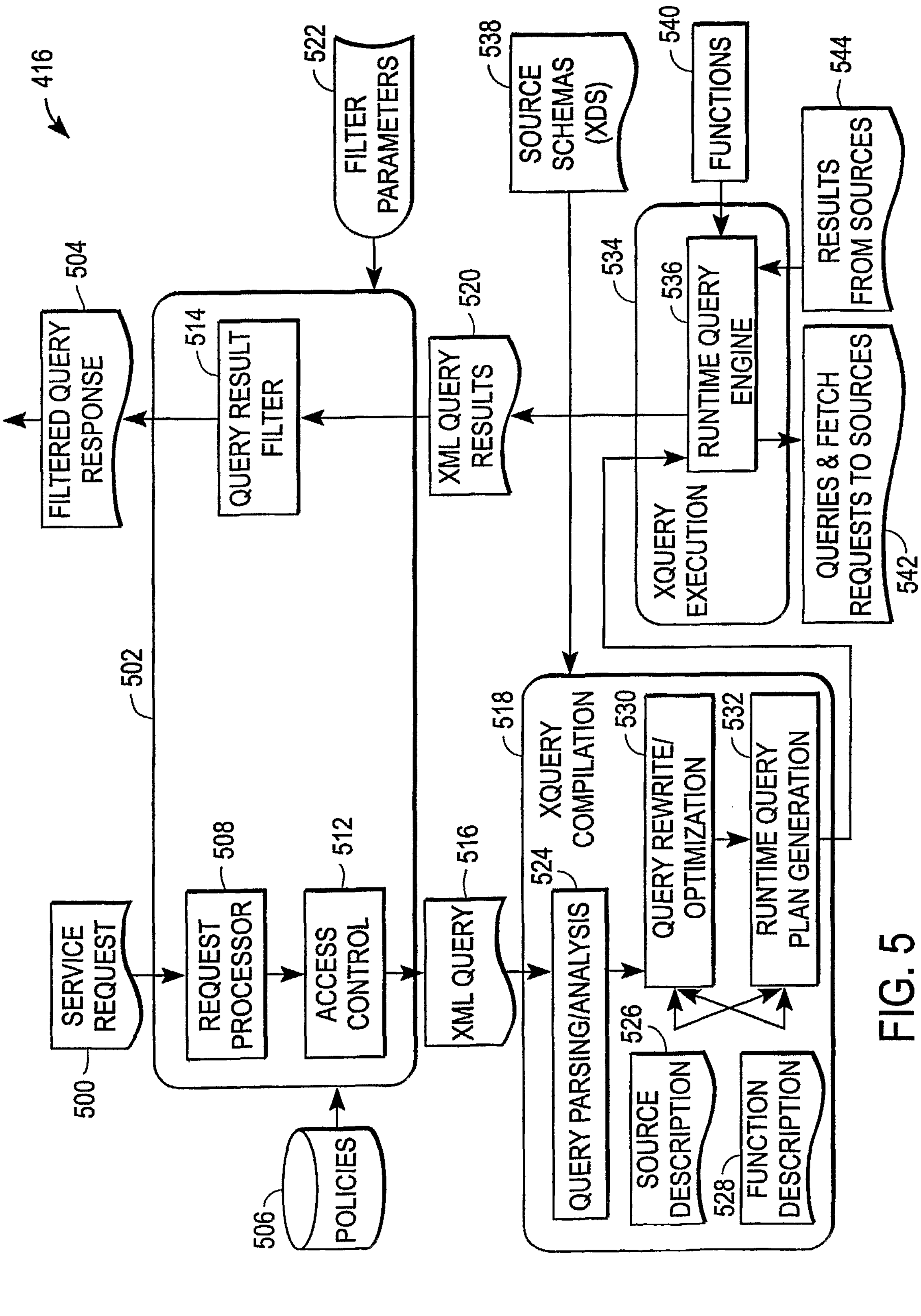
416
SERVICE REQUEST
500
502
REQUEST PROCESSOR
508
ACCESS CONTROL
512
POLICIES
506
QUERY RESULT FILTER
514
FILTERED QUERY RESPONSE
504
FILTER PARAMETERS
522
XML QUERY
516
XML QUERY RESULTS
520
XQUERY COMPILATION
518
QUERY PARSING/ANALYSIS
524
QUERY REWRITE/ OPTIMIZATION
530
RUNTIME QUERY PLAN GENERATION
532
SOURCE DESCRIPTION
526
FUNCTION DESCRIPTION
528
SOURCE SCHEMAS (XDS)
538
FUNCTIONS
540
XQUERY EXECUTION
534
RUNTIME QUERY ENGINE
536
QUERIES & FETCH REQUESTS TO SOURCES
542
RESULTS FROM SOURCES
544

FIG. 5

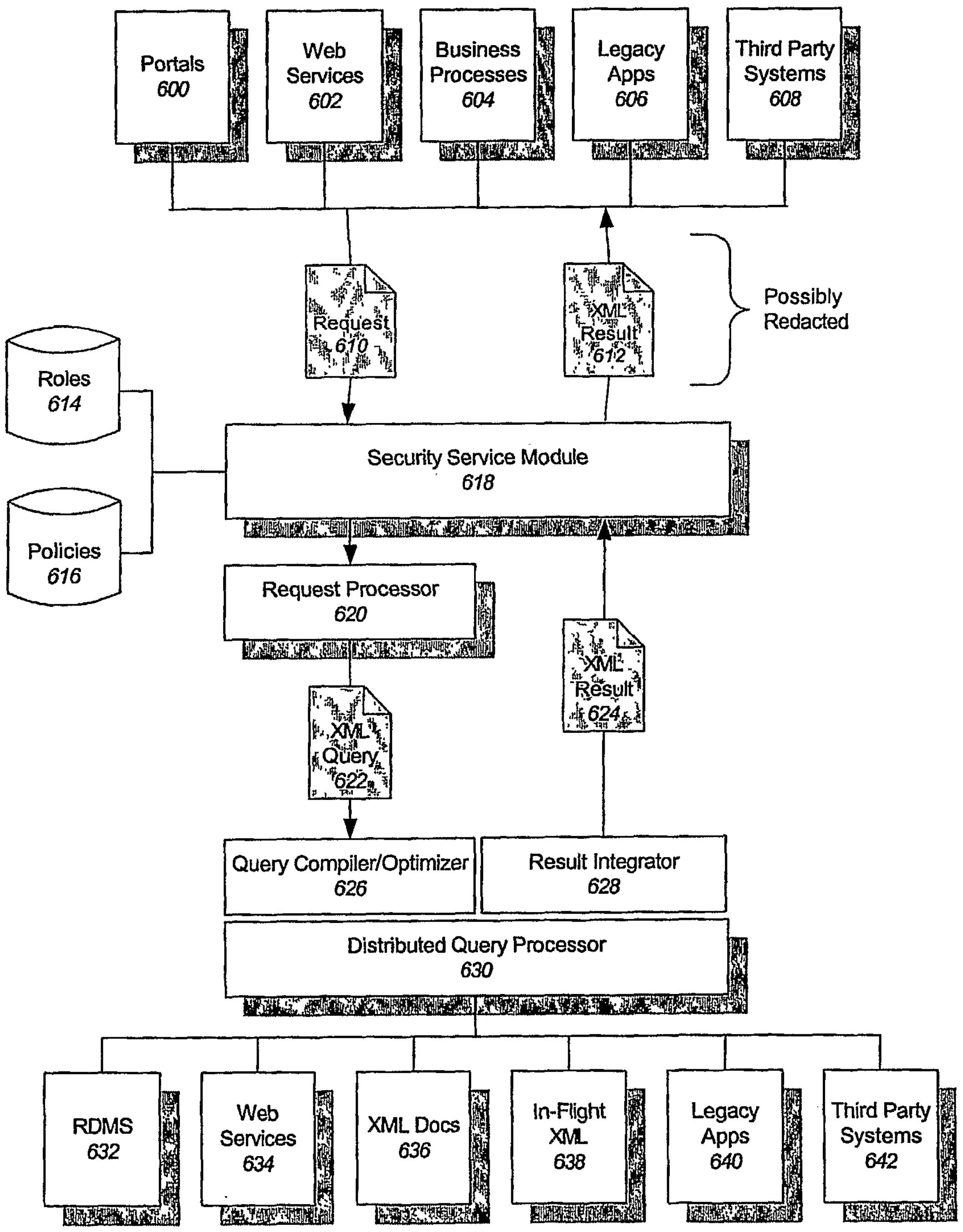
Portals 600
Web Services 602
Business Processes 604
Legacy Apps 606
Third Party Systems 608
Request 610
XML Result 612
Possibly Redacted
Roles 614
Policies 616
Security Service Module 618
Request Processor 620
XML Query 622
XML Result 624
Query Compiler/Optimizer 626
Result Integrator 628
Distributed Query Processor 630
RDMS 632
Web Services 634
XML Docs 636
In-Flight XML 638
Legacy Apps 640
Third Party Systems 642

FIG. 6

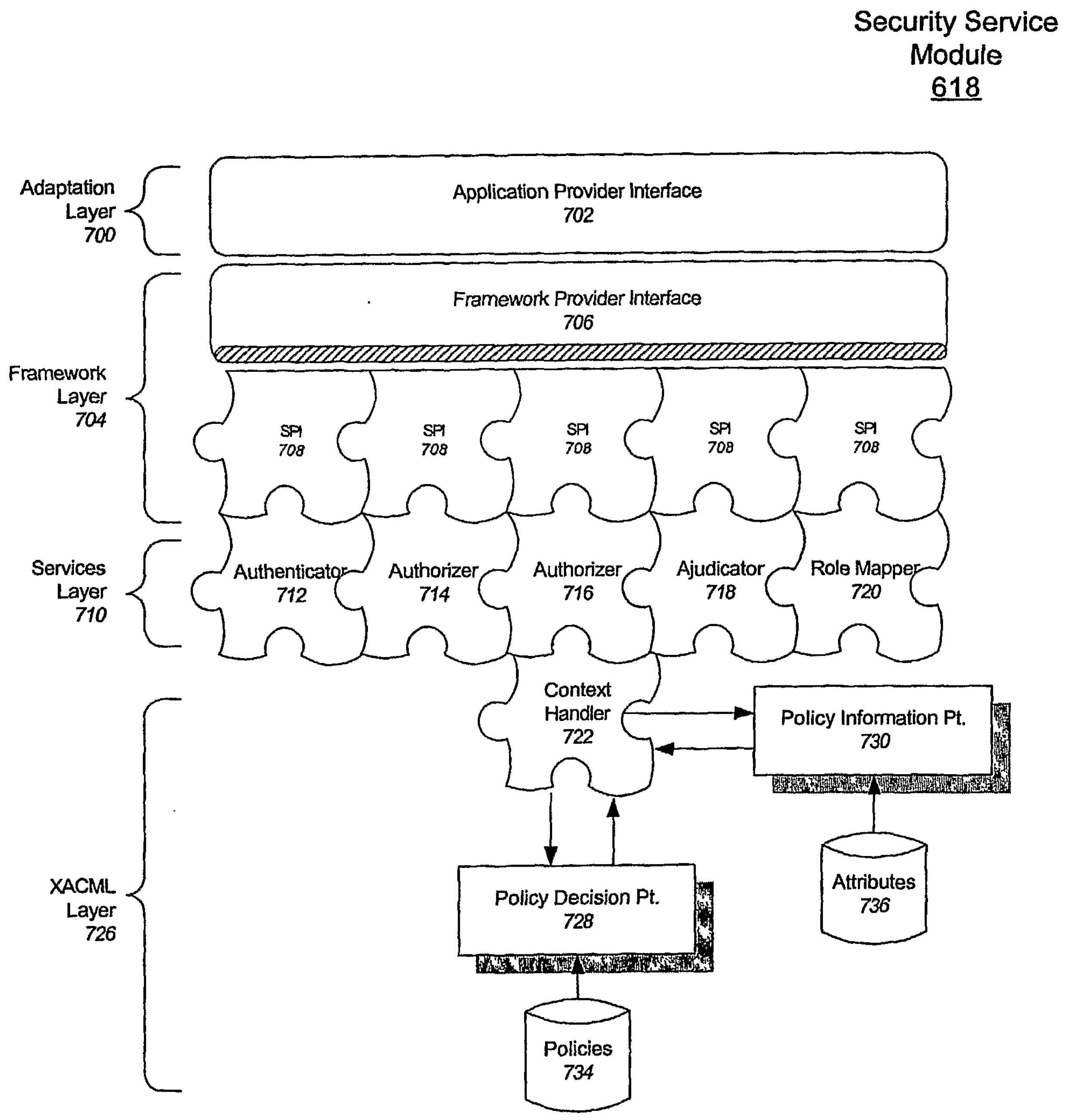
Security Service Module 618
Adaptation Layer 700
Application Provider Interface 702
Framework Provider Interface 706
Framework Layer 704
SPI 708
SPI 708
SPI 708
SPI 708
SPI 708
Services Layer 710
Authenticator 712
Authorizer 714
Authorizer 716
Ajudicator 718
Role Mapper 720
Context Handler 722
Policy Information Pt. 730
XACML Layer 726
Policy Decision Pt. 728
Attributes 736
Policies 734

FIG. 7

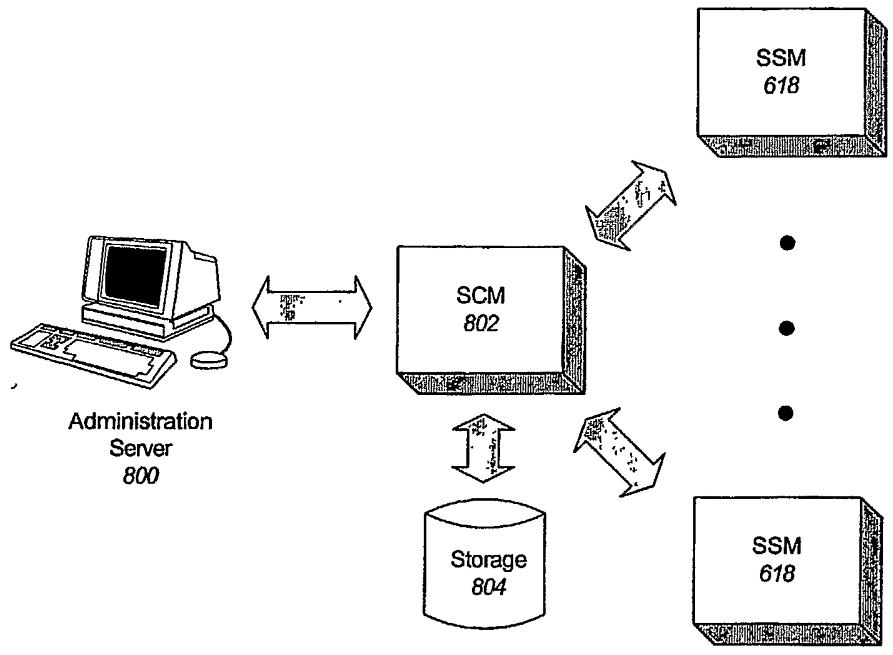
SSM
618
SCM
802
Administration
Server
800
Storage
804
SSM
618

FIG. 8

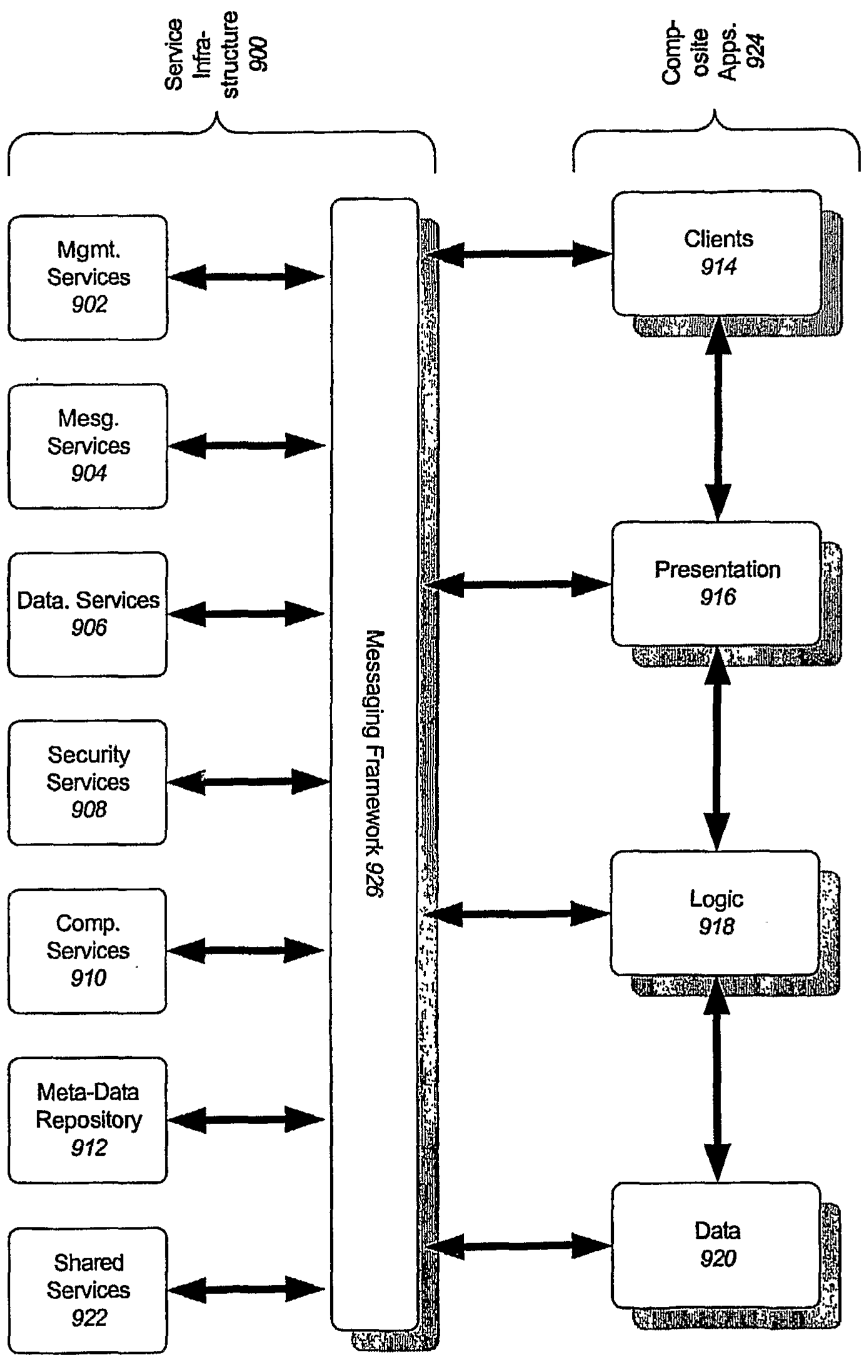
Service Infra-structure 900
Comp-osite Apps. 924
Mgmt. Services 902
Mesg. Services 904
Data. Services 906
Security Services 908
Comp. Services 910
Meta-Data Repository 912
Shared Services 922
Messaging Framework 926
Clients 914
Presentation 916
Logic 918
Data 920

FIG. 9

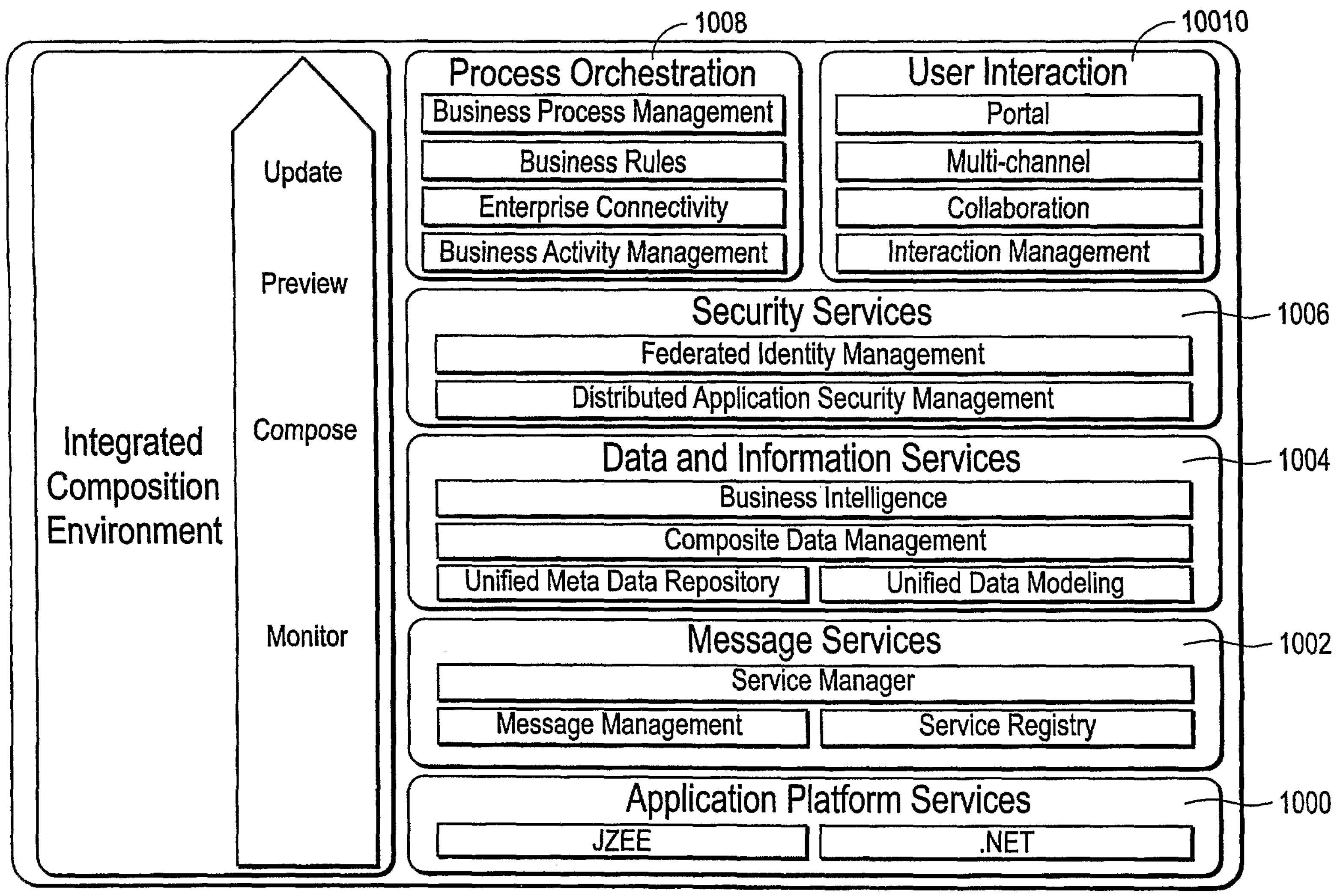
1008
10010
Process Orchestration
Business Process Management
Business Rules
Enterprise Connectivity
Business Activity Management
User Interaction
Portal
Multi-channel
Collaboration
Interaction Management
Security Services
Federated Identity Management
Distributed Application Security Management
1006
Data and Information Services
Business Intelligence
Composite Data Management
Unified Meta Data Repository
Unified Data Modeling
1004
Message Services
Service Manager
Message Management
Service Registry
1002
Application Platform Services
JZEE
.NET
1000
Integrated Composition Environment
Update
Preview
Compose
Monitor

FIG. 10